Report

Phase II Lake Study Report

Scope I.D.: 00L008

Long Lake Advancement Association

August 2005

Long Lake Association
Phase II Report

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1 Introduction

Long Lake is located in eastern Manitowoc County approximately 3 miles south of the city of Brillion. The lake covers 119 acres with a maximum depth of 38 feet. A dam on the south end of the lake controls the water level in the lake.

The Long Lake Advancement Association completed a Phase I lake planning study in May 2003. The study showed the lake to be highly eutrophic with a relatively small watershed. Phosphorus concentrations were high and have led to elevated algae levels and excessive weed growth. Chemical treatment for phosphorus removal was identified as a potential lake management strategy. Northern pike spawning was evaluated with a focus on the dam. Controlling water levels and providing increased spawning areas are a key in improving northern pike populations in the lake.

In October 2003, the Long Lake Advancement Association was awarded a Lake Planning Grant from the Wisconsin Department of Natural Resources (WDNR) to conduct a Phase II study to consider the sources of phosphorus loading to the lake.

1.1 Authorization

The Long Lake Advancement Association authorized Foth & Van Dyke to complete the Phase II study for Long Lake, and to prepare a report identifying the results. The study was completed through a collaborative effort between Foth & Van Dyke and the Long Lake Advancement Association volunteers.

1.2 Purpose

The purpose of the Phase II lake study was to address the following areas:

- Evaluate the septic systems around Long Lake. Determine the potential impact the septic systems have on the lake.
- Evaluate the impact of stormwater runoff on the lake. Make recommendations to improve stormwater management around Long Lake.
- Evaluate flows in and out of Long Lake and measure phosphorus in the inlet and outlet streams. Use the information to model phosphorus concentrations in the lake.
- Identify potential northern pike spawning areas and the means to improve these areas.

The results of the study will be used to provide the Long Lake Advancement Association with an understanding of the impact from septic systems and stormwater runoff on the lake water quality. This report may be used in conjunction with the Phase I study and possibly with future studies to develop a long term lake management plan for Long Lake.

2 Septic System Evaluation

A sanitary survey was conducted on July 3, 2004 at Long Lake. Staff from Foth & Van Dyke collected information from 62 residences. The completed survey forms are included in Appendix A.

The intent of the survey was to gather information on the type of septic systems, the system age, the system location in relation to the lake, and document any problems with the septic systems. A point system was developed for each of the categories. The point system is as follows:

Category	Criteria	Points
Septic System Age	Over 20 years	1
	11-20 years	2
	0-10 years	3
Horizontal Distance From Lake	0-50 feet	1
	51-100 feet	2
	101-150 feet	3
	151-200 feet	4
	Over 200 feet	5
Vertical Distance Above Lake	0-5 feet	1
	6-10 feet	2
	11-15 feet	3
	16-20 feet	4
	Over 20 feet	5
Septic System Operation	Problem	1
	No Problem	2

A septic system that graded as the worst possible would have 4 points with one point for each category. A septic system that graded as the best possible would have 15 points total. Generally, septic systems that score less than 10 points have a higher potential to impact the lake.

A total of 62 septic systems were evaluated. There were 42 holding tanks and 5 outhouses for which no score was given. Of the remaining 15 systems, 12 were conventional septic tank and disposal field type and 3 were mound systems. Adequate information was available for a complete score for 13 systems. The scores ranged from 5 to 14. There were 10 systems that scored 9 points or less and have a high potential to impact the lake. These systems represent 16% of the total systems evaluated. Note that of the 13 systems that had complete scores, 77% had scores of 9 or less and have a high potential to impact the lake. Most of the systems with a high potential for impacting the lake were located on West Shore Retreat and Popp Lane. These

areas are relatively low in relation to the lake and may not have adequate area for suitable septic systems.

With 68% of the on-site systems using holding tanks, the trend is to replace septic systems and fields with holding tanks. Many of the sites along the lake are on small lots and suitable areas for wastewater disposal are not available. Holding tanks are a good alternative to septic systems to eliminate potential discharges to groundwater.

3 Stormwater Impacts

Stormwater can affect the lake water quality by carrying pollutants into the lake. The pollutants get into stormwater when stormwater erodes soil or when contaminants are dissolved from the soil surface. Improving stormwater management around the lake can reduce the amount of pollutants that enter the lake.

3.1 Residential Stormwater

The sanitary survey form also included questions and space for drawing stormwater runoff patterns at each lot. Appendix A contains the sanitary survey forms. Information on stormwater is contained on the back side of each form. Erosion and stormwater runoff are difficult to quantify thus the survey form did not include numerical values for each lot. The information obtained did contain general trends that showed the following:

- Most lots slope to the lake but have a relatively low slope.
- The soil around the lake is generally clay loam and slowly permeable. Vegetation growth is good when established.
- Lawn grass is commonly planted over much of the property and close to the lake.
- Rip rap or stone walls are commonly placed along shore to control erosion.

Based on the observations made during the sanitary survey, Foth & Van Dyke recommends that homeowners work to channel clean water to the lake. Soil infiltration should be promoted but due to the low permeability of the soil, stormwater will often exceed the capacity of the soil and runoff into the lake. The following recommendations can be used by homeowners to improve stormwater management on their property:

A. If a house has no gutters, install a raised gravel bed beneath the roofline. Stormwater will run off the roof and fall onto the raised gravel bed. There the water will be stored and soak into the ground without causing runoff and erosion.

B. If a house has gutters and downspouts, there are several alternatives to reduce runoff and erosion:
   - Directly connect the downspouts to buried perforated plastic tubing that allows the rainwater to infiltrate into the ground. Due to low permeability, the plastic tubing should discharge to the lake or non-eroding channel.
   - Directly connect the downspouts to non-eroding channels to direct water to the lake.

C. Where water comes from driveways or offsite, use non-eroding channels or pipes to direct the clean water to the lake.

D. Construct terraces on sloped lots to reduce runoff.

E. Remove leaves and other vegetation from the yard in areas where stormwater can wash the vegetation into the lake. Leaves contain high concentrations of phosphorus and nitrogen that can break down in the lake releasing the nutrients as potential food for algae and lake weeds.

F. Use zero phosphorus lawn fertilizers to limit phosphorus getting into lake from lawns.

G. Plant a vegetated buffer strip along the lake rather than lawn. The vegetated buffer strip will help reduce runoff getting into the lake.

WDNR has good information on residential practices to reduce runoff and erosion.

Foth & Van Dyke noted an area on the north end of Sunset Lane where residents have disposed of yard waste and lake weeds. This area is adjacent to the wetland between Boot Lake and Long Lake. The vegetative waste disposed of in this area will decompose and runoff into the wetland and eventually into the lake. The Lake Association should consider establishing a place where residents can take yard waste and lake weeds for disposal that does not impact the lake.

3.2 Non-Residential Stormwater

In addition to runoff on residential property, significant runoff can occur from roads, agricultural sites, construction sites and other areas that drain to the lake. The sanitary survey found significant runoff and pollution potential from agricultural areas on the west shore of the lake. Much of the agricultural runoff enters the lake from an agricultural area southwest of West Shore Retreat. In 2004, the field was planted in corn and with the high rainfall in spring, a large amount of water and sediment runoff entered the lake. Residents in the south portion of West Shore Retreat verified runoff flowing through their yards to the lake.

Potential improvements to reduce agricultural runoff include:

- Changing the crop to a perennial hay crop and reduce plowing the field
- Establish a vegetated buffer between the field and the property line to trap sediment
- Construct a stormwater detention pond to reduce sediment transport to the lake.

In addition, there are eroded ditches in the West Shore Retreat area. These were dry at the time of the inspection but residents say the ditches flow with water in spring and after rain events. Improvements to this area could include reinforcing the ditch sides with rip rap. Upstream of the ditches, water management to reduce runoff will aid in reducing erosion in the ditches.

4 Stream Flow/Lake Level Monitoring

The Phase I study identified water level management as a potential key to improving northern pike spawning success. The high phosphorus levels in the lake also required more data gathering in regard to where phosphorus comes into the lake. To aid in learning more about the lake, the inlet stream at the north end of the lake and an outlet stream at the south end of the lake were monitored for flow and phosphorus concentration. Lake levels were also monitored. Data was collected during the 2004 open water season (April 11 to December 12).

The inlet stream was monitored at the Boot Lake Road crossing. A staff gauge was installed and flow measurements were taken at three different times (April, May, and July) to create a stream flow/staff gauge chart. Staff gauge readings were taken weekly during the open water monitoring season. The detailed measurements and stream flows are contained in Appendix B. The peak staff gauge measurement occurred on May 25, 2004 correlating to an estimated flow of 1.89 cfs. The inlet stream flow was consistently above 0.5 cfs from early April until late June. After July 19, the inlet stream flow was reduced to near zero. The water in the inlet stream was impacted by the lake level. The staff gauge readings continued to drop throughout the summer even though there was little or no flow in the inlet stream because the lake level also dropped. The inlet stream flow beginning April 1, 2004 is estimated at 61.5 million gallons.

With significant stream inflow beginning with the first readings in April, it is assumed that the inlet stream was contributing flow in March. The March precipitation at Brillion was 4", well above normal and resulted in significant runoff into the stream. With April stream inflow estimated at 13.18 million gallons with 1.7" of precipitation, the March stream inflow is estimated at 15 million gallons. The annual inlet stream flow for 2004 is estimated at 76.5 million gallons.

The outlet stream was monitored at the County Line Road downstream of the Long Lake dam. A staff gauge was installed and flow measurements taken during April, May, and July to create a stream flow/staff gauge chart. See Appendix B for detailed information on the measurements and flows during the study period. The peak staff gauge measurement occurred on May 25 correlating to an estimated flow of 5.37 cfs. The outlet stream was dry in late June and dry after early August for the remainder of the year. The outlet stream flow beginning April 1, 2004 is estimated at 93.9 million gallons.

With high stream inflow estimated in March and an outlet stream discharge measured at the first reading in April, it is assumed that the outlet stream was discharging in March. With April stream outflow estimated at 1.4 million gallons, it is estimated that the March outflow is 3.0 million gallons. The annual outlet stream flow for 2004 is estimated at 96.9 million gallons.

The lake level was monitored near the middle of the lake during the open water season. The lake level began relatively high at a reading of 9.29, peaked on May 24 at 9.77, dropped to 8.56 in October and ended at 8.86 in December. The water level fluctuated 1.21 feet during the open water season. The level of the top of the dam in relation to the staff gauge is about 9.2. Elevations above this level had water going over the dam. Elevations below this level showed no water going over the dam. The effluent creek was dry beginning in early August and stayed dry for the remainder of the year.

The precipitation for 2004 totaled about 33.5 inches and was above the average of 30.2 inches. Based on precipitation, the inlet and outlet stream annual flow was also above normal. In a normal or dry year, stream flow would be lower and lake levels would likely be lower especially in spring.

4.1 Hydrologic Budget

The annual hydrologic budge of lakes can be estimated by the following formula:

$$\Delta S = (PPT + SW_{In} + GW_{In}) - (Evap + SW_{Out} + GW_{Out})$$

Due to the lack of long term data, ΔS is estimated at 0. Then the following values are used:

PPT = precipitation = 33 inches = 327 acre-ft.
SW_{In} = Surface Water In = 76.5 million gallons = 235 acre-ft.
GW_{In} = Groundwater In or other surface water not measured ≈ 33 acre-ft

Evap = Evaporation = 30 inches = 298 acre-ft
SW_{Out} = Surface Water Out = 96.9 million gallons = 297 acre-ft.
GW_{Out} = Groundwater Out = Not measured ≈ 0

The water input not measured is estimated at 33 acre-ft. This water could be groundwater or surface water that entered the lake by direct runoff or through wetlands. The water balance and nearby wetlands all along the lake indicate no significant net increase or decrease in water from groundwater.

5 Phosphorus Evaluation

Phosphorus concentrations were measured four times during the 2004 open water season. The detailed results are shown in Appendix C. The summary of the results are shown below.

Table 5-1
2004 Total Phosphorus Concentrations – ug/l

Sample Point	April	May	July	August	Average
Inlet Stream	167	305	518	377	342
Mid-Lake Surface	95	69	94	79	84
Mid-Lake Bottom	95	84	946	988	528
Outlet Stream	83	59	136	Dry	93

The water quality samples in the Phase I report were collected in the lake on the north end and south end of the lake. In the Phase II study, the inlet and outlet streams were sampled. The lake sample was near the lake center and in one of the deepest areas of the lake.

5.1 Mid-Lake Phosphorus

The total phosphorus concentration at the lake surface in Phase I (2001 and 2002) averaged 105 ug/l. The mid-lake surface concentrations in Phase II (2004) averaged 84 ug/l.

The samples collected at the lake bottom in Phase II were in one of the deepest parts of the lake (over 20 feet). Samples collected in April and May averaged 90 ug/l total phosphorus and were similar to surface water concentrations. In July and August, the lake bottom concentrations increased by a factor of 10, averaging 967 ug/l total phosphorus.

An explanation for this large increase is the potential for water in the deepest part of the lake to become anaerobic due to lack of oxygen in mid to late summer. Once a thermocline is established, the lower levels of a lake are cut off from oxygen sources and biological activity can deplete the available oxygen. Phosphorus contained in organic matter can be released during anaerobic decomposition. Phosphorus precipitated with natural iron compounds can also be released to solution under anaerobic conditions.

The Phase I report did note oxygen reduction in the lower parts of the lake during the summer months but only a small increase in phosphorus concentration was observed. The deeper sampling point in Phase II likely had oxygen depletion and the anaerobic conditions caused a significant phosphorus release. This phosphorus release was documented in the Phase I report. The October sampling event was taken during lake turnover and showed phosphorus concentrations of 180 ug/l average. The average phosphorus concentration during the remaining samples in Phase I was 106 ug/l. The high concentration of phosphorus during the fall turnover was likely caused by summer phosphorus release in the deepest part of the lake that mixed with the entire lake during the fall turnover.

5.2 Inlet Stream Phosphorus

The phosphorus concentration measured from the inlet stream was significantly higher than the average phosphorus concentration in the lake. The average of the four samples was 342 ug/l.

The phosphorus loading from the inlet stream was calculated based on the measured stream flow and measured phosphorus concentration. Appendix C contains a table with calculations showing the total phosphorus for the open water season. The total phosphorus loading from the inlet stream was estimated at 163 pounds for the time period beginning in April and based on the measured flow of 61.5 million gallons.

Note that the annual estimated flow of 76.5 million gallons was based on increased stream inflow during March. If the average phosphorus concentration for March was the same as the April data, then an additional 21 pounds of phosphorus were discharged into the lake for a total of 184 pounds.

5.3 Outlet Stream Phosphorus

The phosphorus concentration measured from the outlet stream was similar to the average surface phosphorus concentration measured in the lake. Only three samples were collected because the August sampling event found the stream to be dry. The average of the three samples was 93 ug/l.

The phosphorus loading from the outlet stream was calculated based on the measured stream flow and measured phosphorus concentration. Appendix C contains a table with calculations showing the total phosphorus for the open water season. The total phosphorus loading from the inlet stream was estimated at 52 pounds.

Note that the annual estimated outflow of 96.9 million gallons was based on additional stream outflow during March. If the average phosphorus concentration for March was the same as the April data, then an additional 2 pounds of phosphorus were discharged into the lake for a total of 54 pounds.

5.4 Phosphorus Budget

A phosphorus budget for the 2004 season was estimated based on available data. The hydrological budget along with phosphorus sampling of the inlet and outlet streams was used to develop the phosphorus budget.

The Phase I study showed Long Lake to be highly eutrophic. This Phase II study identifies a preliminary phosphorus budget by evaluating phosphorus inputs to the lake from the inlet stream and other sources as well as phosphorus discharge through the outlet stream. Figure 5-1 below shows the phosphorus budget for 2004.

The overall budget measured in 2004 is estimated at 246 pound of phosphorus per year. The largest input was from the inlet stream with 184 pounds (75%). Direct precipitation accounted for 32 pounds (13%) and other water inputs from groundwater or surface runoff accounted for 27 pounds (11%). Septic systems were estimated to contribute 3 pound (1%).

The outlet stream was estimated to discharge 54 pounds of phosphorus (22%). The largest output of phosphorus was deposition into the lake sediment with a total of 192 pounds (78%).

The WILMS model was developed for Long Lake. The total loading was estimated to be between 164 pounds and 750 pounds with a most likely value of 405 pounds. The model details are contained in Appendix C. The calculated phosphorus loading of 246 pounds is within the model range.

5.5 Internal Phosphorus Loading

The Phase I report conducted phosphorus testing throughout 12 month period in 2001 and 2002. The data collected included periods during lake turnover. A significant increase in total phosphorus occurred in October coinciding with the fall turnover.

Data collected in Phase II in July and August showed a significant increase in the bottom phosphorus concentrations with levels averaging 967 ug/l. This high level of phosphorus in the lower levels during summer indicates anoxic sediment phosphorus release. This phosphorus stays in the hypolimnion until fall turnover when all lake water is mixed. The increased phosphorus concentrations seen in October 2001 now are consistent with the observed summer anoxic sediment release observed in August 2004. Anoxic phosphorus release occurs in the hypolimnion of a lake where the oxygen is used up. Phosphorus in particulate form under aerobic conditions is changed to soluble phosphorus under anoxic conditions.

The data from the Phase I report shows the average water column concentration in Long Lake was 106 ug/l for the 5 samples not including October. The October average water column concentration was 180 ug/l. Assuming the lake averages 11.5 feet deep gives a total volume of about 450 million gallons. The mass of phosphorus at 106 ug/l is 395 pounds and the mass of phosphorus at 180 ug/l is 671 pounds. The difference in the two values is the internal phosphorus release calculated to be 276 pounds.

Note that the internal phosphorus release is greater than the annual phosphorus loading estimated in the above phosphorus budget.

The WILMS Internal Load Estimator Module was developed for Long Lake. The total loading was estimated to be between 61 pounds and 611 pounds with a most likely value of 469 pounds. The model details are contained in Appendix C. The calculated internal phosphorus loading of 276 pounds is within the model range.

6 Fishery Spawning Area Enhancement

Improving northern pike spawning success is one of the Lake Association's goals for fishery improvement. Northern pike spawn in April and prefer to lay eggs in shallow flooded marshes or grass. The marsh should remain flooded for 30 or 40 days after spawning to provide protection to newly hatched northern pike. The water depth in the flooded marsh area should be 6 to 12 inches.

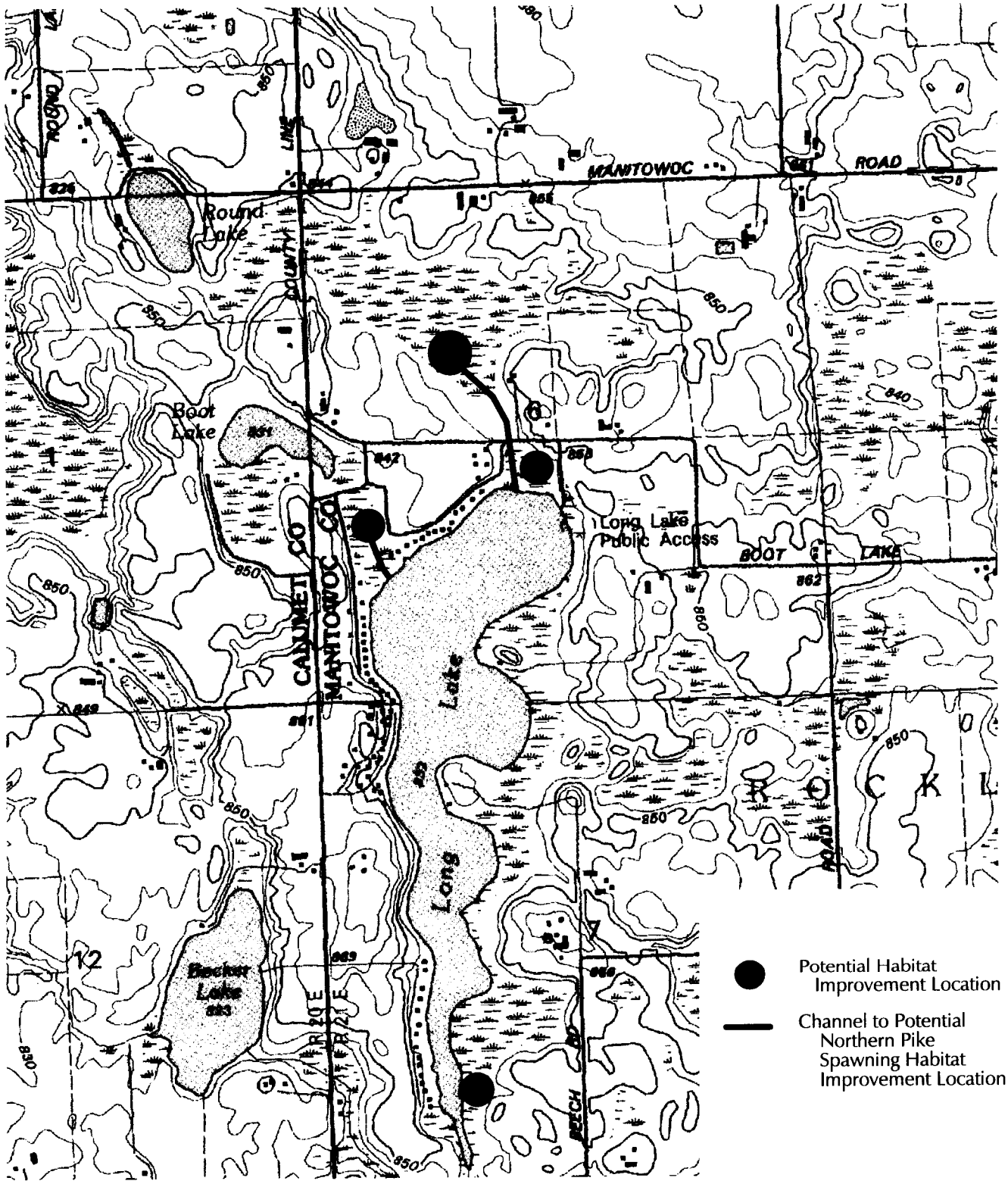
Based on water level readings taken during the 2004 season, the water levels were high in spring and remained relatively high until the end of June. If the proper northern pike habitat existing in the lake, spawning could have been successful in 2004 without manipulating the water levels.

Good spawning habitat in Long Lake is limited due to shoreline development and marshes that have overgrown with woody vegetation. Foth & Van Dyke reviewed the existing spawning habitat with WDNR in July 2004 at Long Lake. Several sites for habitat improvement were identified and are shown on Figure 6-1.

The wetlands identified as potential spawning habitat are currently limited by lack of access to Long Lake, unsuitable vegetation, or improper depth. An ideal spawning marsh would be 1 acre up to 10 acres in size. The depth would 0 to 3 feet for over 50% of the marsh with a gently sloping gradient from the edge to the center. The center of the marsh should be up to 6 feet deep to allow cover for larger fish and prevent the marsh from overgrowing with vegetation. A center island would provide additional spawning habitat. The spawning marsh should be connected to the lake or inlet stream by a narrow, deep channel (6 feet wide and 6 feet deep). The channel will provide year round access by adult fish and newly hatched fish to and from the main lake. The channel depth will prevent vegetation from growing and clogging the channel. Appendix D contains a description of a northern pike spawning marsh.

The best sites for habitat improvement are the wetland between Long Lake and Boot Lake on the northwest corner of the lake and the large wetland adjacent to the inlet stream. An added benefit of constructing a spawning marsh in these areas would be the marsh would also act as a sedimentation basin and reduce the amount of phosphorus and other pollutants that enter the lake.

Construction of a spawning marsh will require removing existing vegetation, grading the marsh to the proper depth, and creating a connecting channel. When construction is completed, the marsh should be planted with native emergent vegetation. Issues involved with creating a spawning marsh are access for construction and maintenance and ownership of the land.



This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Source: U.S.G.S. 7.5 minute topographic quadrangle - Brillion (1992), Manitowoc County.
Classification derived from LANDSAT Thematic Mapper (TM) satellite imagery from 1991, 1992, and 1993. The classification has been "smoothed" to a 1-acre minimum mapping unit. (4 contiguous pixels) from the original 30-meter pixel size. Wetlands smaller than 1-acre and open water pixels were not smoothed. Classification was done at the Wisconsin DNR. GEO Services Section.

N

Foth & Van Dyke

0 750 1500 Feet

m:\00l008\apr\long_lake1.apr

LONG LAKE

FIGURE 6-1

NORTHERN PIKE SPAWNING AREA
Potential Habitat Improvement Locations
Manitowoc, Wisconsin

Scale: AS SHOWN	Date: June 7, 2005	
Drawn By: kpk1	Checked By: pak	Scope: 00L008

7 Conclusions and Recommendations

7.1 Conclusions

- Most on-site wastewater treatment systems around the lake were holding tanks (68%). Approximately 16% of the on-site wastewater treatment systems were septic tank/absorption field type that could potentially impact the lake.

- Residential stormwater management can be improved with the use of non-eroding channels or pipes to take clean water directly to the lake. Good yard maintenance should include eliminating phosphorus fertilizers and reducing runoff from lawns.

- Some yard waste and lake weeds are currently being disposed of in wetlands adjacent to the lake. This material can add nutrients to the lake as it decomposes.

- Agricultural runoff is significant on the west side of the lake near West Shore Retreat.

- A hydrologic budget was prepared using data collected from the inlet and outlet streams. Most of the water entered the lake from precipitation or the inlet stream. Water that left the lake was through the outlet stream or evaporation. Little groundwater flow was measured.

- The inlet stream had a phosphorus concentration that averaged 342 ug/l and contributed 75% of the annual phosphorus budget. The outlet stream averaged 93ug/ and accounted for 22% of the annual phosphorus discharge. Most of the phosphorus that left the lake water was deposited in the lake sediment (78% of annual phosphorus budget)

- Internal phosphorus loading was estimated to be at 276 pounds per year with anoxic sediment releasing phosphorus during the summer stratification period. The internal phosphorus loading was greater than the annual external phosphorus loading of 246 pounds.

- Potential fish spawning areas were identified with the best opportunities in the wetlands on the north end of the lake.

7.2 Recommendations

- Replace septic tanks with holding tanks where possible for optimum on-site treatment.

- Work with agricultural land user near West Shore Retreat to minimize runoff into the lake. Options include using a perennial hay crop, a vegetated buffer, and stormwater detention pond for sediment removal.

- Stormwater channels in West Shore Retreat should be improved to prevent erosion. Rip rap lined banks and stream bottom is recommended.

- Provide a site for disposal of yard waste and lake weeds that will prevent these materials from getting into the lake water.

- Improve stormwater runoff on residential lots by providing channels for clean water to get to lake, increasing natural vegetation near the lake, and using zero phosphorus lawn fertilizers.

- Develop a plan to significantly reduce phosphorus in the lake to improve water quality. The plan should consider the following alternatives:
  1. Aerate the deepest parts of the lake to prevent anoxic phosphorus release and minimize internal phosphorus loading.

  2. Chemically treat the lake with alum to reduce phosphorus in the lake water and seal the bottom sediments to minimize internal phosphorus loading.

  3. Conduct a more detailed analysis of the source of phosphorus in the inlet stream. If natural, consider chemical treatment of the inlet stream during periods of significant flow. If pollution sources are identified, develop a plan to reduce the pollution at the source.

- Develop a plan to enhance northern pike spawning. Identify specific sites where spawning areas can be constructed. Make contacts with land owners to assess interest in working to develop spawning areas. Prepare cost estimates for land, excavation, and other construction activities.

- Prepare a lake management plan based on the findings of the Phase I and Phase II reports and further studies into the source of phosphorus in the inlet stream. Apply for a final lake management grant from WDNR to accomplish the lake management plan. The lake management plan will be the basis for future lake protection activities including construction grant applications for funding the lake protection projects.

Appendix B

Stream Flow – Lake Level Monitoring

Long Lake Association

Lake Gauge Surface Water Monitoring Field Form

To be completed once a week

Date	Inlet Stream Gauge Reading	Mid-Lake Gauge Reading	Outlet Stream Gauge Reading
4/11/2004	5.34	9.29	1.17
4/18/2004	5.34	9.26	0.94
4/24/2004	5.35	9.26	1.22
5/2/2004	5.29	9.23	0.96
5/9/2004	5.52	9.43	2.02
5/16/2004	5.47	9.40	1.80
5/24/2004		9.77	
5/25/2004	5.64		2.87
5/26/2004		9.52	
5/31/2004	5.61	9.57	2.62
6/5/2004	5.43	9.37	1.80
6/13/2004	5.54	9.48	2.40
6/20/2004	5.31	9.27	1.11
6/28/2004	5.22	9.17	0.04
7/5/2004	5.27	9.20	1.13
7/11/2004	5.27	9.20	0.101
7/18/2004	5.19	9.12	0.96
7/25/2004	5.10	9.04	0.81
8/1/2004	5.08	9.01	0.81
8/7/2004	4.98	8.94	Dry
8/15/2004	4.88	8.82	Dry
8/22/2004	4.88	8.82	Dry
8/30/2004	4.91	8.85	Dry
9/6/2004	4.91	8.85	Dry
9/12/2004	4.82	8.75	Dry
9/19/2004	4.80	8.73	Dry
9/26/2004	4.70	8.63	Dry
10/3/2004	4.65	8.59	Dry
10/9/2004	4.62	8.56	Dry
10/16/2004	4.62	8.56	Dry
10/23/2004	4.62	8.57	Dry
11/1/2004	4.68	8.62	Dry
11/7/2004	4.67	8.61	Dry
11/16/2004	4.72	8.63	Dry
11/28/2004	4.74	8.70	Dry
12/12/2004	4.90	8.86	Dry
12/14/2004	Lake Froze Over		

2.1" of rain on 5/8/04

2.35" of rain on 5/21 & 22

1.08" of rain on 5/29 & 30

No water going over dam, outlet creek
below dam dry and full of dead carp
1.375" of rain on 7/3

Lake level 2.5" below top of dam steel piling
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
No Water in Outlet Creek
1" rain on 10/22/04
1.15" rain on 10/29/04
.35" rain on 11/2/04
No Water in Outlet Creek
Trace of Snow
Rain & Snow throughout week of 12/5

STREAM CALIBRATION TABLE

Long Lake Upstream

LOCATION: **Long Lake -Inlet Stream** **METER:** FLOMATE
DATE: 4/2/2004 **START TIME:** 9:30
TECHNICIAN(S): S. Janssen/Foth & Van Dyke **FINISH TIME:** 10:15
GAUGE READING : 5.49

STARTING POINT Below bridge on Boot Lake Rd

WEATHER, STREAM CONDITIONS & NOTES:
North Wind very windy 40

STATION NUMBER	DISTANCE FROM BANK	DEPTH (ft)	AVERAGE DEPTH (ft)	WIDTH (ft)	VELOCITY (ft/sec)	FLOW (cfs)
5.8	0.0	0.00	0.00	0.10	0.00	0
6.0	0.2	0.20	0.10	0.60	-0.06	-0.0036
7.0	1.2	0.70	0.45	1.00	0.06	0.027
8.0	2.2	1.10	0.90	1.00	0.04	0.036
9.0	3.2	1.20	1.15	1.00	0.05	0.0575
10.0	4.2	2.15	1.68	1.00	0.02	0.0335
11.0	5.2	2.15	2.15	1.00	0.05	0.1075
12.0	6.2	2.25	2.20	1.00	0.04	0.088
13.0	7.2	2.30	2.28	1.00	0.00	0
14.0	8.2	2.40	2.35	1.00	0.02	0.047
15.0	9.2	2.25	2.33	1.00	0.09	0.20925
16.0	10.2	2.15	2.20	1.00	0.04	0.088
17.0	11.2	1.95	2.05	1.00	0.02	0.041
18.0	12.2	1.80	1.88	1.00	0.08	0.15
19.0	13.2	1.65	1.73	1.00	0.15	0.25875
20.0	14.2	1.10	1.38	1.00	0.13	0.17875
21.0	15.2	0.55	0.83	1.00	0.19	0.15675
22.0	16.2	0.40	0.48	0.80	0.15	0.057
22.6	16.8	0	0.20	0.30	0.00	0
				16.80		
						1.5324

Long Lake Downstream

LOCATION: **Long Lake Outlet Stream** **METER:** FLOMATE
DATE: 4/2/2004 **START TIME:** 11:15
TECHNICIAN(S): S. Janssen/Foth & Van Dyke **FINISH TIME:** 11:45
GAUGE READING : 2.61

STARTING POINT below dam aprroximately 25' narrows to channel

WEATHER, STREAM CONDITIONS & NOTES:
North Wind very windy 40

STATION NUMBER	DISTANCE FROM BANK	DEPTH (ft)	AVERAGE DEPTH (ft)	WIDTH (ft)	VELOCITY (ft/sec)	FLOW (cfs)
4.6	0.00	0.60	0.20	0.20	1.05	0.042
5.0	0.40	0.55	0.58	0.45	1.00	0.25875
5.5	0.90	0.60	0.58	0.30	0.67	0.115575
5.6	1.00	0.00	0.30	0.55	0.00	0
6.6	2.00	0.00	0.00	0.55	0.00	0
6.7	2.10	0.40	0.20	0.20	0.73	0.0292
7.0	2.40	0.40	0.40	0.65	0.86	0.2236
8.0	3.40	1.05	0.73	0.60	0.44	0.1914
8.2	3.60	0.00	0.53	0.45	0.00	0
8.9	4.30	0.00	0.00	0.40	0.00	0
9.0	4.40	0.30	0.15	0.55	1.01	0.083325
10.0	5.40	0.50	0.40	1.00	1.44	0.576
11.0	6.40	0.70	0.60	1.00	1.22	0.732
12.0	7.40	1.00	0.85	1.00	1.00	0.85
13.0	8.40	1.10	1.05	1.00	0.38	0.399
14.0	9.40	0.90	1.00	1.00	0.16	0.16
15.0	10.40	0.50	0.70	0.75	0.04	0.021
15.5	10.90	0.10	0.30	1.00	0.00	0.0003
17.0	12.40	0.1	0.10	0.75	0.00	0
				12.40		
						3.68215

Prepared By: SDJ
Checked By: PAK

STREAM CALIBRATION TABLE

Long Lake Upstream

LOCATION: **Long Lake -Inlet Stream** **METER:** FLOMATE
DATE: 5/11/2004 **START TIME:** 8:30
TECHNICIAN(S): S. Janssen/Foth & Van Dyke **FINISH TIME:** 9:00
GAUGE READING : 5.48

STARTING POINT Below bridge on Boot Lake Rd

WEATHER, STREAM CONDITIONS & NOTES:
North EastWind very windy 55

STATION NUMBER	DISTANCE FROM BANK	DEPTH (ft)	AVERAGE DEPTH (ft)	WIDTH (ft)	VELOCITY (ft/sec)	FLOW (cfs)
6.0	0.0	0.00	0.00	0.00	0.00	0
7.0	1.0	0.30	0.15	1.00	0.01	0.0015
8.0	2.0	0.70	0.50	1.00	-0.04	-0.02
9.0	3.0	1.00	0.85	1.00	0.02	0.017
10.0	4.0	1.30	1.15	1.00	0.05	0.0575
11.0	5.0	1.60	1.45	1.00	0.10	0.145
12.0	6.0	1.90	1.75	1.00	0.04	0.07
13.0	7.0	2.15	2.03	1.00	0.05	0.10125
14.0	8.0	2.30	2.23	1.00	0.05	0.11125
15.0	9.0	2.40	2.35	1.00	0.04	0.094
16.0	10.0	2.35	2.38	1.00	0.04	0.095
17.0	11.0	2.15	2.25	1.00	0.05	0.1125
18.0	12.0	1.90	2.03	1.00	0.06	0.1215
19.0	13.0	1.45	1.68	1.00	0.04	0.067
20.0	14.0	1.10	1.28	1.00	0.00	0
21.0	15.0	0.95	1.03	1.00	-0.01	-0.01025
22.0	16.0	0.60	0.78	1.00	-0.02	-0.0155
23.0	17.0	0.30	0.45	1.00	0.00	0
24.0	18.0	0	0.15	0.50	0.00	0
				17.50		
						0.94775

Long Lake Downstream

LOCATION: **Long Lake Outlet Stream** **METER:** FLOMATE
DATE: 5/11/2004 **START TIME:** 10:30
TECHNICIAN(S): S. Janssen/Foth & Van Dyke **FINISH TIME:** 11:00
GAUGE READING : 1.98

STARTING POINT below dam aprroximately 25' narrows to channel

WEATHER, STREAM CONDITIONS & NOTES:
North EastWind very windy 55

STATION NUMBER	DISTANCE FROM BANK	DEPTH (ft)	AVERAGE DEPTH (ft)	WIDTH (ft)	VELOCITY (ft/sec)	FLOW (cfs)
4.6	0.00	0.55	0.20	0.20	0.74	0.0296
5.0	0.40	0.55	0.55	0.45	0.50	0.12375
5.5	0.90	0.60	0.58	0.30	0.00	0
5.6	1.00	0.00	0.30	0.55	0.00	0
6.6	2.00	0.00	0.00	0.55	0.00	0
6.7	2.10	0.30	0.15	0.20	0.78	0.0234
7.0	2.40	0.50	0.40	0.35	0.60	0.084
7.4	2.80	0.90	0.70	0.40	0.41	0.1148
7.8	3.20	0.50	0.70	0.55	0.91	0.35035
8.5	3.90	0.30	0.40	0.60	1.25	0.3
9.0	4.40	0.60	0.45	0.75	1.19	0.401625
10.0	5.40	0.40	0.50	1.00	0.67	0.335
11.0	6.40	0.70	0.55	1.00	0.42	0.231
12.0	7.40	0.90	0.80	1.00	0.41	0.328
13.0	8.40	0.90	0.90	1.00	0.38	0.342
14.0	9.40	1.10	1.00	1.00	0.26	0.26
15.0	10.40	0.50	0.80	0.60	0.05	0.024
15.2	10.60	0.00	0.25	0.10	0.00	2.5E-05
				10.60		
						2.94755

Prepared By: SDJ
Checked By: PAK

Long Lake Inlet Stream **6/6/2005**

DATE	GAUGE (X)	CFS (Y)	n	(X*X)	(Y*Y)	(X*Y)	(X*X*X*X)	(X*X*Y)
4/2/2004	5.49	1.5324	3	30.1401	2.3482498	8.412876	908.425628	46.18668924
5/11/2004	5.48	0.944775		30.0304	0.8925998	5.177367	901.8249242	28.37197116
7/12/2004	5.25	0.3145		27.5625	0.0989103	1.651125	759.6914063	8.66840625

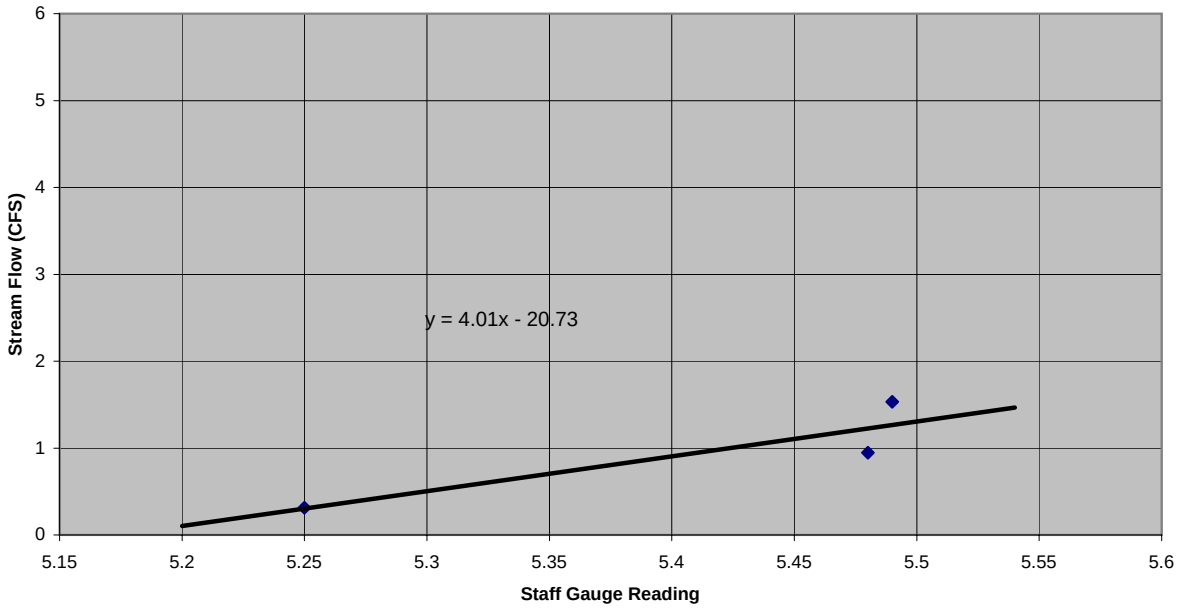
SUM (X)	SUM (Y)		SUM (X*X)	SUM (Y*Y)	SUM (X*Y)	SUM (X*X*X*X)	SUM (X*X*Y)
16.22	2.791675		87.733	3.3397598	15.241368	2569.941958	83.22706665

[S(X)] ^2	[S(Y)] ^2		[S(X*X)] ^2
263.0884	7.793449306		7697.079289

AVE (X)	AVE (Y)		AVE (X*X)
5.406666667	0.930558333		29.24433333

LINEAR		**PARABOLIC**	
SLOPE	4.00665009	SLOPE	0.373368765
Y-INTERCEPT	-20.7320632	Y-INTERCEPT	-9.988362298
CORRELATION	0.893126492	CORRELATION	0.893488404

Stream Flow as a function of Staff Gauge Reading



Prepared By; SDJ
Checked By: PAK

Long Lake Outlet Stream Stream **6/6/2005**

DATE	GAUGE (X)	CFS (Y)	n	(X*X)	(Y*Y)	(X*Y)	(X*X*X*X)	(X*X*Y)
4/2/2004	2.41	3.68215	3	5.8081	13.558229	8.8739815	33.73402561	21.38629542
5/11/2004	1.98	2.947555		3.9204	8.6880805	5.8361589	15.36953616	11.55559462
7/12/2004	1.2	0.005875		1.44	3.452E-05	0.00705	2.0736	0.00846

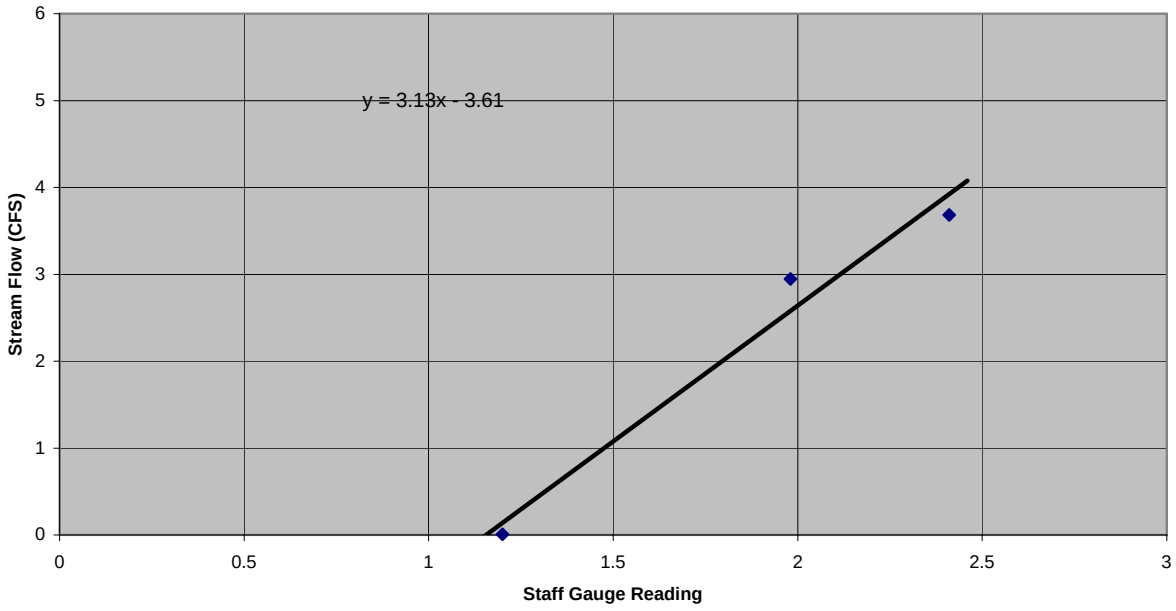
SUM (X)	SUM (Y)		SUM (X*X)	SUM (Y*Y)	SUM (X*Y)	SUM (X*X*X*X)	SUM (X*X*Y)
5.59	6.63558		11.1685	22.246344	14.71719	51.17716177	32.95035004

[S(X)] ^2	[S(Y)] ^2		[S(X*X)] ^2
31.2481	44.03092194		124.7353923

AVE (X)	AVE (Y)		AVE (X*X)
1.863333333	2.21186		3.722833333

LINEAR		**PARABOLIC**	
SLOPE	3.126906618	SLOPE	0.859199018
Y-INTERCEPT	-3.61460933	Y-INTERCEPT	-0.986794744
CORRELATION	0.985890514	CORRELATION	0.967542547

Stream Flow as a function of Staff Gauge Reading



Prepared By; SDJ

Checked By: PAK

2004 GAUGE-TO-CFS CONVERSION CHART

LONG LAKE - OUTLET STREAM

GAUGE	CFS	GAUGE	CFS	GAUGE	CFS	GAUGE	CFS	GAUGE	CFS	GAUGE	CFS
0	-3.61	1.25	0.30	1.6	1.40	1.95	2.49	2.3	3.59	2.65	4.68
0.1	-3.30	1.26	0.33	1.61	1.43	1.96	2.52	2.31	3.62	2.66	4.72
0.2	-2.98	1.27	0.37	1.62	1.46	1.97	2.56	2.32	3.65	2.67	4.75
0.3	-2.67	1.28	0.40	1.63	1.49	1.98	2.59	2.33	3.68	2.68	4.78
0.4	-2.36	1.29	0.43	1.64	1.52	1.99	2.62	2.34	3.71	2.69	4.81
0.5	-2.05	1.3	0.46	1.65	1.55	2	2.65	2.35	3.75	2.7	4.84
0.6	-1.73	1.31	0.49	1.66	1.59	2.01	2.68	2.36	3.78	2.71	4.87
0.7	-1.42	1.32	0.52	1.67	1.62	2.02	2.71	2.37	3.81	2.72	4.90
0.8	-1.11	1.33	0.55	1.68	1.65	2.03	2.74	2.38	3.84	2.73	4.93
0.9	-0.79	1.34	0.58	1.69	1.68	2.04	2.78	2.39	3.87	2.74	4.97
1	-0.48	1.35	0.62	1.7	1.71	2.05	2.81	2.4	3.90	2.75	5.00
1.01	-0.45	1.36	0.65	1.71	1.74	2.06	2.84	2.41	3.93	2.76	5.03
1.02	-0.42	1.37	0.68	1.72	1.77	2.07	2.87	2.42	3.96	2.77	5.06
1.03	-0.39	1.38	0.71	1.73	1.80	2.08	2.90	2.43	4.00	2.78	5.09
1.04	-0.35	1.39	0.74	1.74	1.84	2.09	2.93	2.44	4.03	2.79	5.12
1.05	-0.32	1.4	0.77	1.75	1.87	2.1	2.96	2.45	4.06	2.8	5.15
1.06	-0.29	1.41	0.80	1.76	1.90	2.11	2.99	2.46	4.09	2.81	5.19
1.07	-0.26	1.42	0.83	1.77	1.93	2.12	3.03	2.47	4.12	2.82	5.22
1.08	-0.23	1.43	0.87	1.78	1.96	2.13	3.06	2.48	4.15	2.83	5.25
1.09	-0.20	1.44	0.90	1.79	1.99	2.14	3.09	2.49	4.18	2.84	5.28
1.1	-0.17	1.45	0.93	1.8	2.02	2.15	3.12	2.5	4.21	2.85	5.31
1.11	-0.14	1.46	0.96	1.81	2.06	2.16	3.15	2.51	4.25	2.86	5.34
1.12	-0.10	1.47	0.99	1.82	2.09	2.17	3.18	2.52	4.28	2.87	5.37
1.13	-0.07	1.48	1.02	1.83	2.12	2.18	3.21	2.53	4.31	2.88	5.40
1.14	-0.04	1.49	1.05	1.84	2.15	2.19	3.24	2.54	4.34	2.89	5.44
1.15	-0.01	1.5	1.09	1.85	2.18	2.2	3.28	2.55	4.37	2.9	5.47
1.16	0.02	1.51	1.12	1.86	2.21	2.21	3.31	2.56	4.40	2.91	5.50
1.17	0.05	1.52	1.15	1.87	2.24	2.22	3.34	2.57	4.43	2.92	5.53
1.18	0.08	1.53	1.18	1.88	2.27	2.23	3.37	2.58	4.47	2.93	5.56
1.19	0.11	1.54	1.21	1.89	2.31	2.24	3.40	2.59	4.50	2.94	5.59
1.2	0.15	1.55	1.24	1.9	2.34	2.25	3.43	2.6	4.53	2.95	5.62
1.21	0.18	1.56	1.27	1.91	2.37	2.26	3.46	2.61	4.56	2.96	5.65
1.22	0.21	1.57	1.30	1.92	2.40	2.27	3.50	2.62	4.59	2.97	5.69
1.23	0.24	1.58	1.34	1.93	2.43	2.28	3.53	2.63	4.62	2.98	5.72
1.24	0.27	1.59	1.37	1.94	2.46	2.29	3.56	2.64	4.65	2.99	5.75

Prepared By: PAK

Checked By: SGL

2004 GAUGE-TO-CFS CONVERSION CHART

LONG LAKE - INLET STREAM

GAUGE	CFS	GAUGE	CFS	GAUGE	CFS	GAUGE	CFS	GAUGE	CFS
0	-20.73	3	-8.70	5.1	-0.28	5.4	0.92	5.7	2.13
0.1	-20.33	3.1	-8.30	5.11	-0.24	5.41	0.96	5.71	2.17
0.2	-19.93	3.2	-7.90	5.12	-0.20	5.42	1.00	5.72	2.21
0.3	-19.53	3.3	-7.50	5.13	-0.16	5.43	1.04	5.73	2.25
0.4	-19.13	3.4	-7.10	5.14	-0.12	5.44	1.08	5.74	2.29
0.5	-18.73	3.5	-6.70	5.15	-0.08	5.45	1.12	5.75	2.33
0.6	-18.32	3.6	-6.29	5.16	-0.04	5.46	1.16	5.76	2.37
0.7	-17.92	3.7	-5.89	5.17	0.00	5.47	1.20	5.77	2.41
0.8	-17.52	3.8	-5.49	5.18	0.04	5.48	1.24	5.78	2.45
0.9	-17.12	3.9	-5.09	5.19	0.08	5.49	1.28	5.79	2.49
1	-16.72	4	-4.69	5.2	0.12	5.5	1.32	5.8	2.53
1.1	-16.32	4.1	-4.29	5.21	0.16	5.51	1.37	5.81	2.57
1.2	-15.92	4.2	-3.89	5.22	0.20	5.52	1.41	5.82	2.61
1.3	-15.52	4.3	-3.49	5.23	0.24	5.53	1.45	5.83	2.65
1.4	-15.12	4.4	-3.09	5.24	0.28	5.54	1.49	5.84	2.69
1.5	-14.72	4.5	-2.69	5.25	0.32	5.55	1.53	5.85	2.73
1.6	-14.31	4.6	-2.28	5.26	0.36	5.56	1.57	5.86	2.77
1.7	-13.91	4.7	-1.88	5.27	0.40	5.57	1.61	5.87	2.81
1.8	-13.51	4.8	-1.48	5.28	0.44	5.58	1.65	5.88	2.85
1.9	-13.11	4.9	-1.08	5.29	0.48	5.59	1.69	5.89	2.89
2	-12.71	5	-0.68	5.3	0.52	5.6	1.73	5.9	2.93
2.1	-12.31	5.01	-0.64	5.31	0.56	5.61	1.77	5.91	2.97
2.2	-11.91	5.02	-0.60	5.32	0.60	5.62	1.81	5.92	3.01
2.3	-11.51	5.03	-0.56	5.33	0.64	5.63	1.85	5.93	3.05
2.4	-11.11	5.04	-0.52	5.34	0.68	5.64	1.89	5.94	3.09
2.5	-10.71	5.05	-0.48	5.35	0.72	5.65	1.93	5.95	3.13
2.6	-10.30	5.06	-0.44	5.36	0.76	5.66	1.97	5.96	3.17
2.7	-9.90	5.07	-0.40	5.37	0.80	5.67	2.01	5.97	3.21
2.8	-9.50	5.08	-0.36	5.38	0.84	5.68	2.05	5.98	3.25
2.9	-9.10	5.09	-0.32	5.39	0.88	5.69	2.09	5.99	3.29

Prepared By: PAK

Checked By: SGL

Long Lake Association

Inlet Stream Flow Calculation

Date	Inlet Stream Gauge Reading	Flow cfs	Flow MGD	Weekly Average MGD	Total Million Gallons
4/11/2004	5.34	0.68	0.44	0.44	4.86
4/18/2004	5.34	0.68	0.44	0.44	3.09
4/24/2004	5.35	0.72	0.47	0.45	2.73
5/2/2004	5.29	0.48	0.31	0.39	2.73
5/9/2004	5.52	1.41	0.91	0.61	4.27
5/16/2004	5.47	1.20	0.78	0.84	5.90
5/25/2004	5.64	1.89	1.22	1.00	8.99
5/31/2004	5.61	1.77	1.14	1.18	7.08
6/5/2004	5.43	1.04	0.67	0.91	4.54
6/13/2004	5.54	1.49	0.96	0.82	6.54
6/20/2004	5.31	0.56	0.36	0.66	4.63
6/28/2004	5.22	0.20	0.13	0.25	1.98
7/5/2004	5.27	0.40	0.26	0.20	1.37
7/11/2004	5.27	0.40	0.26	0.26	1.56
7/18/2004	5.19	0.08	0.05	0.16	1.10
7/25/2004	5.10	0	0	0.03	0.19
8/1/2004	5.08	0	0	0.00	0.00
8/7/2004	4.98	0	0		
8/15/2004	4.88	0	0		
8/22/2004	4.88	0	0		
8/30/2004	4.91	0	0		
9/6/2004	4.91	0	0		
9/12/2004	4.82	0	0		
9/19/2004	4.80	0	0		
9/26/2004	4.70	0	0		
10/3/2004	4.65	0	0		
10/9/2004	4.62	0	0		
10/16/2004	4.62	0	0		
10/23/2004	4.62	0	0		
11/1/2004	4.68	0	0		
11/7/2004	4.67	0	0		
11/16/2004	4.72	0	0		
11/28/2004	4.74	0	0		
12/12/2004	4.90	0	0		
12/14/2004	Lake Froze Over				

Total 61.53
Million Gallons

Long Lake Association

Outlet Stream Flow Calculation

Date	Outlet Stream Gauge Reading	Flow cfs	Flow MGD	Weekly Average MGD	Total Million Gallons
4/11/2004	1.17	0.05	0.03	0.03	0.37
4/18/2004	0.94	0.00	0.00	0.02	0.12
4/24/2004	1.22	0.21	0.13	0.07	0.40
5/2/2004	0.96	0.00	0.00	0.07	0.54
5/9/2004	2.02	2.71	1.75	0.88	6.13
5/16/2004	1.80	2.02	1.31	1.53	10.71
5/25/2004	2.87	5.37	3.47	2.39	21.50
5/31/2004	2.62	4.59	2.97	3.22	19.31
6/5/2004	1.80	2.02	1.31	2.14	10.68
6/13/2004	2.40	3.90	2.52	1.91	15.31
6/20/2004	1.11	0.00	0.00	1.26	8.82
6/28/2004	0.04	0.00	0.00	0.00	0.00
7/5/2004	1.13	0.00	0.00		0.00
7/11/2004	0.101	0.00	0.00		0.00
7/18/2004	0.96	0.00	0.00		0.00
7/25/2004	0.81	0.00	0		
8/1/2004	0.81	0.00	0		
8/7/2004	Dry	0	0		
8/15/2004	Dry	0	0		
8/22/2004	Dry	0	0		
8/30/2004	Dry	0	0		
9/6/2004	Dry	0	0		
9/12/2004	Dry	0	0		
9/19/2004	Dry	0	0		
9/26/2004	Dry	0	0		
10/3/2004	Dry	0	0		
10/9/2004	Dry	0	0		
10/16/2004	Dry	0	0		
10/23/2004	Dry	0	0		
11/1/2004	Dry	0	0		
11/7/2004	Dry	0	0		
11/16/2004	Dry	0	0		
11/28/2004	Dry	0	0		
12/12/2004	Dry	0	0		
12/14/2004					

Total 93.90

Million Gallons

Appendix C

Phosphorus Testing

Wisconsin Department of Natural Resources
Laboratory Report

Laboratory: **Wisconsin State Laboratory of Hygiene** DNR ID **113133790**
2601 Agriculture Dr.
Madison **WI** **537077996**
Phone : **800-442-4618** *Fax Phone :* **608-224-6276**

Sample:

Field #:	**DOWNSTM #4**	*Sample #:*	**IO018285**
Collection Start:	**04/02/2004 12:00 pm**	*Collection End:*	
Collected by:	**JANSSEN**	*Waterbody/Outfall Id:*	**77500**
ID #:	**363327**	*ID Point #:*	
County:	**Manitowoc**	*Account #:*	**LM010**
Sample Location:	**LONG LAKE OUTLET - E COUNTY LINE RD**		
Sample Description:	**STREAM**		
Sample Source:	**SU**	*Sample Depth:*	
Date Reported:	**04/27/2004**	*Sample Status:*	**COMPLETE**
Project No:	**LPL908**		

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**04/07/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.083**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**04/07/2004**	**SAMPLE RECEIVED PAST HOLDING TIME**

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	***ND**	MG/L	0.002		0.006
			LOD=0.00 2				

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**04/06/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

Laboratory: Wisconsin State Laboratory of Hygiene
2601 Agriculture Dr.
Madison WI 537077996
Phone : 800-442-4618 Fax Phone : 608-224-6276

DNR ID 113133790

Sample:

Field #:	SURFACE	Sample #:	IO018286
Collection Start:	04/02/2004 11:40 am	Collection End:	
Collected by:	JANSSEN	Waterbody/Outfall Id:	77500
ID #:	363017	ID Point #:	
County:	Manitowoc	Account #:	LM010
Sample Location:	LONG LAKE		
Sample Description:	DEEP HOLE - SURFACE		
Sample Source:	SU	Sample Depth:	
Date Reported:	04/27/2004	Sample Status:	COMPLETE
Project No:	LPL908		

Analyses and Results:

Analysis Method	Analysis Date	Lab Comment
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	04/07/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
665	PHOSPHORUS TOTAL	7723140	0.095	MG/L	0.005		0.016

Analysis Method	Analysis Date	Lab Comment
DISS REACTIVE PHOSPHORUS AS P (ORTH	04/07/2004	SAMPLE RECEIVED PAST HOLDING TIME

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
671	PHOSPHATE ORTHO DISS	7723140	*0.005	MG/L	0.002		0.006

Analysis Method	Analysis Date	Lab Comment
TEMPERATURE ON RECEIPT-ICED	04/06/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

Wisconsin Department of Natural Resources
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Sample:

Field #: **BOTTOM**
Collection Start: **04/02/2004 11:20 am**
Collected by: **JANSSEN**
ID #: **363017**
County: **Manitowoc**
Sample Location: **LONG LAKE**
Sample Description: **DEEP HOLE - BOTTOM**
Sample Source: **SU**
Date Reported: **04/27/2004**
Project No: **LPL908**

Sample #: **IO018284**
Collection End:
Waterbody/Outfall Id: **77500**
ID Point #:
Account #: **LM010**
Sample Depth:
Sample Status: **COMPLETE**

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**04/07/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.095**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**04/07/2004**	**SAMPLE RECEIVED PAST HOLDING TIME**

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	***0.007**	MG/L	0.002		0.006

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**04/06/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

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Sample:

Field #: **1** *Sample #:* **IO018287**
Collection Start: **04/02/2004 10:00 am** *Collection End:*
Collected by: **JANSSEN** *Waterbody/Outfall Id:* **77500**
ID #: **363326** *ID Point #:*
County: **Manitowoc** *Account #:* **LM010**
Sample Location: **LONG LAKE INLET - BOOT LAKE ROAD**
Sample Description: **STREAM**
Sample Source: **SU** *Sample Depth:*
Date Reported: **04/27/2004** *Sample Status:* **COMPLETE**
Project No: **LPL908**

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**04/07/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.167**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**04/07/2004**	**SAMPLE RECEIVED PAST HOLDING TIME**

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	***0.047**	MG/L	0.002		0.006

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**04/06/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

Wisconsin Department of Natural Resources
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Sample:

Field #:	INLSTREAM1	Sample #:	IO021080
Collection Start:	05/11/2004 09:00 am	Collection End:	
Collected by:	JANSSEN	Waterbody/Outfall Id:	77500
ID #:	363326	ID Point #:	
County:		Account #:	LM010
Sample Location:	LONG LAKE - BOOT LAKE ROAD		
Sample Description:	INLET STREAM		
Sample Source:	SU	Sample Depth:	
Date Reported:	06/08/2004	Sample Status:	COMPLETE
Project No:	LPL908		

Analyses and Results:

Analysis Method	Analysis Date	Lab Comment
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	05/20/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
665	PHOSPHORUS TOTAL	7723140	0.305	MG/L	0.005		0.016

Analysis Method	Analysis Date	Lab Comment
DISS REACTIVE PHOSPHORUS AS P (ORTH	05/12/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
671	PHOSPHATE ORTHO DISS	7723140	0.217	MG/L	0.002		0.006

Analysis Method	Analysis Date	Lab Comment
TEMPERATURE ON RECEIPT-ICED	05/12/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

Wisconsin Department of Natural Resources
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Madison **WI** **537077996**
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Sample:

Field #:	**OUTSTREAM4**	*Sample #:*	**IO021081**
Collection Start:	**05/11/2004 11:00 am**	*Collection End:*	
Collected by:	**JANSSEN**	*Waterbody/Outfall Id:*	**77500**
ID #:	**363327**	*ID Point #:*	
County:		*Account #:*	**LM010**
Sample Location:	**LONG LAKE - E COUNTY LINE RD**		
Sample Description:	**OUTLET STREAM**		
Sample Source:	**SU**	*Sample Depth:*	
Date Reported:	**06/08/2004**	*Sample Status:*	**COMPLETE**
Project No:	**LPL908**		

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**05/20/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.059**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**05/12/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	**0.003**	MG/L	0.002		0.006

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**05/12/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

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Sample:

Field #: BOTTOM 3
Collection Start: 05/11/2004 10:00 am
Collected by: JANSSEN
ID #: 363017
County:
Sample Location: LONG LAKE
Sample Description: DEEP HOLE - BOTTOM
Sample Source: SU
Date Reported: 06/08/2004
Project No: LPL908

Sample #: IO021078
Collection End:
Waterbody/Outfall Id: 77500
ID Point #:
Account #: LM010
Sample Depth:
Sample Status: COMPLETE

Analyses and Results:

Analysis Method	Analysis Date	Lab Comment
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	05/20/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
665	PHOSPHORUS TOTAL	7723140	0.084	MG/L	0.005		0.016

Analysis Method	Analysis Date	Lab Comment
DISS REACTIVE PHOSPHORUS AS P (ORTH	05/12/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
671	PHOSPHATE ORTHO DISS	7723140	0.035	MG/L	0.002		0.006

Analysis Method	Analysis Date	Lab Comment
TEMPERATURE ON RECEIPT-ICED	05/12/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

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Sample:

Field #:	SURFACE 2	Sample #:	IO021079
Collection Start:	05/11/2004 09:45 am	Collection End:	
Collected by:	JANSSEN	Waterbody/Outfall Id:	77500
ID #:	363017	ID Point #:	
County:		Account #:	LM010
Sample Location:	LONG LAKE		
Sample Description:	DEEP HOLE - SURFACE		
Sample Source:	SU	Sample Depth:	
Date Reported:	06/08/2004	Sample Status:	COMPLETE
Project No:	LPL908		

Analyses and Results:

Analysis Method	Analysis Date	Lab Comment
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	05/20/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
665	PHOSPHORUS TOTAL	7723140	0.069	MG/L	0.005		0.016

Analysis Method	Analysis Date	Lab Comment
DISS REACTIVE PHOSPHORUS AS P (ORTH	05/12/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
671	PHOSPHATE ORTHO DISS	7723140	0.002	MG/L	0.002		0.006

Analysis Method	Analysis Date	Lab Comment
TEMPERATURE ON RECEIPT-ICED	05/12/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

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Madison **WI** **537077996**
Phone : **800-442-4618** *Fax Phone :* **608-224-6276**

Sample:

Field #: **SURFACE**
Collection Start: **07/12/2004 11:15 am**
Collected by: **JANSSEN**
ID #: **363017**
County: **Manitowoc**
Sample Location: **LONG LAKE - BOOT LAKE RD**
Sample Description: **DEEP HOLE - SURFACE**
Sample Source: **SU**
Date Reported: **08/24/2004**
Project No: **LPL908**

Sample #: **IP001084**
Collection End:
Waterbody/Outfall Id: **77500**
ID Point #:
Account #: **LM011**
Sample Depth:
Sample Status: **COMPLETE**

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**07/27/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.094**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**07/14/2004**	**MATRIX SPIKE QC EXCEEDED**

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	***0.001**	MG/L	0.002		0.006

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**07/13/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

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Madison **WI** **537077996**
Phone : **800-442-4618** *Fax Phone :* **608-224-6276**

Sample:

Field #: **OUTLETSTRM** *Sample #:* **IP001081**
Collection Start: **07/12/2004 12:00 pm** *Collection End:*
Collected by: **JANSSEN** *Waterbody/Outfall Id:* **77500**
ID #: **363327** *ID Point #:*
County: **Manitowoc** *Account #:* **LM011**
Sample Location: **LONG LAKE - E COUNTY LINE RD**
Sample Description: **OUTLET STREAM**
Sample Source: **SU** *Sample Depth:*
Date Reported: **08/13/2004** *Sample Status:* **COMPLETE**
Project No: **LPL908**

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**07/26/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.136**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**07/14/2004**	**MATRIX SPIKE QC EXCEEDED**

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	***0.047**	MG/L	0.002		0.006

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**07/13/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

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Madison **WI** **537077996**
Phone : **800-442-4618** *Fax Phone :* **608-224-6276**

Sample:

Field #: **BOTTOM**
Collection Start: **07/12/2004 11:00 am**
Collected by: **JANSSEN**
ID #: **363017**
County: **Manitowoc**
Sample Location: **LONG LAKE**
Sample Description: **DEEP HOLE - BOTTOM**
Sample Source: **SU**
Date Reported: **08/13/2004**
Project No: **LPL908**

Sample #: **IP001082**
Collection End:
Waterbody/Outfall Id: **77500**
ID Point #:
Account #: **LM011**
Sample Depth:
Sample Status: **COMPLETE**

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**07/26/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.946**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**07/14/2004**	**SPIKE QC EXCEEDED, SPIKE RECOVERY = 80.2%**

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	***0.764**	MG/L	0.002		0.006

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**07/13/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

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Madison **WI** **537077996**
Phone : **800-442-4618** *Fax Phone :* **608-224-6276**

Sample:

Field #: **INLETSTRM** *Sample #:* **IP001083**
Collection Start: **07/12/2004 10:00 am** *Collection End:*
Collected by: **JANSSEN** *Waterbody/Outfall Id:* **77500**
ID #: **363326** *ID Point #:*
County: **Manitowoc** *Account #:* **LM011**
Sample Location: **LONG LAKE - BOOT LAKE RD**
Sample Description: **INLET STREAM**
Sample Source: **SU** *Sample Depth:*
Date Reported: **08/13/2004** *Sample Status:* **COMPLETE**
Project No: **LPL908**

Analyses and Results:

Analysis Method	*Analysis Date*	*Lab Comment*
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	**07/26/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
665	**PHOSPHORUS TOTAL**	7723140	**0.518**	MG/L	0.005		0.016

Analysis Method	*Analysis Date*	*Lab Comment*
DISS REACTIVE PHOSPHORUS AS P (ORTH	**07/14/2004**	**MATRIX SPIKE QC EXCEEDED**

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
671	**PHOSPHATE ORTHO DISS**	7723140	***0.414**	MG/L	0.002		0.006

Analysis Method	*Analysis Date*	*Lab Comment*
TEMPERATURE ON RECEIPT-ICED	**07/13/2004**	

Code	*Description*	*Cas No*	*Result*	*Units*	*LOD*	*Report Limit*	*LOQ*
136	**TEMPERATURE AT LAB**	E1645696	**ICED**	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

Laboratory: Wisconsin State Laboratory of Hygiene
2601 Agriculture Dr.
Madison WI 537077996
Phone : 800-442-4618 Fax Phone : 608-224-6276

DNR ID 113133790

Sample:

Field #: INLET STRM
Collection Start: 08/19/2004 03:00 pm
Collected by: JANSSEN
ID #: 363326
County: Manitowoc
Sample Location: LONG LAKE - BOOT LAKE RD
Sample Description: INLET STREAM
Sample Source: SU
Date Reported: 09/09/2004
Project No: LPL908

Sample #: IP005412
Collection End:
Waterbody/Outfall Id: 77500
ID Point #:
Account #: LM011
Sample Depth:
Sample Status: COMPLETE

Analyses and Results:

Analysis Method	Analysis Date	Lab Comment
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	08/26/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
665	PHOSPHORUS TOTAL	7723140	0.377	MG/L	0.005		0.016

Analysis Method	Analysis Date	Lab Comment
DISS REACTIVE PHOSPHORUS AS P (ORTH	08/26/2004	SAMPLE RECEIVED PAST HOLDING TIME

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
671	PHOSPHATE ORTHO DISS	7723140	*0.068	MG/L	0.002		0.006

Analysis Method	Analysis Date	Lab Comment
TEMPERATURE ON RECEIPT-ICED	08/24/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

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Laboratory Report

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Madison WI 537077996
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DNR ID 113133790

Sample:

Field #: BOTTOM
Collection Start: 08/19/2004 04:20 pm
Collected by: JANSSEN
ID #: 363017
County: Manitowoc
Sample Location: LONG LAKE
Sample Description: DEEP HOLE - BOTTOM
Sample Source: SU
Date Reported: 09/09/2004
Project No: LPL908

Sample #: IP005413
Collection End:
Waterbody/Outfall Id: 77500
ID Point #:
Account #: LM011
Sample Depth:
Sample Status: COMPLETE

Analyses and Results:

Analysis Method	Analysis Date	Lab Comment
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	08/26/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
665	PHOSPHORUS TOTAL	7723140	0.988	MG/L	0.005		0.016

Analysis Method	Analysis Date	Lab Comment
DISS REACTIVE PHOSPHORUS AS P (ORTH	08/26/2004	SAMPLE RECEIVED PAST HOLDING TIME

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
671	PHOSPHATE ORTHO DISS	7723140	*0.784	MG/L	0.002		0.006

Analysis Method	Analysis Date	Lab Comment
TEMPERATURE ON RECEIPT-ICED	08/24/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

Wisconsin Department of Natural Resources
Laboratory Report

Laboratory: Wisconsin State Laboratory of Hygiene
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Phone : 800-442-4618 Fax Phone : 608-224-6276

DNR ID 113133790

Sample:

Field #: SURFACE
Collection Start: 08/19/2004 04:00 pm
Collected by: JANSSEN
ID #: 363017
County: Manitowoc
Sample Location: LONG LAKE
Sample Description: DEEP HOLE - SURFACE
Sample Source: SU
Date Reported: 09/09/2004
Project No: LPL908

Sample #: IP005414
Collection End:
Waterbody/Outfall Id: 77500
ID Point #:
Account #: LM011
Sample Depth:
Sample Status: COMPLETE

Analyses and Results:

Analysis Method	Analysis Date	Lab Comment
TOTAL PHOSPHORUS (AS P) (EPA 365.1)	08/26/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
665	PHOSPHORUS TOTAL	7723140	0.079	MG/L	0.005		0.016

Analysis Method	Analysis Date	Lab Comment
DISS REACTIVE PHOSPHORUS AS P (ORTH	08/26/2004	SAMPLE RECEIVED PAST HOLDING TIME

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
671	PHOSPHATE ORTHO DISS	7723140	*0.003	MG/L	0.002		0.006

Analysis Method	Analysis Date	Lab Comment
TEMPERATURE ON RECEIPT-ICED	08/24/2004	

Code	Description	Cas No	Result	Units	LOD	Report Limit	LOQ
136	TEMPERATURE AT LAB	E1645696	ICED	C		0	

Long Lake Association

Inlet Stream Flow Calculation

Date	Inlet Stream Gauge Reading	Flow cfs	Flow MGD	Weekly Average MGD	Total Million Gallons
4/11/2004	5.34	0.68	0.44	0.44	4.86
4/18/2004	5.34	0.68	0.44	0.44	3.09
4/24/2004	5.35	0.72	0.47	0.45	2.73
5/2/2004	5.29	0.48	0.31	0.39	2.73
5/9/2004	5.52	1.41	0.91	0.61	4.27
5/16/2004	5.47	1.20	0.78	0.84	5.90
5/25/2004	5.64	1.89	1.22	1.00	8.99
5/31/2004	5.61	1.77	1.14	1.18	7.08
6/5/2004	5.43	1.04	0.67	0.91	4.54
6/13/2004	5.54	1.49	0.96	0.82	6.54
6/20/2004	5.31	0.56	0.36	0.66	4.63
6/28/2004	5.22	0.20	0.13	0.25	1.98
7/5/2004	5.27	0.40	0.26	0.20	1.37
7/11/2004	5.27	0.40	0.26	0.26	1.56
7/18/2004	5.19	0.08	0.05	0.16	1.10
7/25/2004	5.10	0	0	0.03	0.19
8/1/2004	5.08	0	0	0.00	0.00
8/7/2004	4.98	0	0		
8/15/2004	4.88	0	0		
8/22/2004	4.88	0	0		
8/30/2004	4.91	0	0		
9/6/2004	4.91	0	0		
9/12/2004	4.82	0	0		
9/19/2004	4.80	0	0		
9/26/2004	4.70	0	0		
10/3/2004	4.65	0	0		
10/9/2004	4.62	0	0		
10/16/2004	4.62	0	0		
10/23/2004	4.62	0	0		
11/1/2004	4.68	0	0		
11/7/2004	4.67	0	0		
11/16/2004	4.72	0	0		
11/28/2004	4.74	0	0		
12/12/2004	4.90	0	0		
12/14/2004	Lake Froze Over				

Total 61.53
Million Gallons

Long Lake Association

Outlet Stream Flow Calculation

Date	Outlet Stream Gauge Reading	Flow cfs	Flow MGD	Weekly Average MGD	Total Million Gallons
4/11/2004	1.17	0.05	0.03	0.03	0.37
4/18/2004	0.94	0.00	0.00	0.02	0.12
4/24/2004	1.22	0.21	0.13	0.07	0.40
5/2/2004	0.96	0.00	0.00	0.07	0.54
5/9/2004	2.02	2.71	1.75	0.88	6.13
5/16/2004	1.80	2.02	1.31	1.53	10.71
5/25/2004	2.87	5.37	3.47	2.39	21.50
5/31/2004	2.62	4.59	2.97	3.22	19.31
6/5/2004	1.80	2.02	1.31	2.14	10.68
6/13/2004	2.40	3.90	2.52	1.91	15.31
6/20/2004	1.11	0.00	0.00	1.26	8.82
6/28/2004	0.04	0.00	0.00	0.00	0.00
7/5/2004	1.13	0.00	0.00		0.00
7/11/2004	0.101	0.00	0.00		0.00
7/18/2004	0.96	0.00	0.00		0.00
7/25/2004	0.81	0.00	0		
8/1/2004	0.81	0.00	0		
8/7/2004	Dry	0	0		
8/15/2004	Dry	0	0		
8/22/2004	Dry	0	0		
8/30/2004	Dry	0	0		
9/6/2004	Dry	0	0		
9/12/2004	Dry	0	0		
9/19/2004	Dry	0	0		
9/26/2004	Dry	0	0		
10/3/2004	Dry	0	0		
10/9/2004	Dry	0	0		
10/16/2004	Dry	0	0		
10/23/2004	Dry	0	0		
11/1/2004	Dry	0	0		
11/7/2004	Dry	0	0		
11/16/2004	Dry	0	0		
11/28/2004	Dry	0	0		
12/12/2004	Dry	0	0		
12/14/2004					

Total 93.90

Million Gallons

Date: 07/28/2005 Scenario: 1

Lake Id: Long Lake
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 684.5 acre
Total Unit Runoff: 7.6 in.
Annual Runoff Volume: 433.5 acre-ft
Lake Surface Area <As>: 119 acre
Lake Volume <V>: 1373 acre-ft
Lake Mean Depth <z>: 11.5 ft
Precipitation - Evaporation: 3.2 in.
Hydraulic Loading: 465.3 acre-ft/year
Areal Water Load <qs>: 3.9 ft/year
Lake Flushing Rate <p>: 0.34 1/year
Water Residence Time: 2.95 year
Observed spring overturn total phosphorus (SPO): 101 mg/m^3
Observed growing season mean phosphorus (GSM): 60 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low Loading (kg/ha-year)	Most Likely Loading (kg/ha-year)	High Loading (kg/ha-year)	Loading %	Low Loading (kg/year)	Most Likely Loading (kg/year)	High Loading (kg/year)
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	451.4	0.30	0.80	1.40	79.6	55	146	256
Pasture/Grass	14.2	0.10	0.30	0.50	0.9	1	2	3
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	67.7	0.30	0.50	0.80	7.5	8	14	22
Rural Res (>1 Ac)	0.0	0.05	0.10	0.25	0.0	0	0	0
Wetlands	140.5	0.10	0.10	0.10	3.1	6	6	6
Forest	10.7	0.05	0.09	0.18	0.2	0	0	1
Lake Surface	119.0	0.10	0.30	1.00	7.9	5	14	48

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	30				
% Phosphorus Retained by Soil		98	90	80	
Septic Tank Loading (kg/year)		0.18	1.50	4.80	0.8

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	164.2	404.7	749.5	100.0
Total Loading (kg)	74.5	183.6	340.0	100.0
Areal Loading (lb/ac-year)	1.38	3.40	6.30	0.0
Areal Loading (mg/m^2-year)	154.69	381.23	705.95	0.0
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	153.2	369.6	632.7	99.2
Total NPS Loading (kg)	69.5	167.6	287.0	99.2

Expanded Trophic Response Module

Date: 07/28/2005 Scenario: 1
Total Phosphorus: 100 mg/m^3
Growing Season

Chorophyll a: 34 mg/m^3
Secchi Disk Depth: 1.3 m

Cholorphyll a Nuisance Frequency

Chla Mean Min: 5
Chla Mean Max: 100
Chla Mean Increment: 5
Chla Temporal CV: 0.62
Chla Nuisance Criterion: 20

Mean	Freq %
5	0.5
10	7.7
15	21.9
20	37.8
25	52.0
30	63.5
35	72.3
40	79.0
45	84.1
50	87.9
55	90.7
60	92.8
65	94.4
70	95.6
75	96.6
80	97.3
85	97.8
90	98.3
95	98.6
100	98.9

Summary Trophic Response Module

Date: 07/28/2005 Scenario: 1
Average Spring Mixed Total Phosphorus:: 100 mg/m^3
Growing Season Chlorophyll_a:: 29.0 mg/m^3
Average Growing Season Chlorophyll_a:: 60 mg/m^3

Natural Lake Secchi Depth (m)		Impoundment Secchi Depth (m)	
Mixed	Stratified	Mixed	Stratified
0.62	0.86	0.64	0.99

Wisconsin Trophic State Index (TSI)

Total Phosphorus::	100 mg/m^3	TSI = 64
Chlorophyll a::	34 mg/m^3	TSI = 61
Secchi Disc Depth::	1.3 m	TSI = 56

Phosphorus Prediction and Uncertainty Analysis Module

Date: 07/28/2005 Scenario: 1
Observed spring overturn total phosphorus (SPO): 101.0 mg/m^3
Observed growing season mean phosphorus (GSM): 60.0 mg/m^3
Back calculation for SPO total phosphorus: 101 mg/m^3
Back calculation GSM phosphorus: 60 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 28 kg

Lake Phosphorus Model	Low Total P (mg/m^3)	Most Likely Total P (mg/m^3)	High Total P (mg/m^3)	Predicted -Observed (mg/m^3)	% Dif.
Walker, 1987 Reservoir	31	77	142	17	28
Canfield-Bachmann, 1981 Natural Lake	35	63	92	3	5
Canfield-Bachmann, 1981 Artificial Lake	31	51	69	-9	-15
Rechow, 1979 General	12	29	54	-31	-52
Rechow, 1977 Anoxic	80	196	363	136	227
Rechow, 1977 water load<50m/year	26	64	119	4	7
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	55	136	252	35	35
Vollenweider, 1982 Combined OECD	37	77	128	-4	-5
Dillon-Rigler-Kirchner	31	77	143	-24	-24
Vollenweider, 1982 Shallow Lake/Res.	31	68	117	-13	-16
Larsen-Mercier, 1976	48	118	218	17	17
Nurnberg, 1984 Oxic	77	119	178	59	98

Lake Phosphorus Model	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	42	125	Tw	143	GSM
Canfield-Bachmann, 1981 Natural Lake	20	181	FIT	168	GSM
Canfield-Bachmann, 1981 Artificial Lake	16	147	FIT	251	GSM
Rechow, 1979 General	15	48	FIT	376	GSM
Rechow, 1977 Anoxic	109	317	FIT	56	GSM
Rechow, 1977 water load<50m/year	34	106	P Pin	172	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	63	243	FIT	136	SPO
Vollenweider, 1982 Combined OECD	36	138	FIT	193	ANN
Dillon-Rigler-Kirchner	42	125	P qs	240	SPO
Vollenweider, 1982 Shallow Lake/Res.	32	121	FIT	227	ANN
Larsen-Mercier, 1976	67	188	P Pin	158	SPO
Nurnberg, 1984 Oxic	69	191	P	29	ANN

Phosphorus Prediction and Uncertainty Analysis Module

Date: 07/28/2005 Scenario: 2
Observed spring overturn total phosphorus (SPO): 101.0 mg/m^3
Observed growing season mean phosphorus (GSM): 60.0 mg/m^3
Back calculation for SPO total phosphorus: 101 mg/m^3
Back calculation GSM phosphorus: 60 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 125 kg

Lake Phosphorus Model	Low Total P (mg/m^3)	Most Likely Total P (mg/m^3)	High Total P (mg/m^3)	Predicted -Observed (mg/m^3)	% Dif.
Walker, 1987 Reservoir	31	77	142	17	28
Canfield-Bachmann, 1981 Natural Lake	35	63	92	3	5
Canfield-Bachmann, 1981 Artificial Lake	31	51	69	-9	-15
Rechow, 1979 General	12	29	54	-31	-52
Rechow, 1977 Anoxic	80	196	363	136	227
Rechow, 1977 water load<50m/year	26	64	119	4	7
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	55	136	252	35	35
Vollenweider, 1982 Combined OECD	37	77	128	-4	-5
Dillon-Rigler-Kirchner	31	77	143	-24	-24
Vollenweider, 1982 Shallow Lake/Res.	31	68	117	-13	-16
Larsen-Mercier, 1976	48	118	218	17	17
Nurnberg, 1984 Oxic	246	288	347	228	380

Lake Phosphorus Model	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	42	125	Tw	143	GSM
Canfield-Bachmann, 1981 Natural Lake	20	181	FIT	168	GSM
Canfield-Bachmann, 1981 Artificial Lake	16	147	FIT	251	GSM
Rechow, 1979 General	15	48	FIT	376	GSM
Rechow, 1977 Anoxic	109	317	FIT	56	GSM
Rechow, 1977 water load<50m/year	34	106	P Pin	172	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	63	243	FIT	136	SPO
Vollenweider, 1982 Combined OECD	36	138	FIT	193	ANN
Dillon-Rigler-Kirchner	42	125	P qs	240	SPO
Vollenweider, 1982 Shallow Lake/Res.	32	121	FIT	227	ANN
Larsen-Mercier, 1976	67	188	P Pin	158	SPO
Nurnberg, 1984 Oxic	180	442	P	-415	ANN

Water and Nutrient Outflow Module

Date: 07/28/2005 Scenario: 1
Average Annual Surface Total Phosphorus: 101mg/m^3
Annual Discharge: 4.65E+002 AF => 5.74E+005 m^3
Annual Outflow Loading: 122.1 LB => 55.4 kg

Wisconsin Internal Load Estimator

Date: 07/29/2005 Scenario: 1
Method 1 - A Complete Total Phosphorus Mass Budget
Method 1 - A Complete Total Phosphorus Mass Budget 118 mg/m^3
Phosphorus Inflow Concentration: 319.9 mg/m^3

Areal External Loading: 381.2 mg/m^2-year
Predicted Phosphorus Retention Coefficient: 0.78
Observed Phosphorus Retention Coefficient: 0.63
Internal Load: 61 Lb 28 kg

Method 2 - From Growing Season In Situ Phososphorus Increases

Start of Anoxia
Average Hypolimnetic Phosphorus Concentration: 150 mg/m^3
Hypolimnetic Volume: 150 acre-ft
Anoxia Sediment Area: 19 acres

Just Prior To The End of Stratification
Average Hypolimnetic Phosphorus Concentration: 950 mg/m^3
Hypolimnetic Volume: 150 acre-ft
Anoxia Sediment Area: 19 acres
Time Period of Stratification: 120 days
Sediment Phosphorus Release Rate: 16.0 mg/m^2-day 4.36E-002 lb/acre-day
Internal Load: 326 Lb 148 kg

Method 3 - From In Situ Phososphorus Increases In The Fall

Start of Anoxia
Average Hypolimnetic Phosphorus Concentration: 150 mg/m^3
Hypolimnetic Volume: 150 acre-ft
Anoxia Sediment Area: 19 acres

Just Prior To The End of Stratification
Average Water Column Phosphorus Concentration: 180 mg/m^3
Lake Volume: 1373.0 acre-ft
Anoxia Sediment Area Just Before Turnover: 19 acres
Time Period Between Observations: 120 days
Sediment Phosphorus Release Rate: 30.0 mg/m^2-day 8.17E-002 lb/acre-day
Internal Load: 611 Lb 277 kg

Method 4 - From Phososphorus Release Rate and Anoxic Area

Start of Anoxia Anoxic Sediment Area: 19 acre
End of Anoxia Anoxic Sediment Area: 19 acre
Phosphorus Release Rate As Calculated In Method 2: 16.0 mg/m^2-day
Phosphorus Release Rate As Calculated In Method 3: 16.0 mg/m^2-day
Average of Methods 2 and 3 Release Rates: 23.0 mg/m^2-day
Period of Anoxia: 120 days
Default Areal Sediment Phosphorus Release Rates:

	Low	Most Likely	High
	6	14	24
Internal Load: (Lb)	37	87	149
Internal Load: (kg)	17	39	67

Internal Load Comparison (Percentanges are of the Total Estimate Load)

Total External Load: 405 Lb 184 kg

	Lb	kg	%
From A Complete Mass Budget:	61	28	13.1
From Growing Season In Situ Phosphorus Increases:	326	148	44.6
From In Situ Phososphorus Increases In The Fall:	611	277	60.1
From Phososphorus Release Rate and Anoxic Area:	87	39	17.7

Predicted Water Column Total Phosphorus Concentration (ug/l)

Nurnberg+ 1984 Total Phosphorus Model:	Low	Most Likely	High
	76	440	198

Osgood, 1988 Lake Mixing Index: 5.1

Phosphorus Loading Summary:

	Low	Most Likely	High
Internal Load (Lb):	61	468.6	87
Internal Load (kg):	28	212.6	39
External Load (Lb):	164	405	750
External Load (kg):	75	184	340
Total Load (Lb):	225	873	836
Total Load (kg):	102	396	379

Appendix D

Northern Pike Spawning Habitat

NORTHERN PIKE SPAWNING HABITAT

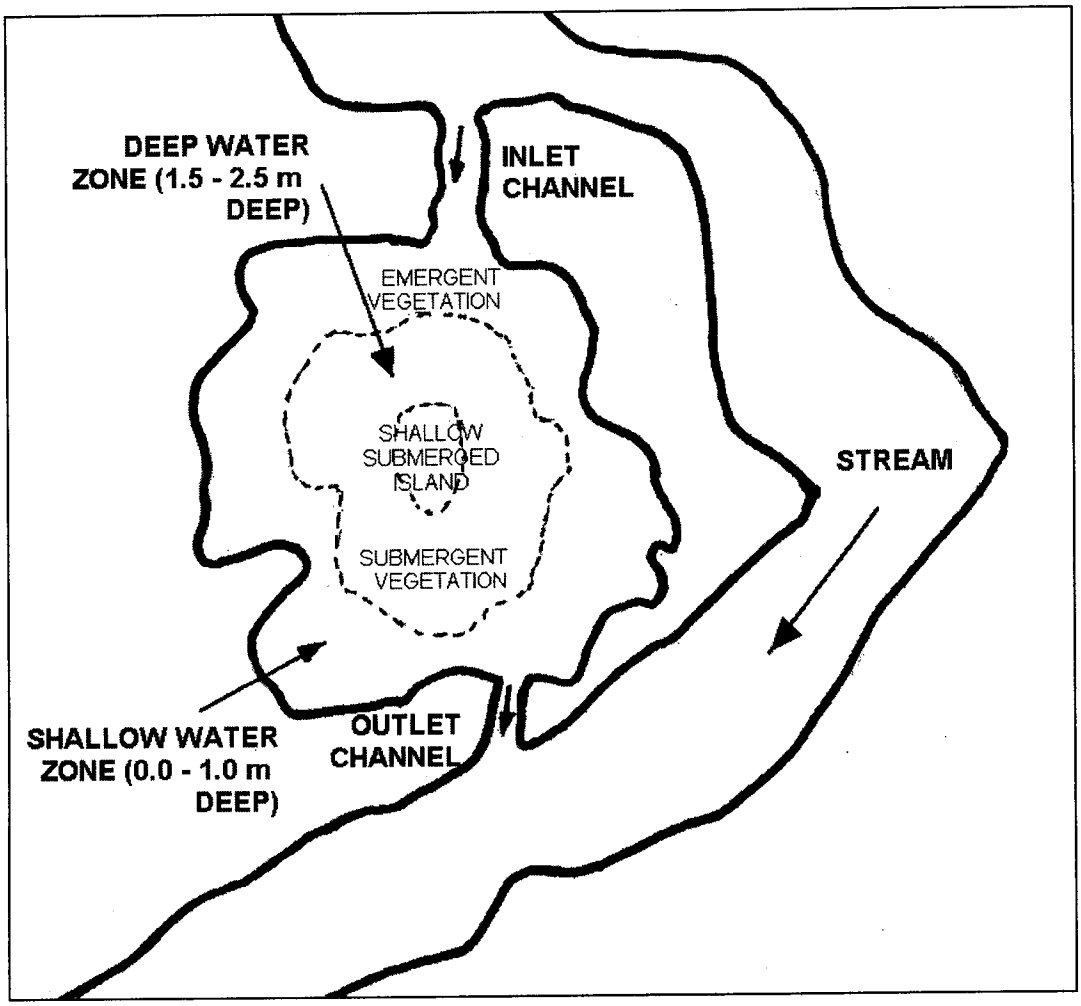
Substrate Modification

C18

FACTSHEET

DESCRIPTION AND PURPOSE

- A shallow, off-channel marsh is excavated adjacent to a stream or river, and planted with aquatic vegetation
- To provide suitable spawning habitat for northern pike within streams and rivers
- Used where existing spawning substrate is limiting (e.g., emergent vegetation within an area of slow velocity water)



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NORTHERN PIKE SPAWNING HABITAT

Substrate Modification

C18

FACTSHEET

2 of 3

APPLICABILITY

- Suitable for small to large watercourses

ADVANTAGES

- Little if any construction material is required - major construction requirement is for excavation
- Other fish species such as yellow perch (*Perca flavescens*), brook stickleback (*Culaea inconstans*), fathead minnow (*Pimephales promelas*), pearl dace (*Margariscus margarita*), spottail shiner (*Notropis hudsonius*), northern redbelly dace (*Phoxinus eos*) and lake chub (*Couesius plumbeus*) may use the marsh for spawning and rearing
- Spawning marshes may provide habitat for other animal species (e.g., ducks, frogs and muskrats)

LIMITATIONS

- Will require the use of heavy equipment to construct
- Can be expensive to construct
- May require aquatic vegetation transplants – plants may be available locally
- Detailed hydrological information may be required

DESIGN AND IMPLEMENTATION (REFER TO FIGURE)

- Northern pike prefer to spawn in shallow water (0.2 to 1.0 m deep) over a substrate of emergent vegetation – sedges (*Carex* spp.), bulrushes (*Scirpus* spp.) and flooded grasses are preferred
- Ideally a low-lying terrestrial or floodplain area adjacent to a watercourse can be excavated to construct a spawning and rearing marsh for northern pike – northern pike spawning marshes have ranged in size from 0.3-7.0 ha
- During excavation the top portion of the organic soil should be set aside so that it can be used as a growing medium for aquatic plants once the marsh is complete
- The spawning marsh is connected to the main waterbody by a narrow, deep channel (e.g., 2 x 2 m) which prevents overgrowth by aquatic vegetation or occlusion by silt
- The spawning marsh should be constructed with an undulating shoreline to maximize the surface area
- Approximately 50% of the marsh area should be constructed with a shallow gradient of 0.0 to 1.0 m depth from the marsh edge inward towards the marsh centre
- The shallowest portion (0.0 to 0.5 m depth) would be transplanted with *Carex* spp. whereas the deeper portion (0.5 to 1.0) would be planted with *Scirpus* spp.
- The most cost-effective method of establishing vegetation is to use a nearby donor wetland where small plots of emergent vegetation (0.3 x 0.3 m) are dug up and transplanted into the new marsh at a 0.8 to 1.5 m spacing during the spring

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NORTHERN PIKE SPAWNING HABITAT

Substrate Modification

C18

FACTSHEET

3 of 3

DESIGN AND IMPLEMENTATION CONT'D

- Inside the shallow outer area there should be a band of deeper water (1.5 to 2.5 m deep) to provide cover for larger fish and to prevent the marsh from overgrowing – a small submerged island (0.5 m below the water surface) can be constructed in the deeper water to provide additional spawning area
- The deeper water will likely be colonized after a period a time by submergent vegetation which provides ideal cover for larger northern pike
- An outlet channel (optional) can be dug to control the water depth of the marsh or alternatively the marsh can be allowed to overflow and flood a low-lying area back to the watercourse - this flooded area may also provide additional spawning habitat
- The outlet/inlet canal should be at an elevation to ensure that young-of-the-year northern pike can emigrate into the main watercourse as water levels subside in the spring

MAINTENANCE

- An inspection should be completed once every several years
- If the marsh becomes overgrown with shrubs and trees they should be removed
- Should the shallow area of the marsh become overgrown with aquatic vegetation and shallower, the area may have to be re-excavated to design specifications
- Monitoring should be completed after construction to determine if northern pike are using marsh for spawning

REFERENCES AND FURTHER READING

Casselman, J.M., and C.A. Lewis. 1996. Habitat requirements of northern pike. Canadian Journal of Fisheries and Aquatic Science 53 (Suppl. 1): 161-174.

Kelso, J.R.M., and Hartig, J.H. 1995. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI Occasional Paper 1: 294 pp.

Hammer, D.A. 1992. Creating freshwater wetlands. Lewis Publishers. 298 pp.

Morrow, J.V., G.L. Miller, and K.J. Killgore. 1997. Density, size, and foods of larval northern pike in natural and artificial wetlands. North American Journal of Fisheries Management 17: 210-214.

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