SUMMARY REPORT

FOR THE

BIRCH LAKE RESTORATION PROJECT – PHASE II

IOWA COUNTY
WISCONSIN

APRIL 2013

PREPARED
FOR
THE VILLAGE OF BARNEVELD

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1 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

Birch Lake is approximately nine acre impoundment in the headwaters of Trout Creek in Iowa County, west of the Village of Barneveld. The dam was constructed in 1964 by the Natural Resource Conservation Service (NRCS) as part of the Twin Park Watershed Work Plan, which was funded under the federal PL566 program. The impoundment was constructed primarily for flood retention and lake recreation. Over time the lake and the adjacent Birch Lake Park became a community gathering place for the Village of Barneveld residents. The Village currently manages the park under a lease from the Wisconsin Department of Natural Resources which is the property owner. The dam, which is identified as "Twin Park Structure 7", is owned and operated by Iowa County.

Current recreational value of the impoundment is considered low and water quality is poor. Despite the degraded conditions, many in the community want the lake restored since it is the focal point for Birch Lake Park. In 2003 a collaboration of federal, state and county partners proposed removing the dam to improve the trout fishery in the popular trout fisheries stream Trout Creek. The community in the Village rejected the proposal and instead voiced their support to maintain the Birch Lake impoundment.

In 2010, Agrecol Environmental Consulting (AEC) developed the Birch Lake Management Plan (AEC, 2010) for the Village of Barneveld, funded by the DNR, to evaluate alternative approaches to improving the water quality of the Birch Lake while improving the trout fishery in Trout Creek. The "Phase 1 Study" presented a series of alternatives and a preferred alternative which included (1) watershed diversion by construction of a separation berm between Trout Creek and Birch Lake, and (2) dredging of the lake to remove sediment accumulated over several decades. This would reduce sediment and phosphorus loads to the Lake, and improve water quality in Trout Creek downstream of the lake, since the lake would no longer be a major source of pollution.

In March 2012, the Village hired a multidisciplinary team of consultants lead by Montgomery Associates to further develop the preferred alternative from the Phase I Study and evaluate the size, layout, construction feasibility and cost of a diversion structure. In particular, the Montgomery Associates team was tasked with:

- Collection of environmental and biological data as well as a survey of key elevations around the lake;
- Analysis of peak discharges, sediment inputs and hydraulic capacity to evaluate size and shape of the diversion infrastructure;
- Preliminary conceptual design and cost of alternatives for watershed diversion;
- Gather input from public and stakeholders and regulatory agencies though public and stakeholder meetings; and
- Preparation of a summary report describing the results of the study that can by used for continued discussions with regulatory agencies and stakeholders (This report).

1.2 Watershed Characteristics

The watershed contributing runoff to Birch Lake is approximately 1.6 square miles. It is the headwaters of Trout Creek, a popular Class I and II trout stream that runs approximately 8 miles towards Mill Creek which eventually drains to the Wisconsin River by Spring Green. The watershed's southern and western boundary is the top of Military Ridge that divides the Wisconsin River and the Pecatonica/Sugar River watersheds and is located within the driftless region of southwest Wisconsin.

The Birch Lake watershed has typical characteristics of watersheds in the driftless area: relatively flat upland areas with deeply dissected river valleys with steep gradients. The slope of the river valley in the Birch Lake watershed is about 170 feet of relief/ mile. Land use in the Birch Lake watershed also has typical features of the driftless area: woodlands covering the steep hills with agriculture and grasslands at the top of the ridges and along the flat upland area. The Village of Barneveld is partially located within the watershed with developed urban areas constituting approximately 5% of the watershed draining to Birch Lake.

Land use in the watershed can be seen in *Table 1.1* below and the adjacent *Figure 1.1*. A larger watershed figure is shown in *Exhibit 1* in *Appendix A*.

Table 1.1. Land Use in Birch Lake Watershed in 2012.

Land Use	Area (Acres)	Percent of Total
Agriculture	413	40%
Grassland	130	13%
Forest	415	41%
Urban	55	5%
Open Water	9	1%
Total	1022	

Agricultural land use has dominated the watershed for many years although agricultural water quality impacts have been reduced with implementation of improved conservation practices. Additionally, more than 100 acres of grasslands have been converted to forested areas since the 1960's and 70's (Cheetam and Wilke, 1975). The Village of Barneveld municipal boundaries cover more than 40% of the watershed area but have only been planned for development immediately adjacent to current urban areas. It is anticipated that any urban development will meet and exceed current stormwater requirements.

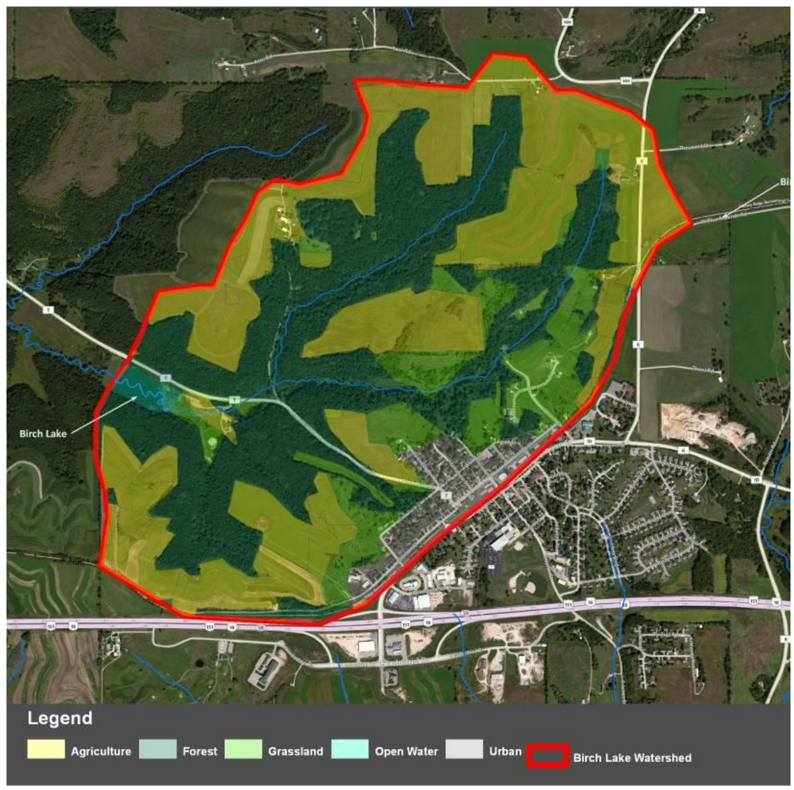

Figure 1.1. Birch Lake watershed boundaries and land use

Soils in the watershed are mainly silt loam or stony and rocky material derived from bedrock, windblown silt and alluvium. Bedrock is generally near the surface (<22 feet) and the St. Peter sandstone forms ledges and cliffs along the ridges of the valleys.

1.3 LAKE DESCRIPTION

Birch Lake is located in a narrow river valley, adjoined by steep bluffs on the south, County Highway T on the north, Birch Lake Park on the east, and the dam creating the impoundment to the west (see *Figure 1.2*).

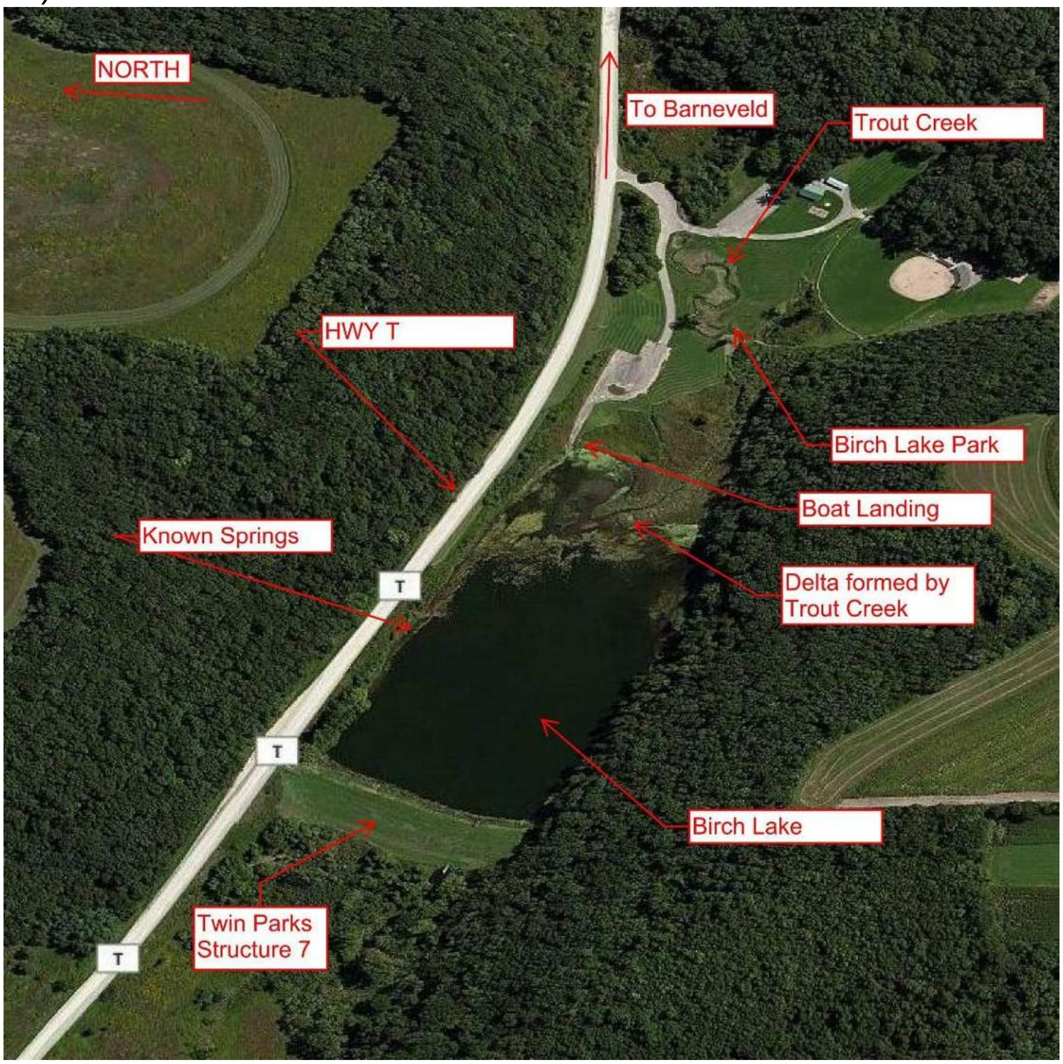

Figure 1.2. Birch Lake overview

The lake is a spring fed impoundment that was originally 11-acres in size but with continued sediment inputs from the upstream watershed, a significant delta has formed at the mouth of the creek, shrinking the lake surface area to approximately 9-acres. It is currently 15 feet deep near the dam forming a bowl shaped bottom. (See *Figure 1.3*).

The lake was formed by the construction of a flood control and sediment storage structure installed in 1964 by the NRCS as part of the PL 566 Twin Park Watershed Work Plan. The dam is at approximately 30-feet high earthen embankment with a concrete box drop spillway structure that also serves a low level outlet. The drop structure has a low flow inlet pipe that captures water from the bottom of the lake and an overflow weir for larger events. The dam is rated high hazard due to the potential for inundating residential structures downstream, which requires a total spillway capacity of the 1000-year event according to current DNR standards in Administrative Code section NR 333. Analyses conducted by

Iowa County and NRCS and accepted by Wisconsin DNR confirm that spillway capacity is adequate for the 1000-year event. Inspections of the dam conducted by an RCS for the county indicate that the embankment and outlet structure are in good condition.

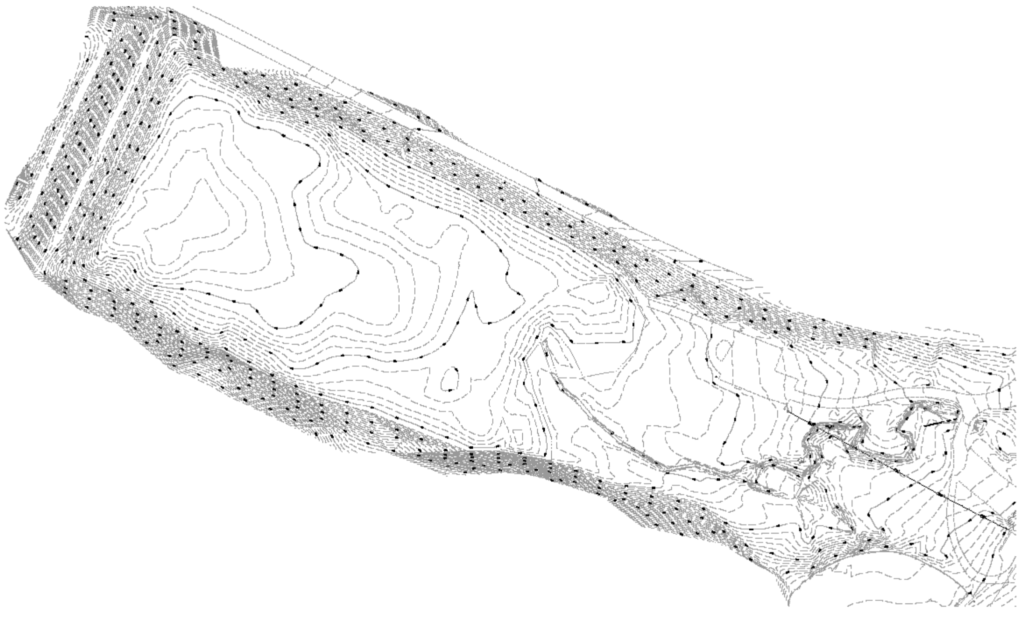

Figure 1.3. Survey and bathymetry 1-foot contours prepared by MSA Professional Services in summer 2012. Note: a large-scale version of this drawing is included as an attachment to this report

The impoundment was designed to have multiple purposes including recreation such as swimming, boating and fishing in addition to flood control and sediment storage which was the original primary purpose of the federal PL 566 project. The lake was originally stocked with rainbow trout for recreational fishing opportunities, but in time, the lake became more eutrophic and bluegills and largemouth bass became the dominant species. As storage capacity declined due to sedimentation (Cheetam and Wilke, 1975, estimated sediment loading to be 986 tons per square mile), water quality declined as well and nuisance levels of filamentous algae, planktonic algae and curly-leaf pondweed rendered the lake undesirable for many local lake users. The sedimentation also resulted in very shallow conditions by the existing boat landing and significant delta forming along the entrance of Trout Creek into the lake, resulting in the development of wetland vegetation along the shoreline to Birch Lake Park. This sedimentation has significantly reduced the access to the lake.

Figure 1.4. Existing dam control structure

2 Environmental Assessment

2.1 Data Collection

The following data collection took place as part of this study:

- Monthly lake water quality sampling was conducted from May 2012 through August 2012. Field parameters included Secchi water clarity and vertical profiles of dissolved oxygen, temperature, pH and specific conductivity. State Lab of Hygiene samples were collected and analyzed for phosphorus and chlorophyll. The values were also transformed into Trophic State Index (TSI).
- Birch Lake fish population data was analyzed to assess the status of sportfish populations in the lake.
- Water quality and flow measurements were collected above and below the lake along with other field parameters to compare upstream-downstream conditions. Temperature monitoring in the stream took the forms of grab measurements and deployed Hobo temperature loggers. Macroinvertebrate samples were collected and analyzed from sites above and below the dam to calculate the Family-level Biotic Index of stream water quality.
- Fish population electroshocking surveys (towed DC barge) were conducted to determine the coldwater Index of Biotic Integrity (IBI) in Trout Creek.

2.2 Findings

<u>Birch Lake Water Quality</u>

- Early in the year, supersaturated levels of dissolved oxygen were evident in the lake and reflected the excessive growths of Elodea and filamentous algae. While adequate levels of dissolved oxygen are important for fish populations, excessively high levels can stress fish and cause gas bubble disease. Dissolved oxygen levels declined in the lake beginning in July as the dense growths of Elodea began to die.
- Birch Lake is too shallow to sustain summer and winter stratification, although somewhat cooler water is present near the bottom of the reservoir during summer months. Both pH and specific conductance respond to changing water quality. Specific conductance increases near the bottom while pH values decrease (hydrogen ion concentration increases). These responses reflected reduced conditions near the lake bottom and an inlake source of pollutants for the lake and stream (internal loading).
- The lake was generally clear, reflecting suppression of planktonic algae due to dense growths of Elodea. Water clarity declined as the Elodea began dying and was replaced with planktonic algae. The dominance of a single rooted plant in high nutrient conditions results in a highly unstable environment. The significant change that occurred in August demonstrates the instability. As the Elodea declined and decayed, the release of nutrients resulted in both a significant increase in total phosphorus and chlorophyll-a concentrations

<u>Birch Lake Fisheries</u>

- Birch Lake is predominantly a largemouth bass-bluegill lake, typical of many fish ponds in Wisconsin. Low numbers of black crappie are also found in the lake.
- The data collected revealed that quality size fish occur in the lake but the overall size structures provides only a modest sport fishery. The data revealed that quality catches of bluegill were limited to about 22% of the population while only 11% of the largemouth bass were legal harvest sizes.

<u>Trout Creek Water Quality</u>

- Stream monitoring demonstrated better quality conditions and colder temperatures in the stream above the lake.
- Daily mean maximum temperatures increased by 14.8 degrees F downstream of the lake. Flow rates increased below the lake and demonstrate that local springs around the lake supplement the flow entering the lake from Trout Creek
- Stream macroinvertebrates (aquatic insects and crustaceans) displayed much better water quality above the dam. The Family-level Biotic Index revealed "excellent" water quality of the stream within the park but "poor" water quality below the dam

<u>Trout Creek Fisheries</u>

- No fish were found above the lake due to poor habitat and dense over-hanging vegetation that undermined sampling effectiveness. The lack of fish above the lake also reflected the effect of the dam as a migration barrier. These findings do not limit fish potential that could follow if there was additional stream habitat restoration and stocking.
- Below the lake, no trout were found and the only species evident were low numbers of small largemouth bass in poor condition. A mile below the lake, the stream displayed partial recovery from the nutrient and thermal inputs and a typical trout stream fish community was found including brown trout, native brook trout and native mottled sculpin.
- The results revealed "very poor" environmental conditions just below the dam but "excellent" conditions 1.1 miles downstream. The partial recovery downstream of the lake likely reflected groundwater inputs to the stream and assimilation of nutrients and other factors discharged from the lake.

2.3 CONCLUSIONS

Degraded conditions in Birch Lake and impacts of the impoundment on the trout stream were evident. Birch Lake displayed highly eutrophic conditions in the forms of dense rooted aquatic plants (mostly Elodea or common waterweed), filamentous algae and severe dissolved oxygen fluctuations. The impacts of the dense aquatic plant growths on habitat include loss of recreational uses in the lake and reduced growth rates of sportfish populations.

The release of nutrient rich warm water from the lake to the trout stream resulted in significant aquatic habitat degradation and higher temperatures which were not suitable for trout populations. The highly eutrophic conditions in the lake and negative impacts to the trout stream will not decrease without alternative management strategies.

3 Birch Lake and Trout Creek Environmental Improvement Goals

The purpose of this study is to explore options to improve the situation so that the following goals can be met:

1. Enhance the access and quality of recreational activities such as fishing, boating and swimming at Birch Lake by:

   a) Improving the water quality and aquatic habitat in the Lake,

   b) Reducing the amount of rooted vegetation

   c) Deepen sections of lake via dredging

2. Reduce the thermal impacts on Trout Creek downstream of the Lake

The environmental analysis has found that the eutrophic condition in the lake does not sustain an ecological system that will support desirable sportfish populations. Further, dense aquatic plant communities and shallow lake depths further reduce the quality of recreational activities at Birch Lake. Additionally, the residence time in the lake during baseflow and low flow conditions results in significant impacts on the downstream trout stream ecology that doesn't start to recover until more than a mile downstream.

The progressive development of eutrophic conditions in Birch Lake is due to excessive inputs of sediment and nutrients from the upstream watershed. Lake management research has shown that lakes that have a watershed-to-lake surface ratio of 10:1 or less can be improved substantially by implementing a program of watershed water quality management. However, Birch Lake watershed-to-lake ratio is closer to 100:1, which even strongly suggests that if the whole watershed were strongly managed to a "natural" state of low sediment and nutrient export, Birch Lake would likely still remain dominated by eutrophic conditions.

Following this reasoning, the recommended management approach proposed in the Phase I Study is to divert flows from Trout Creek upstream of the lake, around the lake, which has the effect of substantially reducing the watershed area directly contributing to the lake. This would result in the lake functioning more as a spring-fed lake with significantly reduced nutrient inputs that could start to reduce the eutrophic conditions. This approach would also reduce thermal loading impacts to Trout Creek downstream of Birch Lake by changing the discharge at the dam from warm reservoir water to cooler inflow stream water that is diverted around the reservoir.

4 Diversion Analysis

This study focused on the feasibility of installing a diversion structure within the footprint of the lake to meet the objectives described in Section 3. The study evaluated both the performance of such a diversion to see whether the proposed solution would in fact improve the conditions in the lake and the stream (Section 4) and it evaluated the economical feasibility of implementing such a diversion (Section 5).

Key criteria used in defining the diversion and evaluating diversion performance is that the original flood control purpose of Birch Lake must be maintained, to maintain the original project purpose and federal funding authorization. This means that large floods entering Birch Lake from Trout Creek upstream need to be discharged into the lake, so that the storage routing discharge reduction action of the reservoir can be maintained. Additionally, as a practical matter, this criteria means that the existing primary spillway structure will remain functional for all large floods, meaning its capacity does not need to be replaced by the diversion of low flows around Birch Lake. The purpose of this diversion analysis was to evaluate what a feasible diversion infrastructure would look like with this limitation in mind.

Four steps were implemented in analyzing the performance of the watershed diversion concept:

1. Flood event discharges were defined;
2. Diversion route alternatives were evaluated;
3. Conveyance capacity of various diversion alternatives were evaluated; and
4. The sediment and nutrient loading for flood events were estimated

4.1 Flood Frequency

Estimating the peak discharge for a certain recurrence interval can be done either by modeling or by comparing to reference streams. The NRCS modeled the watershed using TP-20 methodology in 1963 when designing the dam and outlet structure for Birch Lake and estimated the peak discharge rates for the 10-, 50-, and 100-year flood events to be 425-, 910-, and 1,200- cubic feet per second (cfs) respectively. This kind of modeling approach usually overestimates the discharge for larger, particularly undeveloped watersheds. Another approach to flood discharge estimation is to use statistical regression analysis that use descriptors of watershed characteristics to estimate peak discharge based on analysis of monitoring data from streams that are gauged. The USGS peak discharge estimation procedure developed for Wisconsin (often referred to as the Congers regression analysis procedure) was used to provide an additional estimate of inflow discharge rates to Birch Lake. The results are presented in Table 4.1.

Table 4.1. Estimated flood peak discharge rates for the Birch Lake watershed.

Recurrence Interval	Estimated Discharge
Baseflow	~**-2** cfs
1-year	**30** cfs
2-year	**100**-130 cfs
5-year	**200-**240 cfs
10-year	**330**-425 cfs
100-year	**700-**1,200 cfs

The lower, more frequent discharge rates are primarily based on the USGS regression analysis results, and the highest discharge rates are based on the original NRCS modeling results, with several interpolated values for the smaller events. The range for each recurrence interval is relatively small but increases for the larger events which was expected. The lower end of the range of flood estimates (shown in bold type in the table above) was used in this study.

Baseflow was measured by the study team during the summers of 2009 and 2012 and were consistently measured around 1-2 cfs.

Additionally, NRCS had evaluated the bankfull discharge in the Trout Creek channel in the late 1970's and found that by Birch Lake, the bankfull discharge was around 30 cfs (Wentz, 1982). The bankfull discharge corresponds to the discharge at which channel maintenance is most effective (Dunne and Leopold 1978) and corresponds to a return interval of 1.05 to 1.8 years (USEPA Website accessed February 2013). This corresponds fairly well with the regression analysis results for the 1-year event.

4.2 Diversion Route

Once the peak discharges were defined, we looked at the various options for routing the diverted peak discharges around the lake. Given the geometry of the valley Birch Lake is located in (steep hill on the south and a highway on the north) it was clear that the diversion route would have to be routed along the North or South edge of the lake (see *Figure 4.1*).

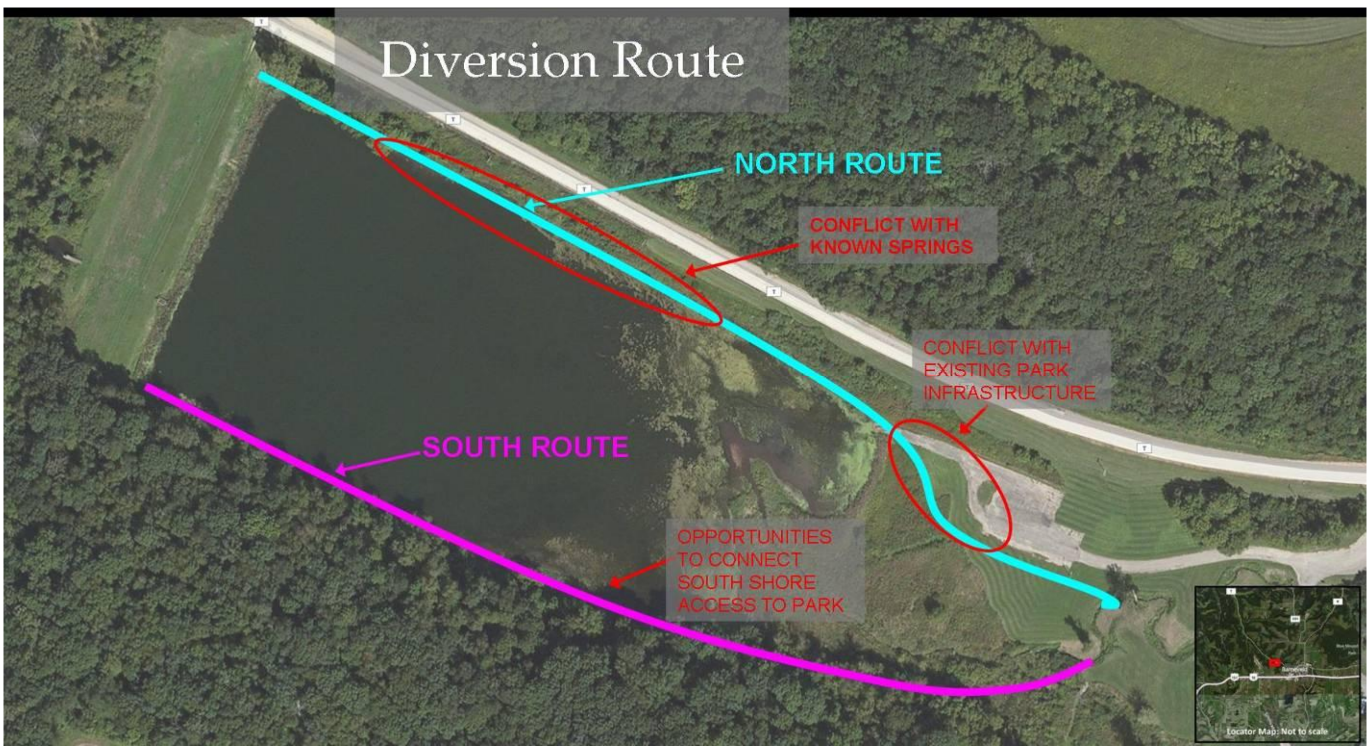

Figure 4.1. Diversion route options.

The general concept of the diversion is to install a diversion structure in the Trout Creek channel upstream of the lake and run a channel or a pipe along the north or south edges of the lake towards the dam. Both of these options would require construction of a berm to form the channel or embed the pipe and result in some challenges and opportunities associated with it. In Table 4.2 the challenges and opportunities for both routes are explored.

Table 4.2. Opportunities and Constraints associated with North or South Diversion Routes

	Opportunities	Constraints
North Route	• Could be integrated into new park layout • Easy access to channel/pipe from road (maintenance)	• Crosses the existing boat landing in roadway access, making direct access to the lake awkward • May intercept and therefore reduce spring flow to the Lake from known springs on the north edge of the lake • Long distance to discharge to existing control structure on dam • Longer route
South Route	• Improves access to the south shore of the lake • Minimizes reworking the park • Shorter route • Shorter distance to existing control structure on dam	• Exposed bedrock could increase construction costs • Drainage from steep hill will be intercepted by the diversion swale and needs to be accounted for • Clearing of wooded vegetation necessary

The South Route appears more favorable, producing opportunities for access to the south side of the lake and improves the recreational value of the Lake. The South Route was selected as we continued to develop the feasible alternatives for this diversion.

4.3 Conveyance Capacity

The conveyance capacity analysis evaluated the trade-off between a hydraulic capacity of the flow diversion system and the practical topographic, size and cost of the diversion channel and structures.

The size of the structure depends on the conveyance capacity. The hydraulic conveyance depends on multiple parameters, but chiefly on the slope, roughness, and cross sectional area of the diversion feature. The slope is primarily controlled by the existing elevations of the dam and upstream channel, and was therefore a “given”. Roughness and cross-sectional area were evaluated for a variety of diversion layouts and options.

<u>Channel Conveyance</u>

The following geometry was used as a conceptual design to evaluate the conveyance capacity for the proposed diversion channel:

- Channel shape = Trapezoidal
- Channel side slopes = 3H:1V

- Channel longitudinal slope = 0.26%
- Channel roughness (manning n) = 0.035 (assuming a clean, straight channel with some weeds and stone)
- Channel bottom width = varied from 5 – 100 feet

Figure 4.2 shows the flow the above described channel geometry can carry at certain flow depths and for varying channel widths. The flow depths in essence define the height of the separation berm that would be required to contain the water in the channel without it overflowing into the lake.

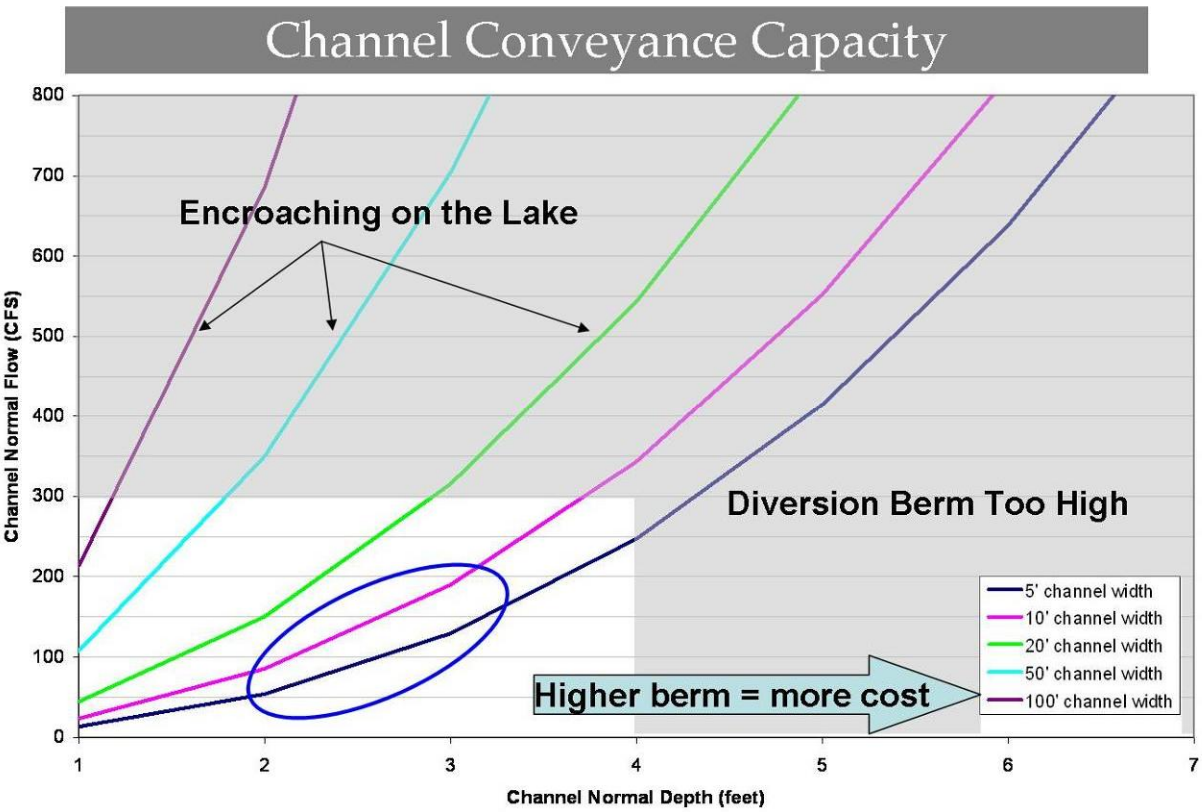

Figure 4.2. Conceptual channel design conveyance capacity

The channel depth also means that the higher the berm is, the more cost is involved in the material and construction of the berm. If the berm is higher than 4-feet, the total footprint at the bottom of the lake would be more than 60 feet (shaded area on the right side of the graph). Also, if the channel starts to be wider than 20 feet, the combined width of the channel the berm footprint would start to significantly encroach on the useable lake surface area and consequently reduce the area available for recreational activities. With the average width of the lake about 400 feet, the berm and channel widths combined, if constructed with parameters shown within the shaded area on *Figure 4.2.*, would end up being 20-50% of the total width of the lake. This is likely unacceptable impact to the lake. Therefore, the area within the blue circle on *Figure 4.2*, a channel 5-10 foot wide, with a berm flow depth of 2-3 feet high, is more manageable approach if channel is used as a diversion mechanism. This analysis indicates that a reasonable diversion capacity is between 100-200 cubic feet per second, which is approximately the 2-5 year event.

Pipe Conveyance

Using a pipe for conveying flood flows is usually less efficient for higher flows compared to channel flow and therefore often more expensive than channel setup for the same discharge. *Figure 4.3* illustrates this clearly. In this case the following geometry was used as a conceptual design to evaluate the conveyance capacity for the proposed diversion pipe:

- Pipe shape = Circular
- Pipe longitudinal slope = 0.26%
- Pipe roughness (manning n) = 0.012 (assuming a smooth walled HDPE or PVC plastic pipe)
- Pipe diameter = varied from 2 – 8 feet

Figure 4.3 shows the flow the above described pipe geometry can carry given certain headwater depth and for varying pipe diameter. The headwater depth is the height of the water column on the upstream end of the pipe that is required to "push" the water into the pipe entrance.

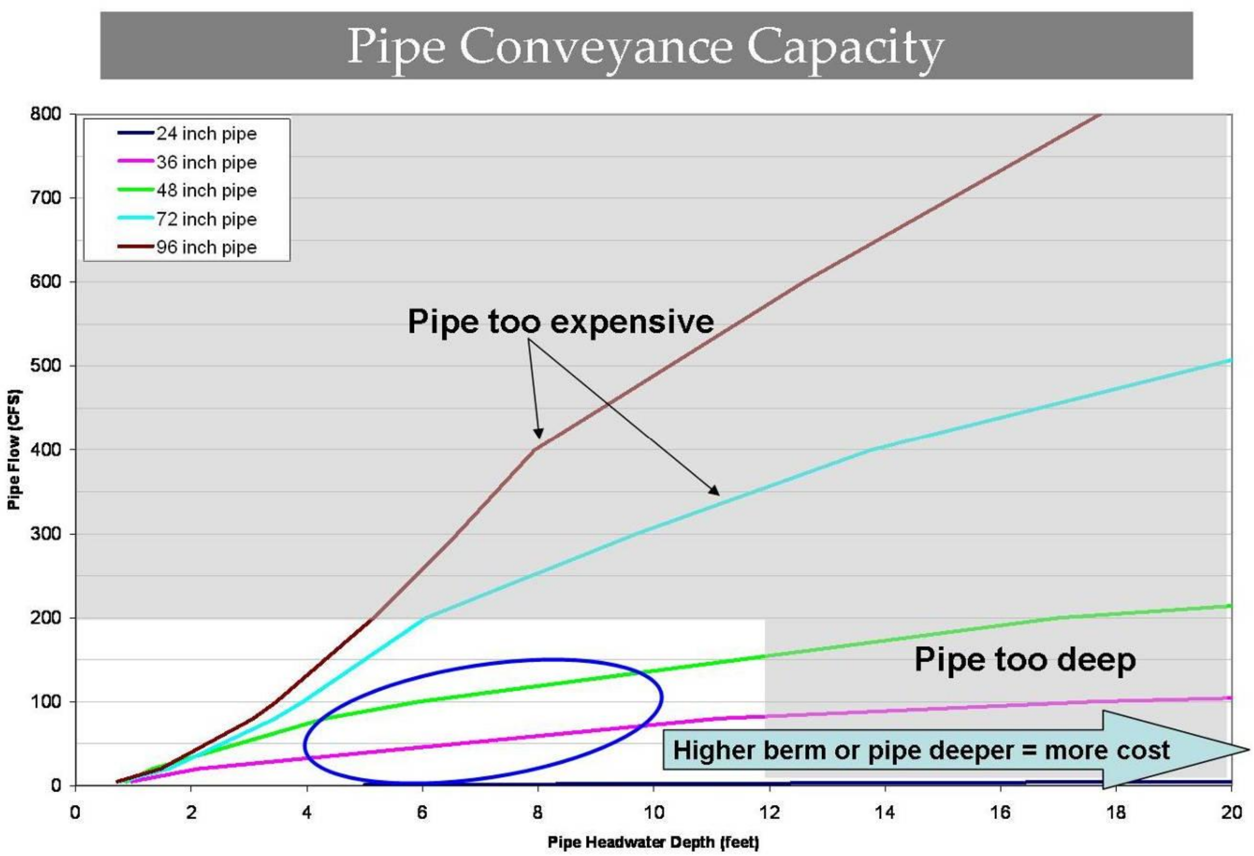

Figure 4.3. Conceptual channel design conveyance capacity

Headwater could be created by either installing the pipe deeper into the ground or by instructing a berm or a basin at the entrance of the pipe that can pull up water higher than the pipe entrance. Both of these approaches have significant cost implications. The shaded areas of the Figure 4.3 show design conditions that are beyond a practical implementation from a constructability and cost. The area in the blue circle shows a more viable design. In this case we can see that 36" – 48" pipes with 6-10 feet of head can carry between 50 and 150 cubic feet per second which is translates to approximately 1 – 2-year event.

New Control Structure vs. Existing Control Structure

An additional important consideration when defining the conveyance capacity of this diversion concept is how we get the flows through the existing dam. Two options are available: a) introduce the diverted discharge into the existing control structure or b) install a completely new control structure for the diverted flows. *Table 4.3* describes the pros and cons with each of the two options.

Table 4.3. New Control Structure vs. Existing Control Structure

	Pros	Cons
Option A - Use Existing Structure	• Less cost - structure already in place • Existing outlet structure has enough capacity • No changes to the dam embankment needed • No change in the flood frequency downstream of dam	• Will have to divert flows from North or South Route to the existing structure with a swale or a pipe installed on the upstream face of the embankment dam
Option B - Construct a New Control Structure	• Flows can be discharged through the dam without diverting to the existing structure • The capacity of the structure can be greater than the existing structure • Shorter route	• Increased cost - entirely new structure constructed • Disturbing the existing dam embankment would have regulatory and structural integrity consequences • Installing a new structure in an existing embankment has several design challenges • Would change flood frequency downstream of dam

Option A, using the existing control structure, is preferable. It is less costly and would not impact any flood risk downstream as the exactly same structure would be used to pass large flood discharge as currently. Option B, building a new structure would have some benefits in that it could be more customized to the proposed design but is more expensive and has significant design challenges and regulatory implications downstream. Option A was used in further developing the diversion alternatives.

4.4 Sediment Analysis

Nutrients contributing to the eutrophication of Birch Lake come from various sources:

- Most of the nutrients are attached to sediment particles that get detached from the soil with the force of the raindrops when it hits the surface

- The sediment particles are transported with runoff into streams and down to the Lake. Runoff from agricultural fields is often a significant portion of downstream sediment and nutrient loading, especially when soil conservation practices are not installed and maintained.
- Some nutrients are dissolved and are a particularly high proportion of total nutrient loading during the spring snowmelt and runoff.
- Channel bank erosion and bed load (sediment carried along the channel bottom) can also be a significant source of sediment and nutrients carried into the lake since much of the eroded sediment from the watershed settles into the channels and doesn't move until a large enough flood event carries it further downstream.

Nutrients and sediment are usually carried into the lake during runoff and flood events. The larger or more intense the runoff/flood event is, the higher the forces are carrying sediment downstream and more sediment gets transported to the lake.

However, on a long term basis, total nutrient delivery is not often dominated by the larger, less frequent discharges. Even though smaller discharges have less sediment transport than the larger discharges, they occur more frequently and the accumulated product of event frequency and sediment transport results in the effective discharge; the discharge that results in most sediment being transported to the stream. *Figure 4.4* taken from USEPA's website, shows schematically how this relationship is envisioned, which applies to both gross nutrient delivery to Birch Lake as well as to the discharges that dominate the channel-forming and channel transport processes.

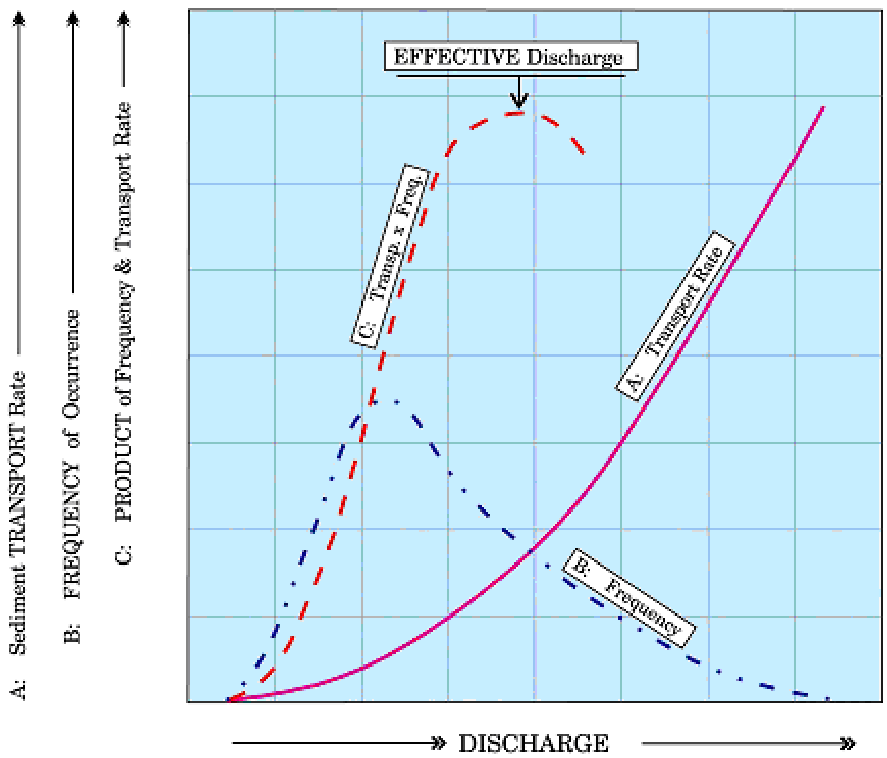

Figure 4.4. Effective discharge, the discharge event where the sediment transport is most effective (after Wolman and Miller 1960).

This effective discharge, also termed bankfull discharge, has been associated with the peak of cumulative sediment transport for a given streamflow magnitude and frequency of occurrence. Research has shown that the majority of the erosive work over time is accomplished at moderate flow rates with somewhere between the 1- and the 2- year return period.

Long term monitoring of discharges and sediment concentrations would be necessary in order to evaluate the sediment delivery and the relationship to flood frequency in order to confirm the bankfull discharge model discussed above applies in the Birch Lake watershed. Data collection upstream of Birch Lake has been very limited although some data collection has taken place further downstream in the past. However, looking at reference streams in watersheds that are also located in the driftless area with similar watershed characteristics that have some long term data collection can provide some indication of the sediment transport in the region.

Data collected from four watersheds in Grant and Iowa Counties, where the Wisconsin DNR had performed 2 year TMDL's studies (DNR, 2007 and DNR, 2008), were evaluated. In addition, in Pleasant Valley, a tributary to the Pecatonica River, located just across Military Ridge, the USGS has been monitoring rainfall, discharge and total suspended solids (TSS) since 2007. Data from all five watersheds indicate that approximately 60% of all sediment load discharged was during high flow events, e.g. times that happened less than 10% of the time (see *Figure 4.5*).

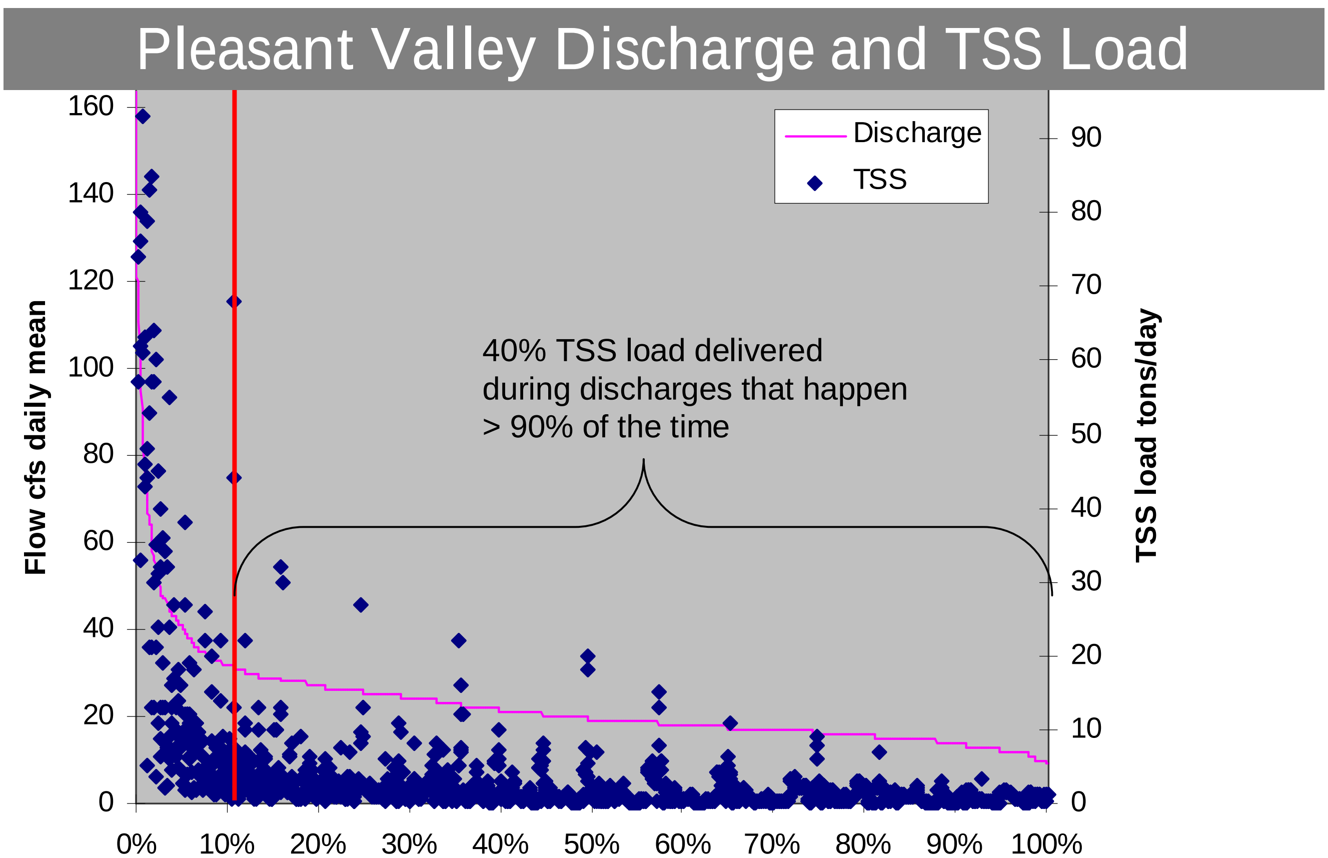

Figure 4.5. Pleasant Valley discharge and TSS load exceedance graph.

The graph in Figure 4.5 indicates that for the majority of the time (over 90% of the time) we have low flow conditions that deliver as much as 40% of the annual sediment loads. The implication for the Birch Lake watershed is that by just diverting the low flows (< 1-year recurrence) significant reduction in annual sediment inputs to the lake could be accomplished. Baseflow sampling from 2009 in Trout Creek upstream of Birch Lake show fairly high TSS concentrations (20 mg/l) similar to what was found in the Pleasant Valley watershed (about 22 mg/l during periods of baseflow or low flow events). The similarity in TSS concentrations suggests that the similar conditions of low flow sediment delivery could be found in the Birch Lake Watershed.

Four years of sediment and flow data collected at the Pleasant Valley watershed had some larger runoff events that were above the 1-year and 2-year flood frequency. The data shows that the largest sediment discharges usually take place during significant runoff events (either snow melt or thunderstorm type rain events) (see *Figure 4.6*). TSS load delivered from the Pleasant Valley watershed during events that were above the 1-year event was about 33% of the total and events above the 2-year event only delivered 12% of the total load during the four year study period. If applicable to the Birch Lake watershed, this suggests that as close to 66 to 88% of the sediment load could be diverted around the lake if the diversion infrastructure would be constructed to divert the 1- and 2-year events respectively.

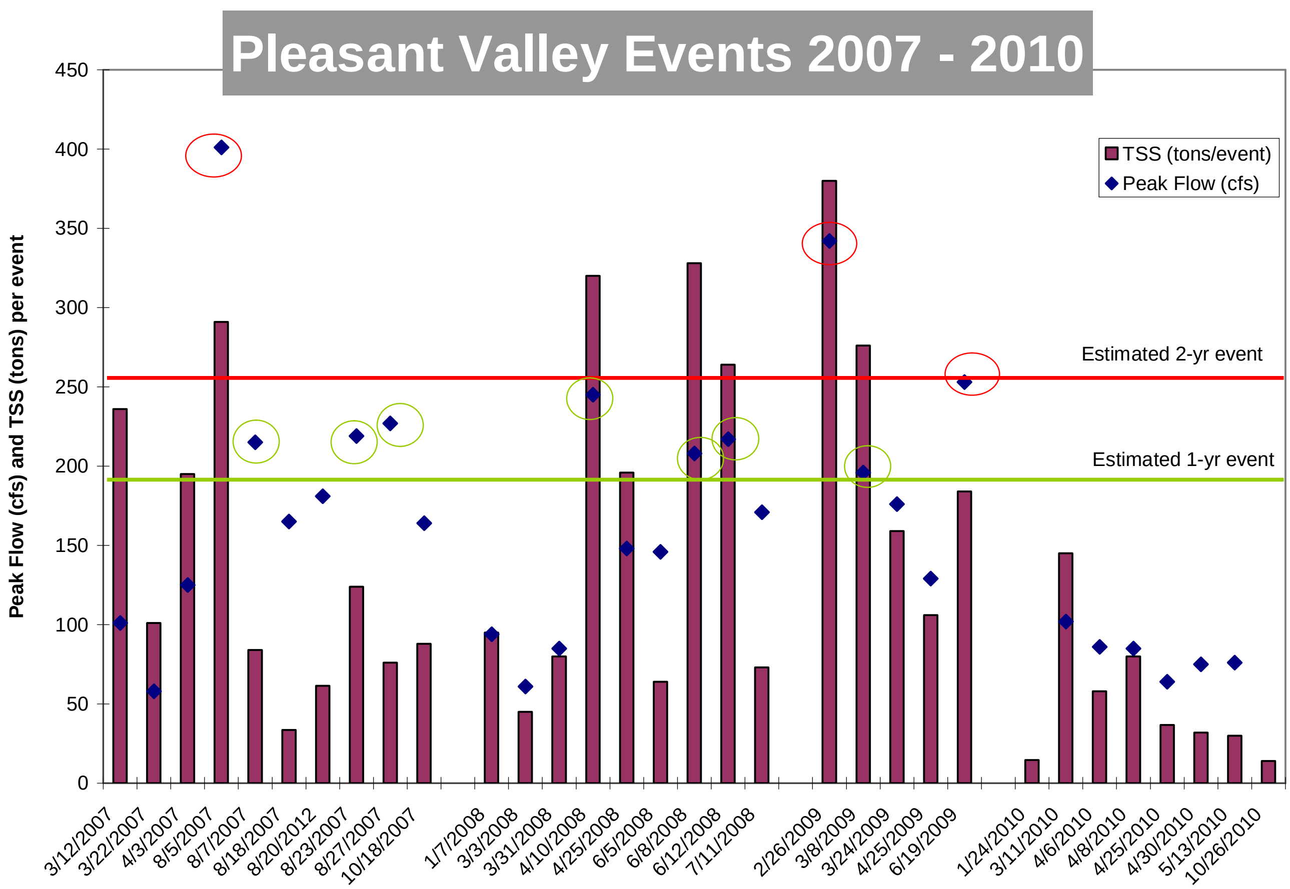

Figure 4.6. Pleasant Valley event based analysis during a four year study period showing event exceeding the estimated 1- and 2-year recurrence flood events

None of the 5 watersheds evaluated had discharges that were beyond a 2-year recurrence interval. However, the Pleasant Valley data was used to extrapolate sediment loading for larger flood recurrences. With an estimate of the larger flood delivery rates and the probability of the larger floods occurring, the performance of a diversion could be evaluated on a long term basis. Five scenarios were evaluated: No diversion, diverting up to the 1-year event, diverting up to the 2-year event, diverting up to the 5-year event, and diverting up to the 10-year event. Over the long term (50-100 years), the percent of diverted sediment for each of the scenarios compared to no diversion can be estimated. Table 4.4 shows the performance in reduction of sediment delivered to the lake if this Pleasant Valley data can be applied to the Birch Lake watershed.

Table 4.4. Percent reduction in sediment loading with diversion on a long term basis.

	Sediment load delivered to Lake (tons/square mile/year)	***Percentage of sediment load diverted around the lake***
No Diversion	52.3	0%
Up to 1-year event diverted	22.2	58%
Up to 2-year event diverted	13.7	74%
Up to 5-year event diverted	10.8	79%
Up to 10-year event diverted	8.8	83%

The results in *Table 4.4* above show that a relatively small diversion capacity can produce significant sediment inflow reduction, and that increasing the diversion capacity results in a situation of "diminishing marginal returns". Once above the 2-year event the percent diverted sediment levels out as the significance of the larger is smaller since they happen less frequently. This is consistent with the bankfull discharge discussion earlier in this section. Diversion infrastructure that capture and diverts smaller to moderate sized events will have the most impact on sediment delivery to Birch Lake.

4.5 Flow Diversion

Based on the analysis discussed above, diverting the baseflow, smaller and moderate sized events could result in significant reductions in nutrient inputs to the lake. Additional infrastructure to go above and beyond the 2-year event would likely result in diminishing return on the investment.

Even if diversion system capacity was, for example, set at the two-year discharge, that capacity would still produce reductions in sediment delivery for larger flood events. Depending upon the flood event size, a fraction of the total inflow would still be diverted around Birch Lake. *Figure 4.7* shows modeled hydrographs for Trout Creek flows entering into Birch Lake that illustrates the volume of flood flow that would be diverted by a diversion system capacity of 100 CFS.

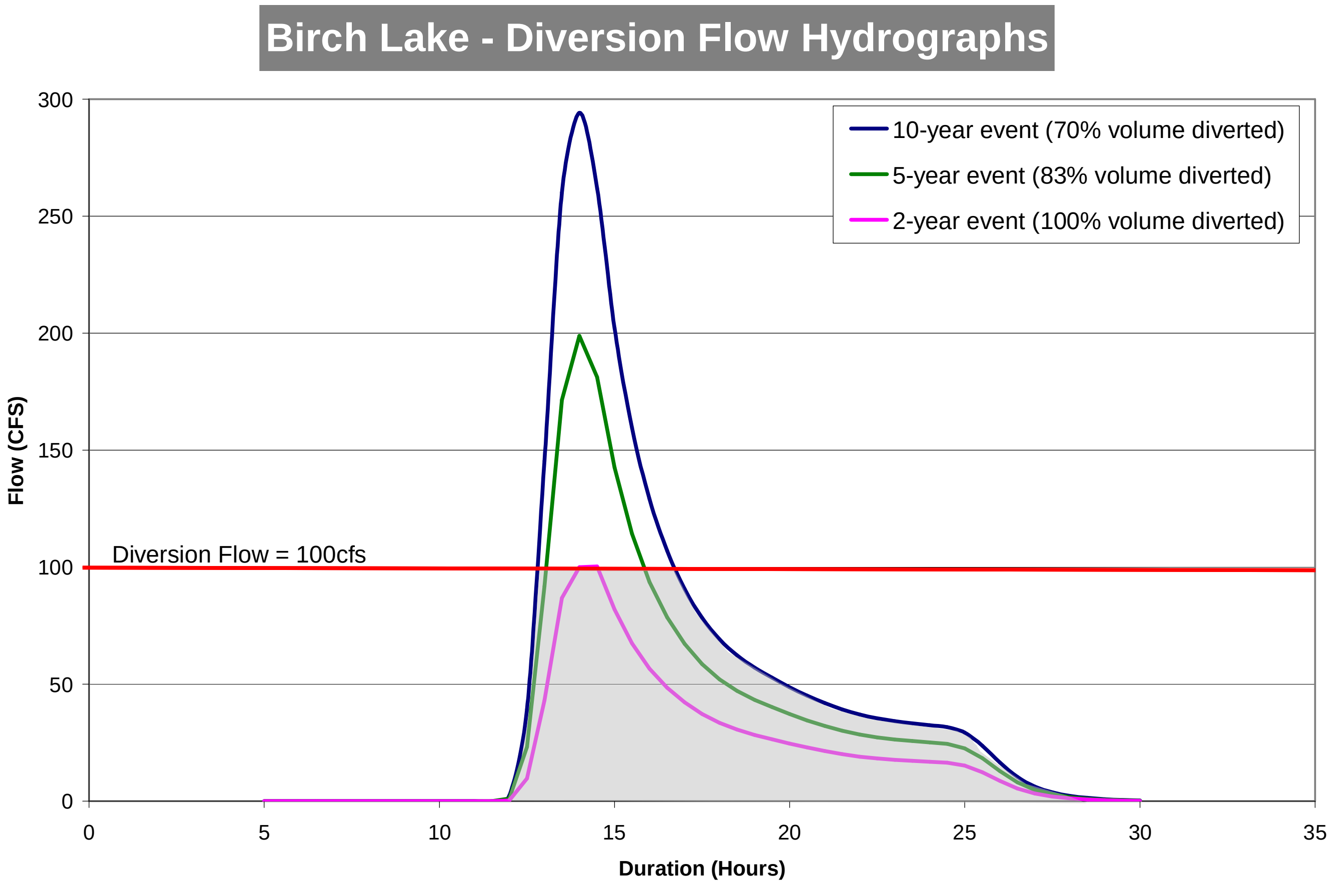

Figure 4.7. Birch Lake flow hydrographs showing volume diverted if 2-year event peak flow is fully diverted.

The red line shows the flow for the 2-year event. The volume of water during an event is represented by the area underneath the lines for each event. The area shaded in gray in *Figure 4.7* represents all volume that is diverted from going into the lake. If 100 cubic feet per second are diverted, then 100% of the 2-year event volume is diverted but up to 83% of the 5-year event and as much as 70% of the 10-year event volume is also bypassed the lake.

Additionally, flow diversion would likely be implemented by installing some sort of low weir in the existing channel which would allow overflow for larger events to be safely passed into the lake. This kind of an arrangement could results in the bed load sediment and heavier particles more easily bypassed the lake, even for larger events since that bed load would continue to follow the stream bottom and therefore not able to reach the overflow elevation that would direct flows into the lake.

The diversion would therefore not be limited to benefits for only the flood event that would be fully diverted around the lake but have beneficial consequences for larger events.

4.6 Benefits to the Lake

A diversion of smaller and moderate sized events will provide significant positive responses to the lake from both a phosphorus and sediment perspective. Reducing the springtime nutrient loading resulting from snowmelt is also a significant improvement compared to existing conditions. Phosphorus loadings would be expected to closely parallel those of sediment loadings given the high dissolved oxygen concentrations present in the inflowing water that would favor phosphorus being attached to sediments.

The diversion would further improve lake conditions by eliminating the continual loading of phosphorus and nitrogen to the lake, a situation that provides plants a source of nutrients at all times. With just episodic event loadings every two years or more, it is expected that plant response would be less than where continual supply of nutrients existed.

We anticipate that groundwater would not contribute a significant amount of phosphorus to the lake. However, it could be a source of nitrogen which is sometimes a limiting nutrient for the rooted plant community. A diversion would reduce some nitrogen loadings but it most likely would not be sufficient to dramatically reduce rooted plant growth in the lake. Deepening of portions of the lake would therefore provide benefits to the lake by reducing the time period where rooted plants became a problem.

4.7 Diversion Analysis Summary

The following is a summary of the conclusions of the diversion analysis:

- Routing the diversion along the south bank of Birch Lake and utilizing the existing control structure will have the least impacts on existing infrastructure, downstream flood frequency, and groundwater inputs to the lake, and have most benefits for lake access and recreational use.
- Diversion infrastructure that would be designed to divert flood flows above the 5- to 10-year event would result in excessive cost and/or significant intrusion into usable area for lake recreation.
- Larger events deliver more sediment and nutrients but happen less frequently and are not the main source of nutrient loading in the long term. Research shows that events between the 1- and 2- year events deliver the most of the sediment in the long term.
- Diverting events above the 1-year event prevents continual discharge of nutrients to the lake with significant improvements to the lake biota. Diverting the 1 through 10 year event could divert between 57 – 83% of sediment/nutrients on a long term basis. Diverting discharges greater than the 2-year event will likely have marginal benefits and reduced return on investment.
- Diversion for smaller events also has significant impacts on the volumes that is diverted from the lake during larger events and significantly reduce sediment/nutrient inputs into the lake.

5 CONCEPTUAL DIVERSION ALTERNATIVES

Conceptual Design

- Construction of a diversion structure in the existing channel upstream of Birch Lake at approximate channel bottom elevation 969. The overflow would be directed into the existing channel downstream of the diversion structure within the existing delta wetland areas to maintain the current conveyance capacity into the lake.
- Construction of an 8-foot wide separation embankment directing the main flow of Trout Creek around the southern perimeter of Birch Lake, diverting nutrient and high suspended solids flow around the Lake for smaller storm events (1 – 5 yr, to be determined in design).
- The separation embankment would be used as a pedestrian access to the southern shoreline of the lake for fishing and other recreational uses.
- Installation of an outlet structure pipe that would be connected into the southern or eastern wall of the existing control structure for the Lake. This outlet structure pipe would be buried into the existing dam embankment directed to the south where it would be connected into the separation embankment discharging the diverted flow.
- Two options are proposed for conveying the flows along the separation embankment:

a) Channel Option:

  - o An 1140-foot long separation embankment would be constructed as a berm separating the Lake from a diversion channel with 3H:1V side slopes and 5-foot wide channel bottom that would channel water along the southern edge of the Lake.
  - o The southern slope of the channel would be cut into the existing shoreline, with some grading up the southern hill and clearing of some trees in order to maximize the size of the lake area.
  - o The channel would connect to approximately 110' long outlet structure pipe with an efficient culvert inlet structure or a concrete weir overflow drop structure (determined during design) that connects into the existing dam control structure.
  - o Berm elevations vary based on the diversion flow objectives (see alternatives discussion below) but would have 1-2 foot freeboard above the maximum water surface elevation in the channel and not overflow until the lake elevations matched the channel elevations to protect the berm structural integrity.
  - o The material used in constructing the core of the separation berm will have to be structurally sound material able to withstand overflow scenarios. Dredge material from the Lake can only be used as topsoil and or upper layers of the berm.

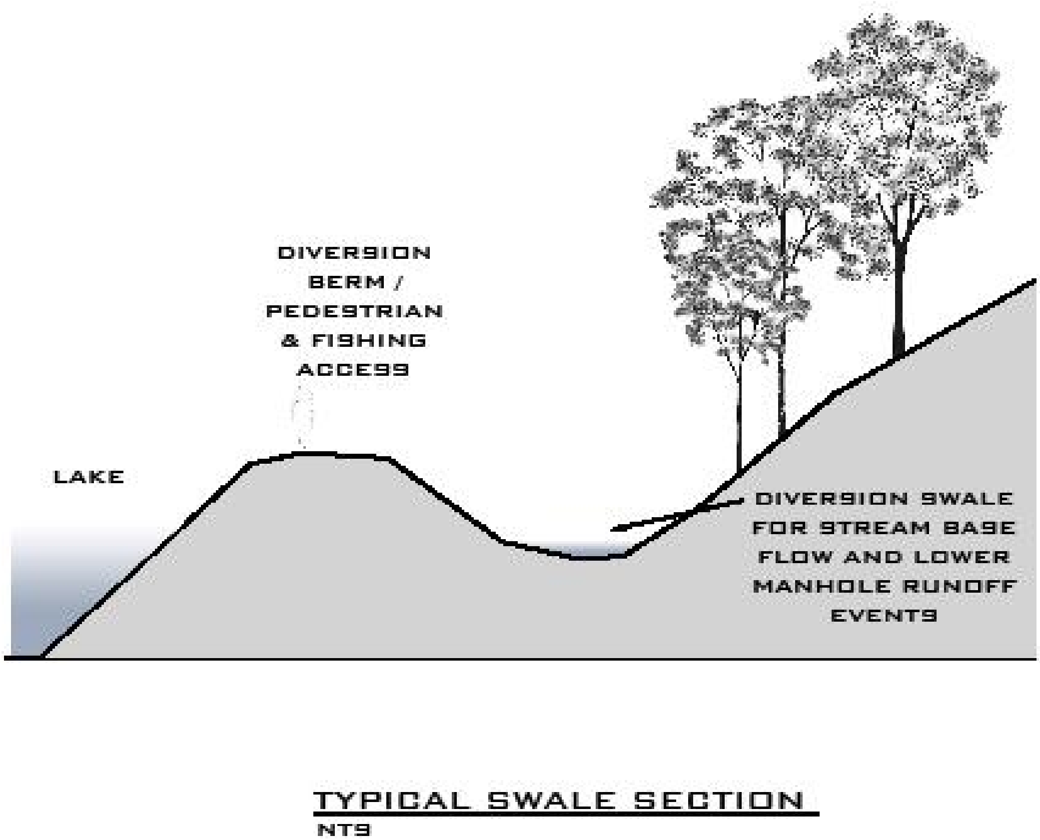

Figure 5.1. Typical section view of a separation berm and a swale.

b) <u>Pipe Option:</u>

- A 1250-foot long smooth walled HDPE pipe would be installed along the southern edge of Birch Lake from the diversion structure to the existing dam control structure. Pipe size varies depending on the diversion flow objectives (see alternatives discussion below).
- The pipe would be embedded into 8-foot wide embankment with 3H:1V side slope and be located immediately adjacent to the southern shore of lake.
- The embankment height would be approximately 2-feet above the normal pool elevation of the lake.
- The material used in constructing the core of the embankment will have to be structurally sound and able to withstand overflow scenarios and not scour away. The dredge material from the Lake can only be used as topsoil and or upper layers of the berm.

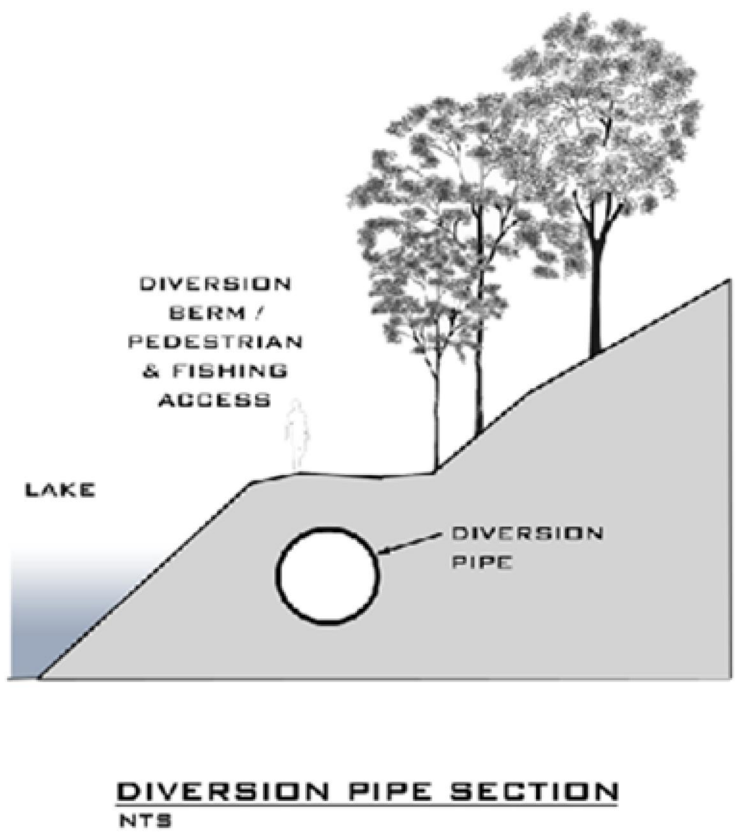

Figure 5.2. Typical section view of a pipe embedded into the diversion berm.

Alternatives:

The following six (6) alternative scenarios were determined in order to evaluate a range of possible options for the above described diversion concept:

1. Channel option diverting up to the 1-year event
2. Pipe option diverting up to the 1-year event
3. Channel option diverting up to the 2-year event
4. Pipe option diverting up to the 2-year event
5. Channel option diverting up to the 5-year event
6. Pipe option diverting up to the 5-year event

Cost:

- Costs were developed for each of these scenarios using discussions with local contractors, cost estimating references, and engineering experience.

The following items were included in the cost estimates:

- Mobilization, bonds & insurance;
- Clearing and grubbing
- Erosion control
- Diversion berm fill
- Outlet structure from swale, outlet structure pipe and connection to existing dam outlet structure
- Flow diversion structure
- Rip Rap
- Site stabilization and restoration
- Engineering costs
- 15% estimating contingency

A detailed preliminary cost estimate for each of the six alternatives can be seen in *Appendix D*.

<u>Summary:</u>

Below is a summary table outlining the differences in the various alternatives proposed and the estimated cost for each scenario. A more detailed conceptual alternatives scenarios matrix can be seen in *Appendix C*.

Table 5.1. Summary of estimated costs and performance for six alternative scenarios for diversion around Birch Lake

Alternative	Description	Estimated Cost	Estimated percent of sediment load diverted *
Alternative 1	Channel diversion up to 1-yr event	$250,000	58%
Alternative 2	Pipe diversion up to 1-yr event	$320,000	58%
Alternative 3	Channel diversion up to 2-yr event	$320,000	74%
Alternative 4	Pipe diversion up to 2-yr event	$400,000	74%
Alternative 5	Channel diversion up to 5-yr event	$420,000	79%
Alternative 6	Pipe diversion up to 5-yr event	$520,000	79%

* (Estimated diverted sediment from Birch Lake over 50-year period (extrapolated from Pleasant Valley data).

Note that the estimated costs for the pipe alternatives approximately 20% greater than that for the channel alternative for the range of capacities indicated. The fact that these estimates are relatively close together suggests that the final selection of a pipe or channel alternative should be based on bid prices received in a competitive process.

6 Lake Dredging and Park Improvements Concept

A companion component of the restoration recommendation for Birch Lake from the Phase I study by Agrecol, was to implement sediment removal and deepening of the lake to improve navigational opportunities and reduce the level of nuisance by rooted vegetation. Although this construction would not affect the diversion of streamflow around Birch Lake, they were evaluated to provide the Village with an idea of the scope of the overall package if choosing to move forward with this project.

Lake dredging can be an expensive component of a restoration project. With the lake drawn down, construction costs can be significantly reduced by using ordinary excavation equipment but hauling and disposing of the material is usually a large portion of the cost associated with dredging projects. Utilizing some of the dredging spoils for general landscaping within Birch Lake Park can help reduce some of those costs. Selective dredging of key areas can also be valuable when thinking about what to choose from. Deeper channels to improve navigation while leaving and possibly improving wetland areas for habitat can be helpful in minimize costs as well as make the project more palatable to regulatory agencies.

Figure 6.1 shows various alternatives for dredging and recreational improvements in the park and around the lake that meet different objectives depending on what fits the overall goals, objectives and budget constraints of the restoration project. The following improvements were evaluated:

- Sediment Removal (~1 – 3' deep over entire lake):
  - Includes removal of the top 1-3 feet of organic rich sediment that has accumulated in the lake in the last 50-years.
  - Will remove possible in-lake sources of nutrients and reduce vegetation growth even further.
  - Total dredging quantity ~5,000 cubic yards
  - Estimated Cost ~ $30,000
- Dredged Channel (~8-10' deep along the boat landing and existing parking lot)
  - This will improve boat and fishing access to the lake
  - Total dredging quantity ~10,000 cubic yards
  - Estimated Cost ~ $80,000
- Dredged Delta (~ 5' deep where the majority of the sediment has deposited)
  - This will increase the total footprint of the lake
  - There will be significant impacts to wetlands that could be difficult to justify to regulatory agencies
  - Total dredging quantity ~10,000 cubic yards
  - Estimated Cost ~ $80,000

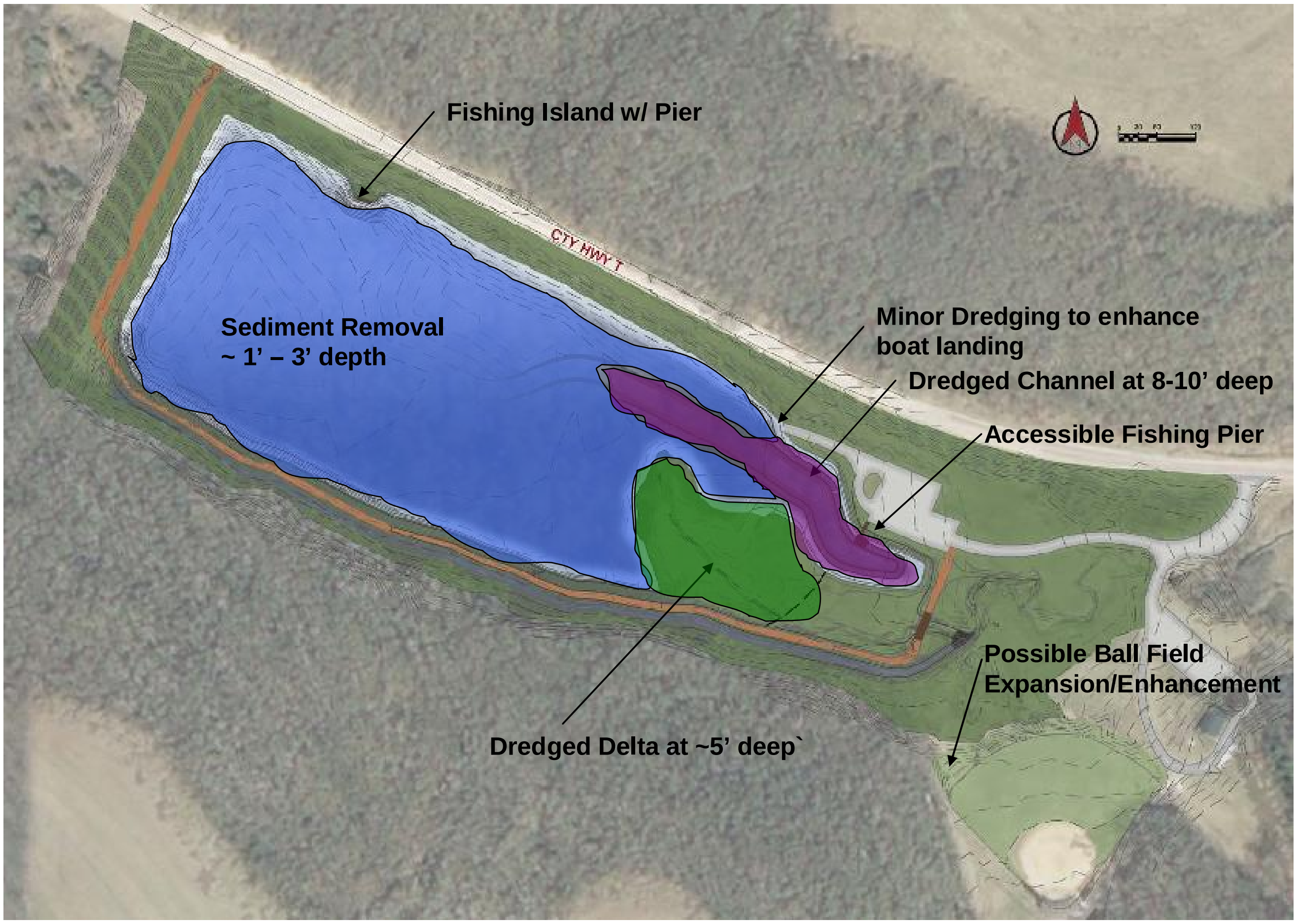

Figure 6.1. Possible dredging, park and lake access improvements.

- Fishing Piers
  - o Installation of two fishing piers is proposed: one by the existing parking lot that would be handicap accessible and one along the north shore of the lake taking advantage of natural spring conditions.
  - o Fishing piers improve recreational opportunities on the lake.
  - o Estimated Cost ~ $60,000
- Ballfield enhancements
  - o This is an opportunity to utilize some of the dredging materials to improve the grade around the existing ball field at the park.
  - o Areas in the outfield would be expanded and restored.
  - o Estimated Cost ~ $25,000

7 Recommended Alternative

7.1 Description

The results from this study are intended to provide the Village with options for various directions to take this project if there is support and willingness to do so. Putting together a combination of diversion infrastructure components and recreational access improvements that will fit the budget will be the most fruitful avenue to a successful project that will actually be accomplished. However, the consultant team has considered the options presented in this report for both diversion and dredging/lake improvements and taken some time to evaluate the costs and benefits as they relate to the environmental improvement goals outlined in Section 4. The following project components are recommended as a cost effective combination of components that meet the goals:

- Diversion Alternative 3 – Channel diversion of events up to the 2-year event (with the expectation of bidding the project using both pipe and channel alternatives to confirm the most cost-effective approach)
- Dredged Channel (~8-10' deep along the boat landing and existing parking lot)
- Fishing Piers
- Ballfield enhancements

Exhibit 3 in *Appendix A* shows a rendered plan view of the recommended alternative to facilitate discussions and present a visual representation of the features proposed.

7.2 Cost

An estimated cost for the recommended alternative is shown in *Table 7.1*:

Table 7.1. Total estimated cost for the recommended combination of alternatives

Diversion Alternative 3	$320,000
Dredged Channel	$80,000
Fishing Piers	$60,000
Ballfield Enhancements	$25,000
Total Estimated Cost	$485,000

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8 ITEMS FOR FUTURE CONSIDERATION

If a project is pursued by the Village, a number of items require continued consideration. Items such as making decisions about pursuing funding, construction design, regulatory approvals, and community planning for open space and pedestrian connections are jus to name few. Below are some of the issues to keep in mind moving forward.

8.1 REGULATORY COORDINATION

Close coordination with the various regulatory entities involved in permitting the Birch Lake restoration project should be initiated as soon as possible to shorten the permitting timeline and provide avenues for design feedback. Dredging of, or filling on, the Lake bottom, modifications to the dam, and disturbance on the lake and creek shoreline will require several permits from multiple regulatory agencies. A brief summary of the potential regulatory entities along with the various permit programs is summarized below.

<u>USACE</u>

- Section 404 Clean Water Act permitting

<u>WDNR</u>

- Navigable Waters (Dredging, Placement of Fill, Structures)
    a. Authorized by Ch. 30 of the State Statutes
    b. Regulated under Wisconsin Administrative Code Chapters NR 300 – 329 and NR 340 – 353
- Dam Ownership
    a. Authorized by Ch. 31 of the State Statutes
    b. Regulated under Wisconsin Administrative Code Chapters NR 300 – 335
- Floodplain
    a. Locally implemented but must meet the requirements listed in Wisconsin Administrative Code Chapter NR 116
- Wetland Fill
    a. Section 401 Water Quality Certification (related to USACE Section 404 Permitting)
- Erosion Control
    a. Regulated under Wisconsin Administrative Code Chapters NR 216 and NR 151

<u>Iowa County/Village Zoning</u>

- Floodplain
    a. Zoning approval, as mandated by WDNR
- Shoreland Zoning and Erosion Control

8.2 Governmental and Landowner Cooperative Agreement

Birch Lake and Birch Lake Community Park are located on State owned land managed by the Wisconsin DNR. The Village of Barneveld has agreement with the DNR of the maintenance and operations of the Park but otherwise has no jurisdiction as a property owner. The Birch Lake Dam (Structure 7) was constructed by NRCS but is owned and maintained by the Iowa County Land Conservation Department. The project, if it is to be moved forward, needs to involve all these agencies. Eventually, an intergovernmental agreement is likely required between the DNR, Iowa County and the Village in order to clearly define the roles and responsibilities of each entity during the design and implementation process.

8.3 Non-Governmental Organization Coordination

The improvements to Birch Lake will undoubtedly have beneficial consequences for Trout Creek downstream of the dam. Trout Creek downstream of the dam is located in the DNR owned land and is a very popular public fishing destination. Non-Governmental Organizations (NGOs), such as Trout Unlimited have a stake in promoting and improving trout habitat in southwest Wisconsin. Trout Unlimited and other non-governmental organizations should be engaged and involved in providing design assistance and feedback and potentially participate in funding or help identify additional funding sources. Additionally, non-regulatory agencies such as the Natural Resource Conservation Service and potentially branches of the DNR may be able to provide design assistance to offset project costs.

8.4 Identifying Other Funding Sources

In addition to discussions with NGOs, the Village should begin identifying potential private and local, state, and federal funding opportunities. Several applicable grant programs exist, such as DNR's River and Lake Protection Grant Program, and these programs typically have application deadlines. Additionally, the Village should coordinate with state and federal representatives to determine potential funding possibilities available under economic stimulus programs.

9 References

Agrecol Environmental Consulting (Richard Wedepohl and David Marshall). January 2010. *Birch Lake Management Plan*. In cooperation with Village of Barneveld, Iowa County Land Conservation Department and Wisconsin Department of Natural Resources.

Cheetam, R. N. and R. F. Wilke. 1975. *Sedimentation in Birch Lake, Iowa County, Wisconsin*. U.S. Department of Agriculture, Soil Conservation Service, Madison, WI.

Dunne, T. and Leopold, L.B., 1978. *Water in Environmental Planning*. W.H. Freeman, San Francisco. 818pp.

USEPA Website, accessed February 2013. *Watershed Assessment of River Stability & Sediment Supply (WARSSS), Hydrologic Processes: Bankfull Discharge*.
http://water.epa.gov/scitech/datait/tools/warsss/bankfull.cfm

Wentz, D.A., David J. Graczyk. August 1982. *Effects of a Floodwater-Retarding Struture on the Hydrology and Ecology of Trout Creek in Southwestern Wisconsin*. USGS, Water Resources Investigations 82-83.

Wisconsin Department of Natural Resources. 2007. *Total Maximum Daily Loads: Martin Branch, Martinville Creek, and Rogers Branch, Grant County Wisconsin*.

Wisconsin Department of Natural Resources. 2008. *Total Maximum Daily Loads: Otter Creek, Iowa County, WI.*

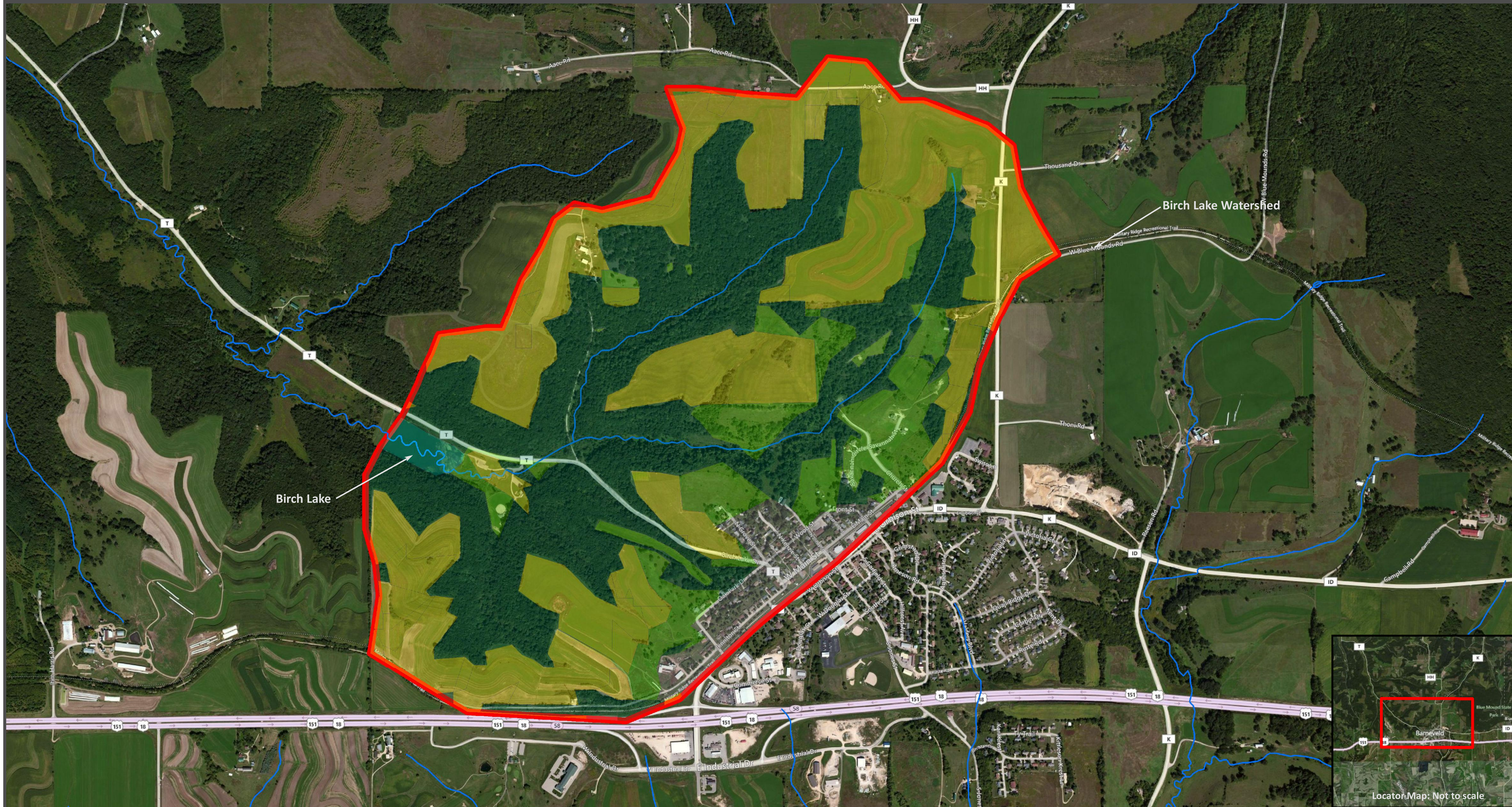
Wolman, M.G. and Miller, J.P., 1960. *Magnitude and Frequency of Forces in Geomorphic Processes*. Journal of Geology, 68, 54-74.

Appendix A
Exhibits

Montgomery Associates: Resource Solutions, LLC
119 South Main Street, Cottage Grove, WI 53527
(608) 839-4422 | www.ma-rs.org | 07/24/2012

EXHIBIT 1 WATERSHED MAP

Birch Lake Restoration Project | Village of Barneveld, WI



Legend

Agriculture
Forest
Grassland
Open Water
Urban
Birch Lake Watershed

N

1 inch = 600 feet
0 300 600
Feet

EXHIBIT 2

PROJECT NO.: XXXXXX	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: XX/XX/XXXX	DRAWN BY: XXX				
CHECKED BY: XXX					
PLOT DATE: 14153000 Existing.dgn 3/13/2013 4:08:45 PM jhellenbrand					

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EXISTING CONDITIONS WITH NEW SURVEY AND BATHYMETRY

BIRCH LAKE STUDY
VILLAGE OF BARNEVELD
IOWA COUNTY, WISCONSIN

FILE NO. 14153000

SHEET 1

BIRCH LAKE RECOMMENDED ALTERNATIVE

APPENDIX B

ENVIRONMENTAL IMPACTS ASSESSMENT SUMMARY REPORT

2012 Birch Lake Management Planning Report

Water Quality and Habitat Assessment

WDNR Lake Planning Grant Project: Sponsored by the Village of Barneveld

Agrecol®
Native Seed, Plants & Restoration

Prepared by

Dave Marshall and Richard Wedepohl

September 2012

Summary

Consistent with previous years, water quality, temperature and biological data collected in 2012 demonstrated degraded condition in Birch Lake and impacts of the impoundment on the trout stream were evident. Birch Lake displayed highly eutrophic conditions in the forms of dense rooted aquatic plants (mostly Elodea or common waterweed), filamentous algae and severe dissolved oxygen fluctuations. The impacts of the dense aquatic plant growths on habitat include loss of recreational uses in the lake and reduced growth rates of sportfish populations. The release of nutrient rich warm water from the lake to the trout stream resulted in significant water quality degradation and higher temperatures which were not suitable for trout populations. The highly eutrophic conditions in the lake and negative impacts to the trout stream will not decrease without alternative management strategies.

Introduction

Birch Lake was constructed in 1964, as part of the U.S. Soil Conservation Service Twin Parks Watershed Work Plan, to reduce flooding in the watershed and provide lake recreation. However, favorable environmental conditions did not last long. Cheetham and Wilke (1975) documented higher than predicted sediment loading to the lake only a decade after it was constructed. Periodic toxic spills and a very high watershed to lake surface area ratio (87:1) resulted in gradual water quality decline in the lake. WDNR had documented lake and stream water quality and habitat degradation in 1995 and again in 2001. Beginning in 2009, Agrecol Environmental Consultants conducted an intensive lake and watershed study on Birch Lake as part of a Lake Planning Grant sponsored by the Village of Barneveld. Findings of that project revealed continued poor water quality in the lake and trout stream below the lake. A number of management alternatives were explored as part of the study. The recommendation selected by the Village, with public input, was to explore the feasibility of a watershed diversion project to reduce sediment and nutrient inputs to the lake and reduce water quality and thermal impacts on the trout stream.

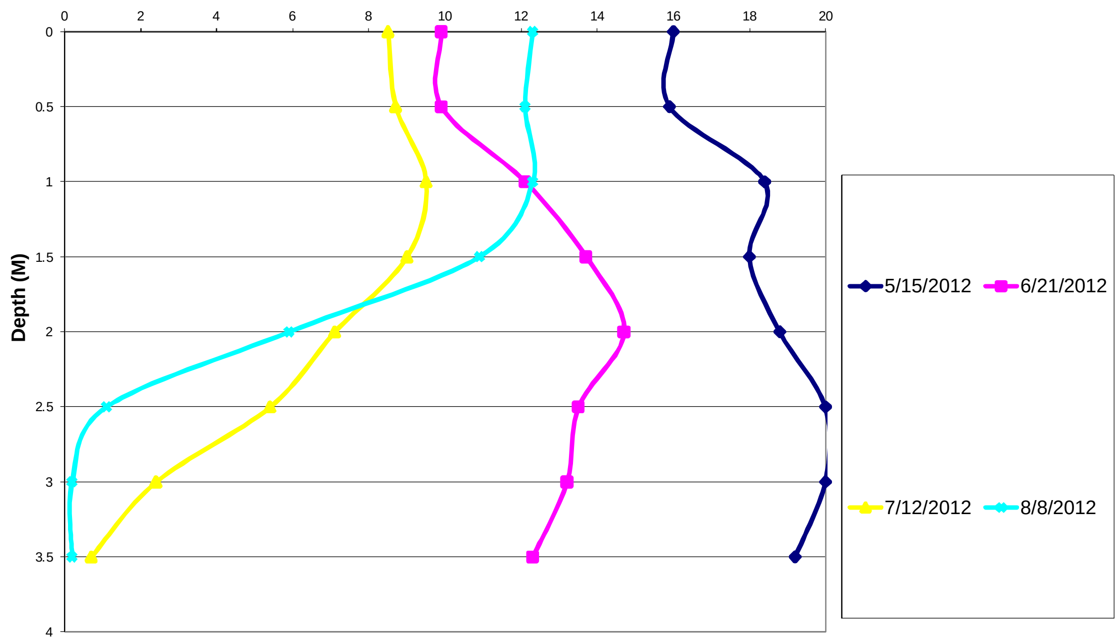
Methods

Lake Sampling: Monthly lake sampling was conducted from May 2012 through August 2012. Field parameters included Secchi water clarity and vertical profiles of dissolved oxygen, temperature, pH and specific conductivity. State Lab of Hygiene samples were collected and analyzed for phosphorus and chlorophyll. The values were also transformed into Trophic State Index (TSI). Overall habitat conditions were documented along with biological observations of dragonflies, waterfowl and amphibians that were recorded as well. Fish population electroshocking surveys (towed DC barge) were conducted to determine the coldwater Index of Biotic Integrity (IBI) in Trout Creek. Birch Lake fish population data was analyzed to assess the status of sportfish populations in the lake. Water quality and flow measurements were collected above and below the lake along with other field parameters to compare upstream-downstream conditions. Temperature monitoring in the stream took the forms of grab measurements and deployed Hobo temperature loggers. Macroinvertebrate samples were collected and analyzed from sites above and below the dam to calculate the Family-level Biotic Index of stream water quality.

Findings

Birch Lake Water Quality: The results of dissolved oxygen (d. o.) profile surveys are displayed in Figure 1. Early in the year, supersaturated levels of dissolved oxygen were evident in the lake and reflected the excessive growths of Elodea and filamentous algae. While adequate levels of dissolved oxygen are important for fish populations, excessively high levels can stress fish and cause gas bubble disease. Dissolved oxygen levels declined in the lake beginning in July as the dense growths of Elodea began to die. Figures 2, 3 and 4 display Birch Lake temperature, pH and specific conductance respectively. Figure 2 demonstrates that Birch Lake is a heat sink with moderately lower temperatures near the bottom. The lake is too shallow to sustain stratification. Both pH and specific conductance respond to changing water quality. Specific conductance increases near the bottom while pH values decrease (hydrogen ion concentration increases). These responses reflected reduced conditions near the lake bottom and an inlake source of pollutants for the lake and stream (internal loading).

Figure 1: 2012 Birch Lake D.O. (mg/l) Profiles



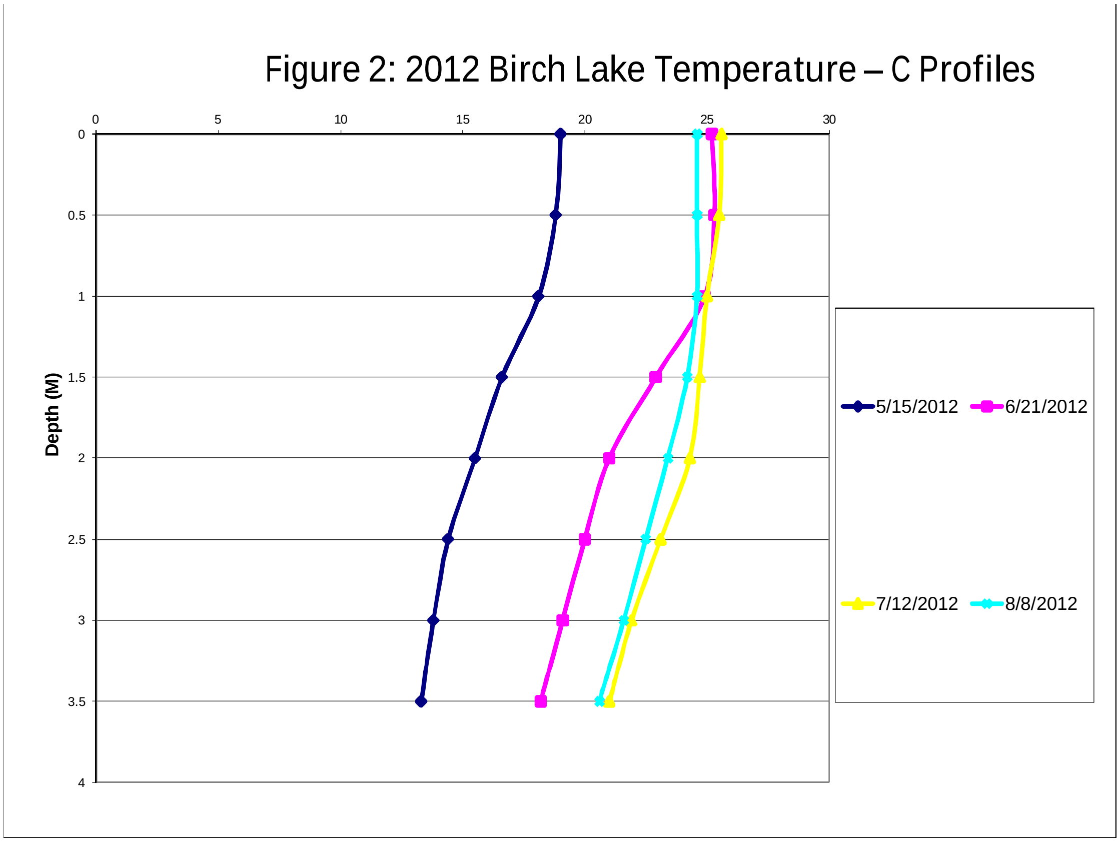


Figure 2: 2012 Birch Lake Temperature – C Profiles
0
5
10
15
20
25
30
0
0.5
1
1.5
2
2.5
3
3.5
4
Depth (M)
5/15/2012
6/21/2012
7/12/2012
8/8/2012

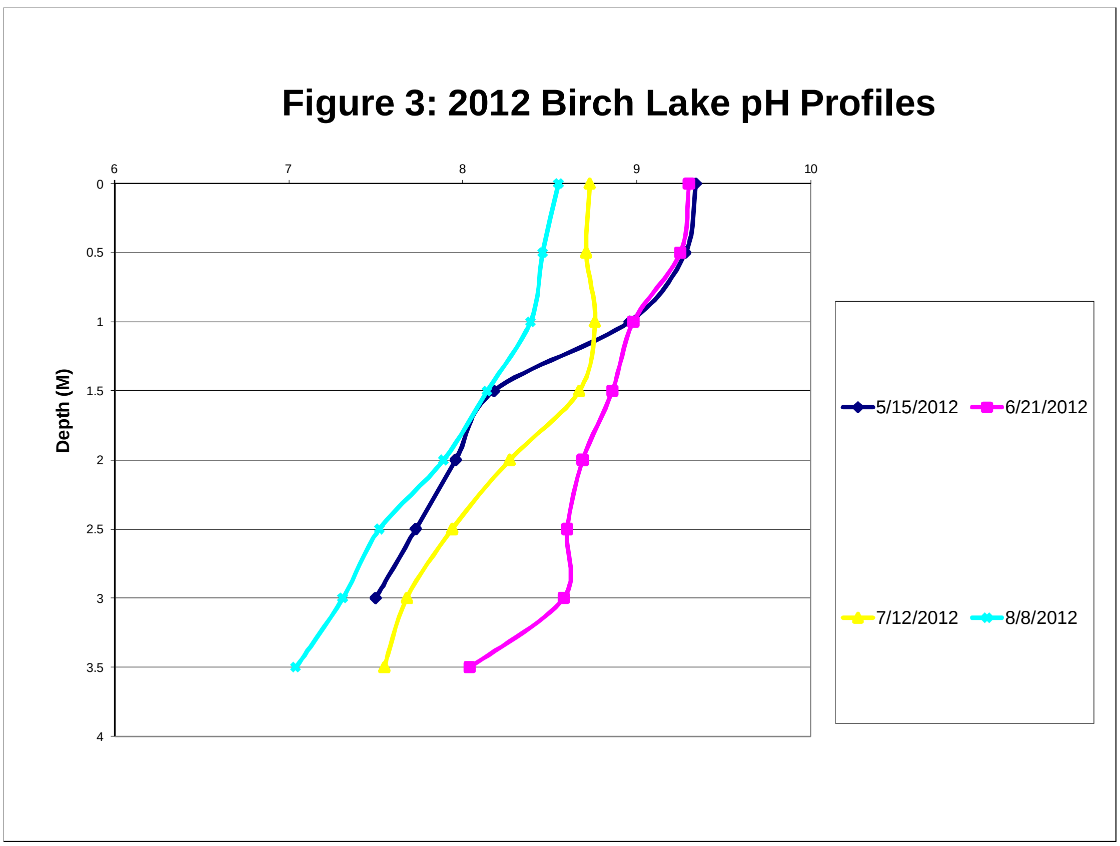


Figure 3: 2012 Birch Lake pH Profiles
6
7
8
9
10
0
0.5
1
1.5
2
2.5
3
3.5
4
Depth (M)
5/15/2012
6/21/2012
7/12/2012
8/8/2012

Figure 4: 2012 Birch Lake Specific Conductance Profiles (uS/cm)

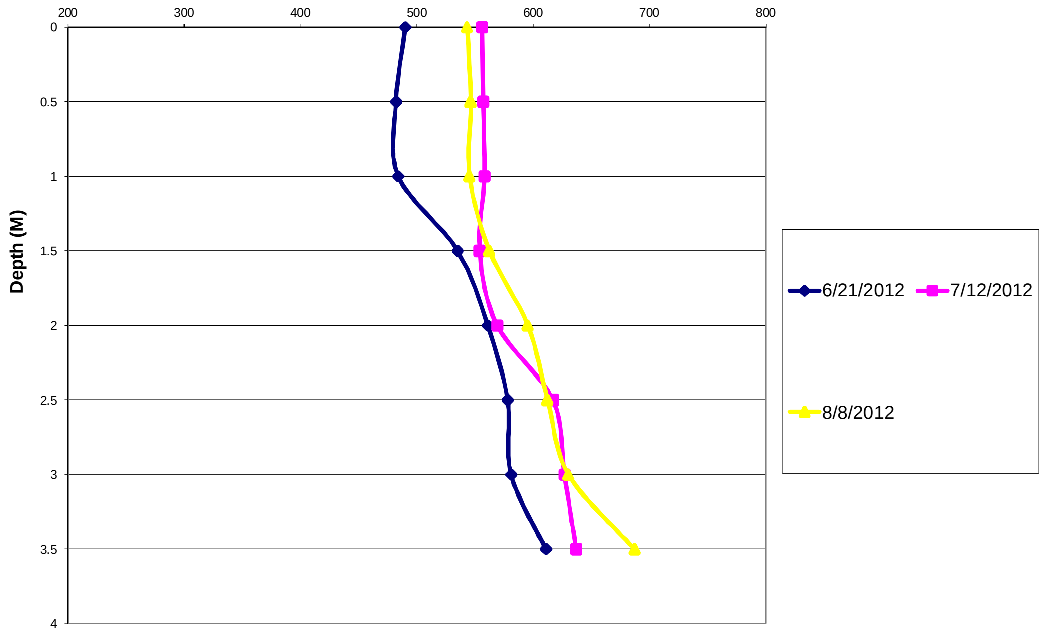


Figure 5 displays the secchi water clarity data for 2012. The lake was generally clear, reflecting suppression of planktonic algae due to dense growths of Elodea. Water clarity declined as the Elodea began dying and was replaced with planktonic algae. The dominance of a single rooted plant in high nutrient conditions results in a highly unstable environment. The significant change that occurred in August demonstrates the instability. As the Elodea declined and decayed, the release of nutrients resulted in both a significant increase in total phosphorus and chlorophyll-a concentrations (Figure 6). The concentrations of both parameters were transformed into TSI values in Figure 7 (water quality index). The concentrations and parameters in July were relatively low but reflect both suppression of algae and sequestration of nutrients by dense growths of Elodea. Poor water quality conditions were evident during August after the plant die-off and nutrient release.

<u>Stream Monitoring</u>: Consistent with previous years, stream monitoring demonstrated better quality conditions and colder temperatures in the stream above the lake. Figure 8 displays water temperatures in the creek above and below the lake, with much higher temperatures downstream of the lake as illustrated in Figure 9. Daily mean maximum temperatures increased by 14.8 degrees F downstream of the lake. Flow rates increased below the lake and demonstrate that local springs around the lake supplement the flow entering the lake from Trout Creek (Figure 14).

Figure 5: 2012 Birch Lake Secchi Depths

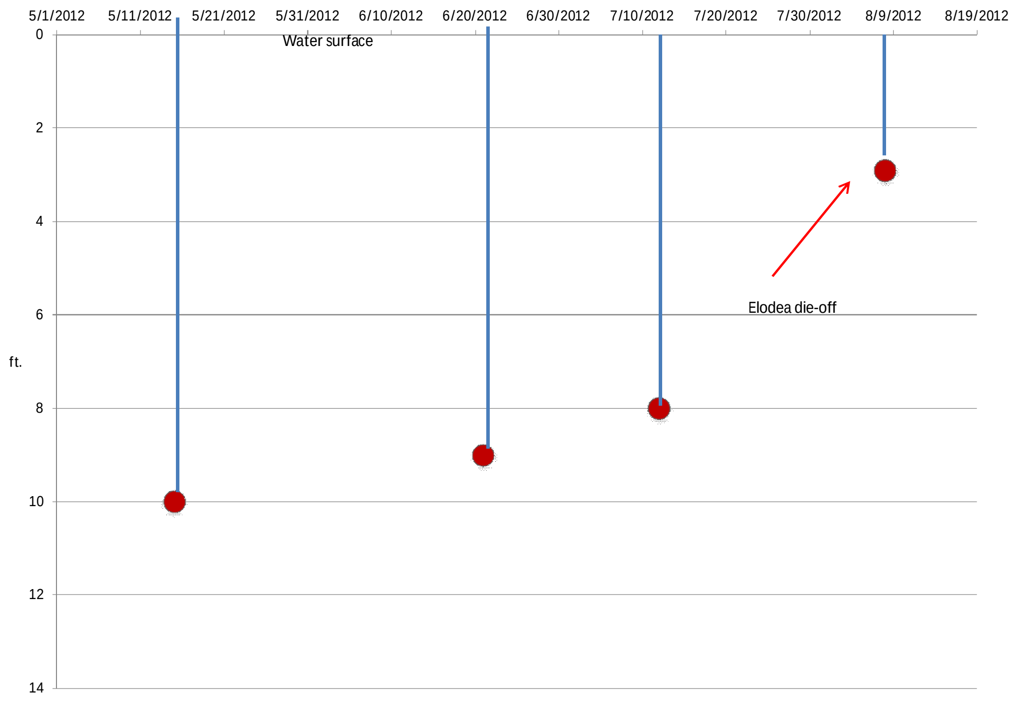
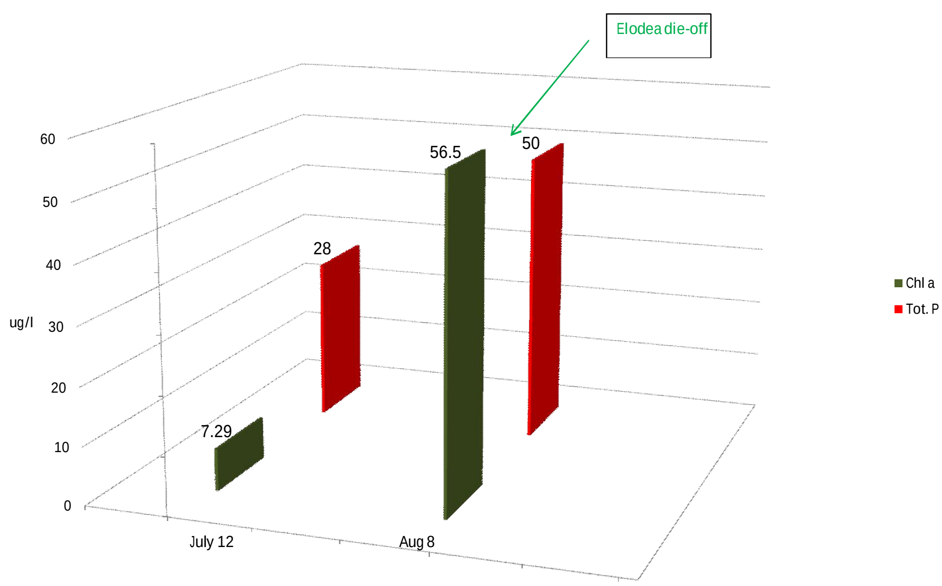
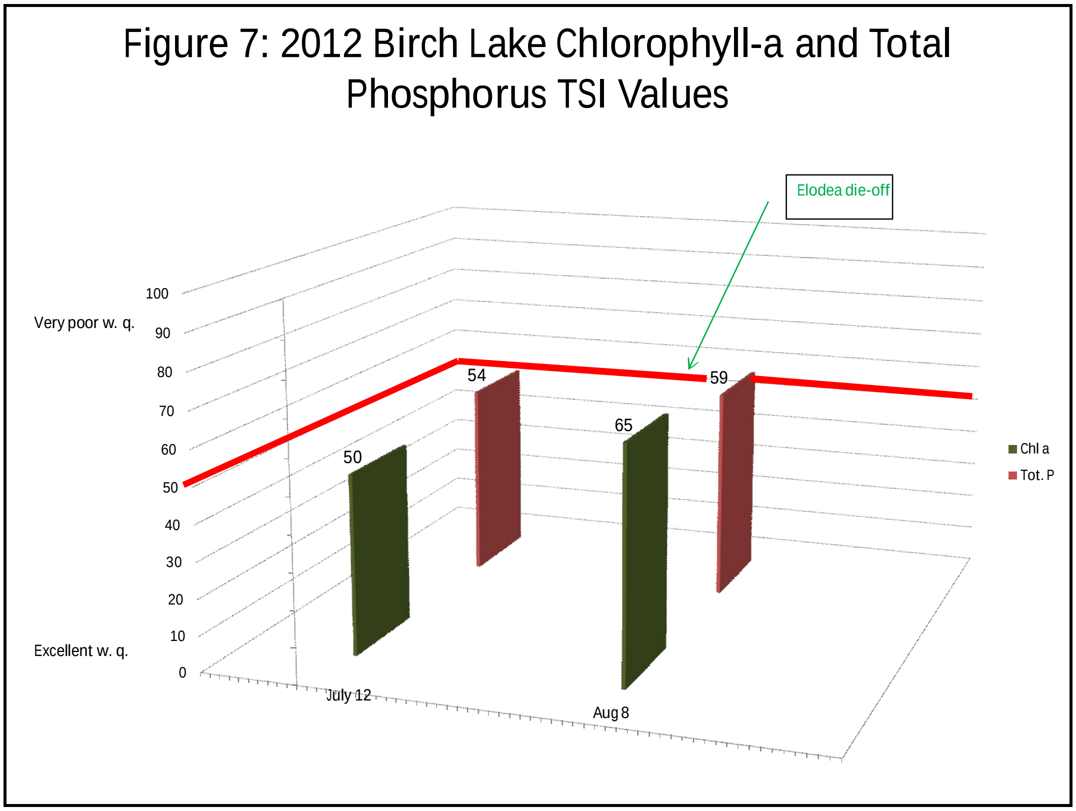
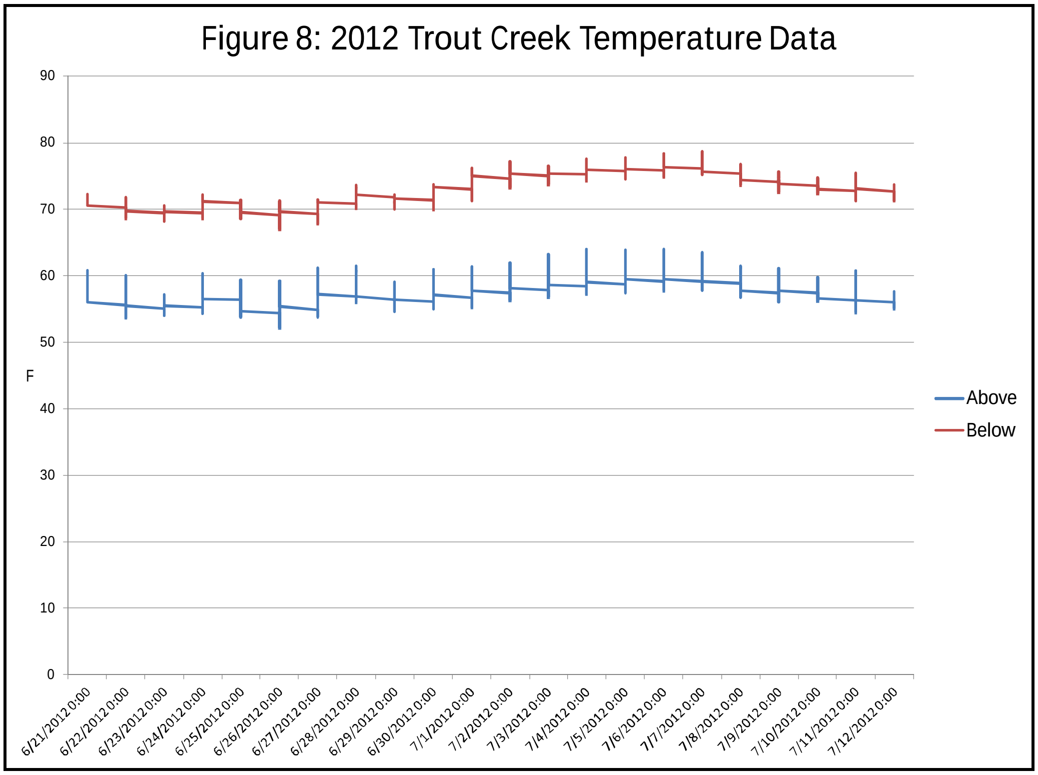


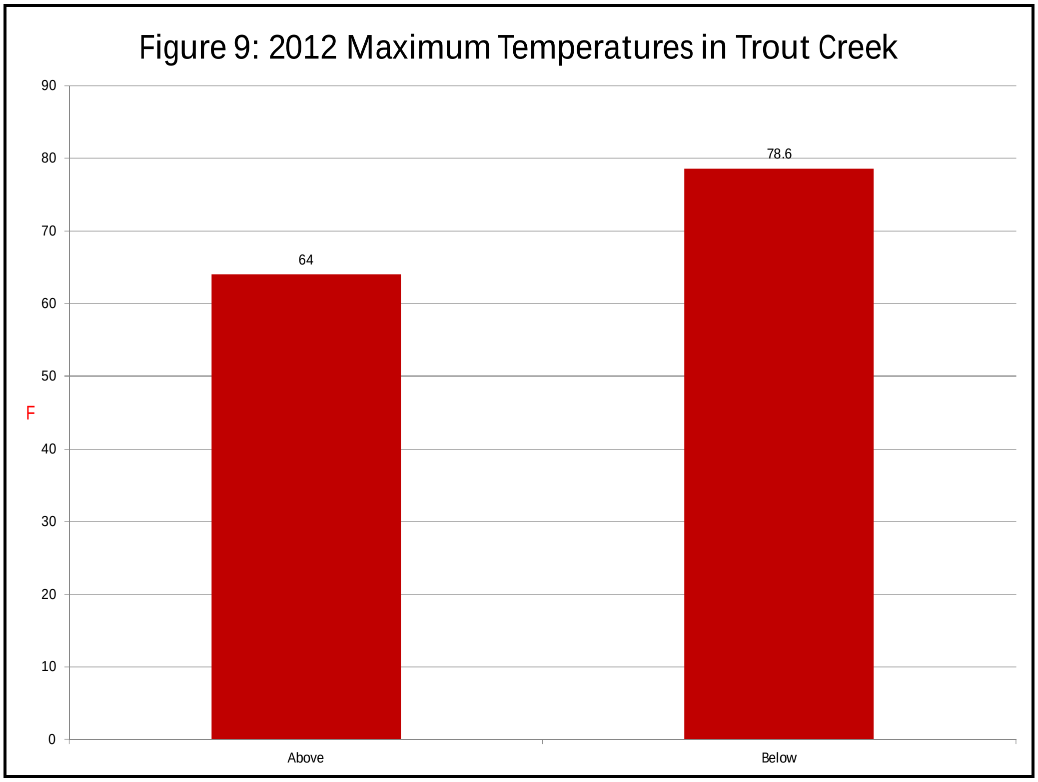
Figure 6: 2012 Birch Lake Chlorophyll-a and Total Phosphorus Data





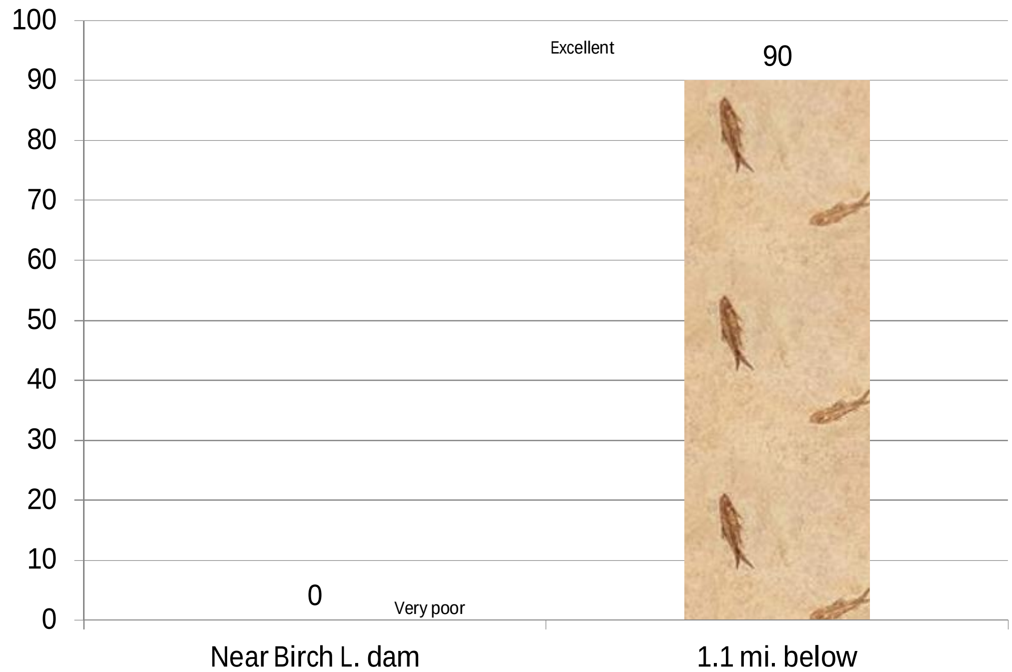
Trout Stream Fisheries: Stream electroshocking surveys were conducted on July 3, 2012 at three locations; above the lake, below the dam and 1.1 miles downstream. No fish were found above the lake due to poor habitat and dense over-hanging vegetation that undermined sampling effectiveness. The dearth of fish above the lake also reflected the migration barrier. These findings do not limit fish potential that could follow if there was additional stream habitat restoration and stocking. Below the lake, no trout were found and the only species evident were low numbers of small largemouth bass in poor condition. A mile below the lake, the stream displayed partial recovery from the pollutants and thermal inputs. A typical trout stream fish community was found including brown trout, native brook trout and native mottled sculpin. These results were transformed into the coldwater Index of Biotic Integrity (IBI) that assesses the environmental condition of trout streams (Figure 10). The results revealed “very poor” environmental conditions below the dam but “excellent” conditions 1.1 miles downstream. The partial recovery downstream of the lake likely reflected groundwater inputs to the stream and assimilation of pollutants discharged from the lake.





In addition to the thermal impacts to the stream, water quality parameters revealed better water quality in the stream above the lake, including higher dissolved oxygen levels and clear water. Below the lake, the stream bed became choked with filamentous algae and bacteria. The water was also tinted due to dissolved organic compounds. Strong Hydrogen sulfide odors below the dam reflected pollutants release at the bottom of Birch Lake.

Figure 10: Trout Creek Coldwater Index of Biotic Integrity



Birch Lake Fish Populations: Recent boomshocking and fyke net surveys conducted by DNR revealed that Birch Lake is predominantly a largemouth bass-bluegill lake, typical of many fish ponds in Wisconsin. Low numbers of black crappie are also found in the lake. Figures 11 and 12 display the length distributions for bluegills and largemouth bass. These data reveal that quality size fish occur in the lake but the overall size structures provides only a modest sport fishery. The dense growths of Elodea can result in over-populations of slow growing panfish and bass. The data revealed that quality catches of bluegill were limited to about 22% of the population while only 11% of the largemouth bass were legal harvest sizes.

Trout Creek Macroinvertebrates: Consistent with both previous studies and other water quality parameters measured during this study, stream macroinvertebrates (aquatic insects and crustaceans) displayed much better water quality above the dam. The Family-level Biotic Index revealed “excellent” water quality of the stream within the park but “poor” water quality below the dam (Figure 13).

Figure 11: Birch Lake Bluegill Size Distribution

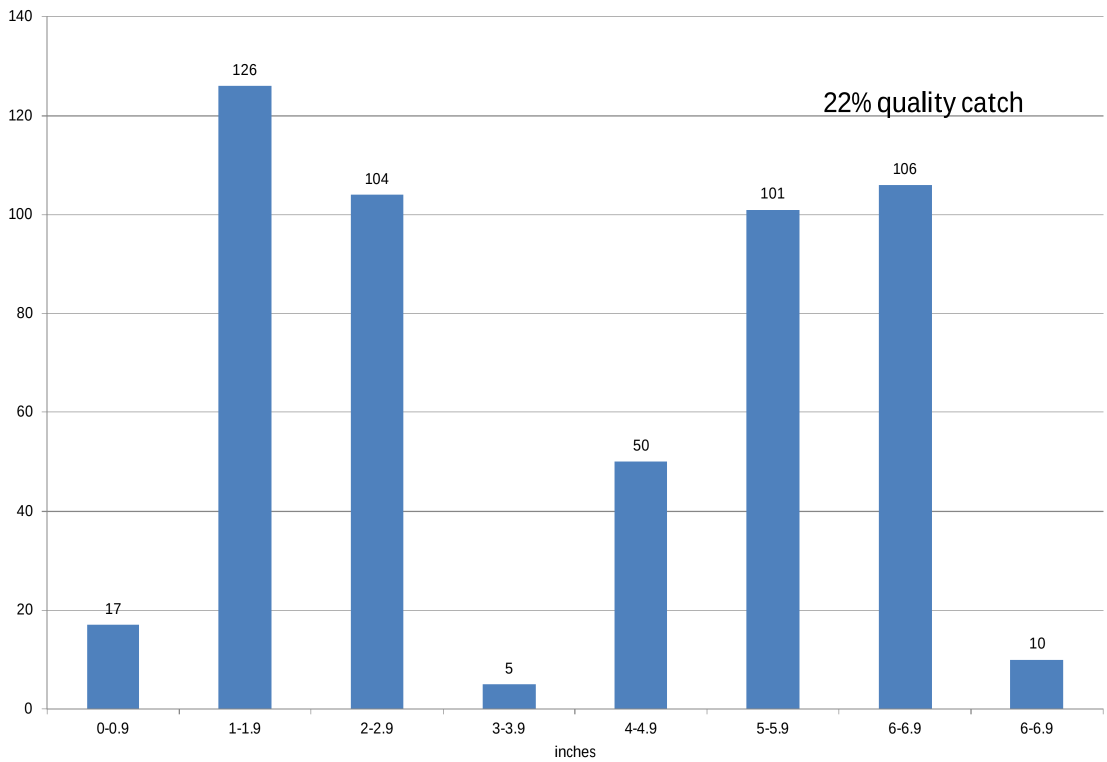
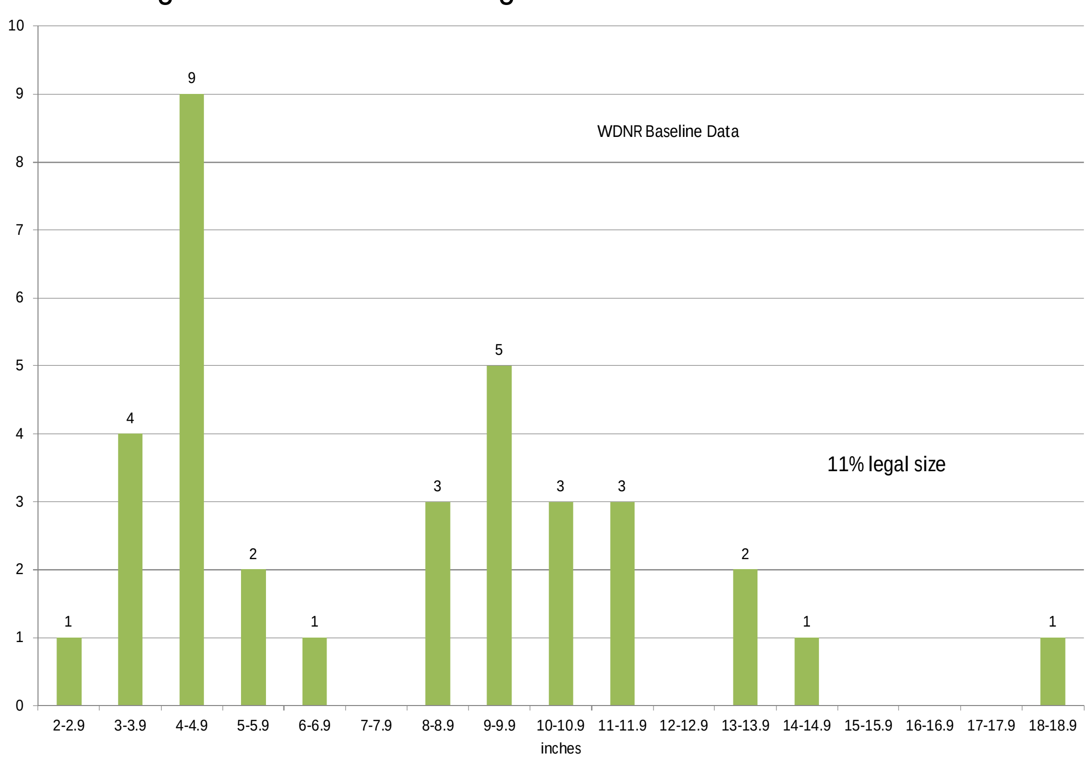


Figure 12: Birch Lake Largemouth Bass Size Distribution



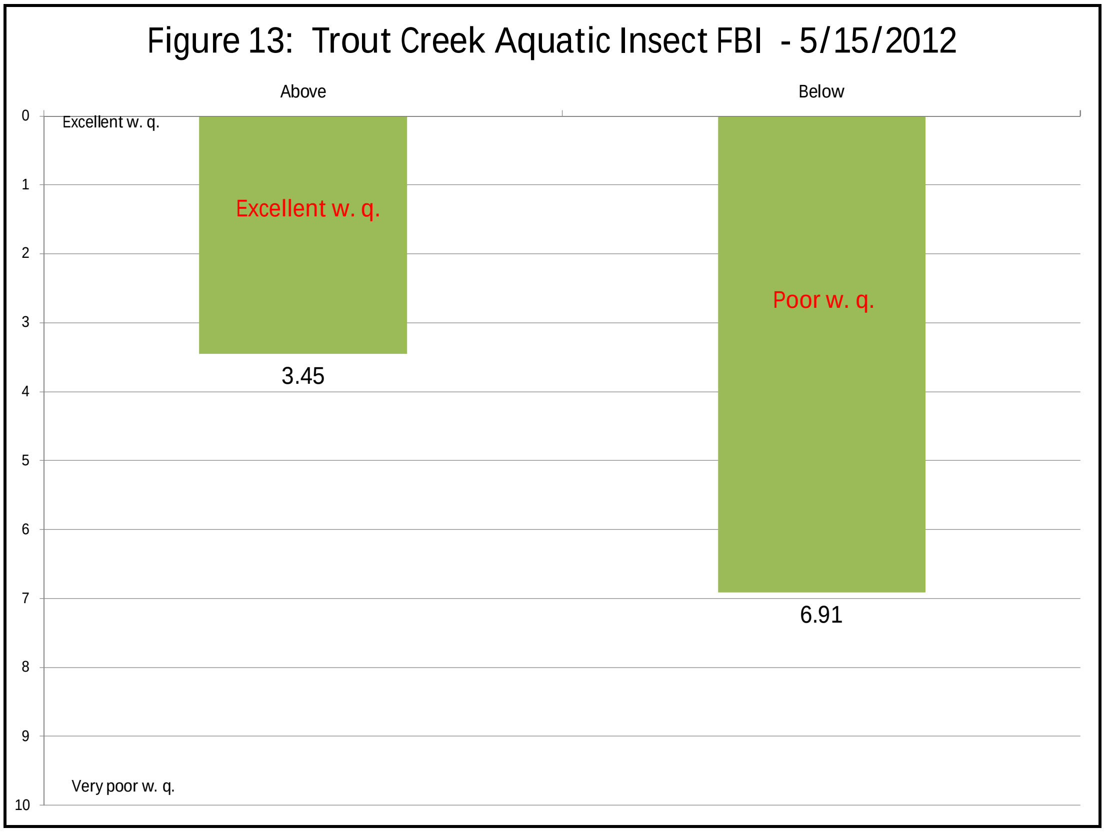


Figure 13: Trout Creek Aquatic Insect FBI - 5/15/2012
Above
Below
Excellent w. q.
Excellent w. q.
Poor w. q.
3.45
6.91
Very poor w. q.
0
1
2
3
4
5
6
7
8
9
10

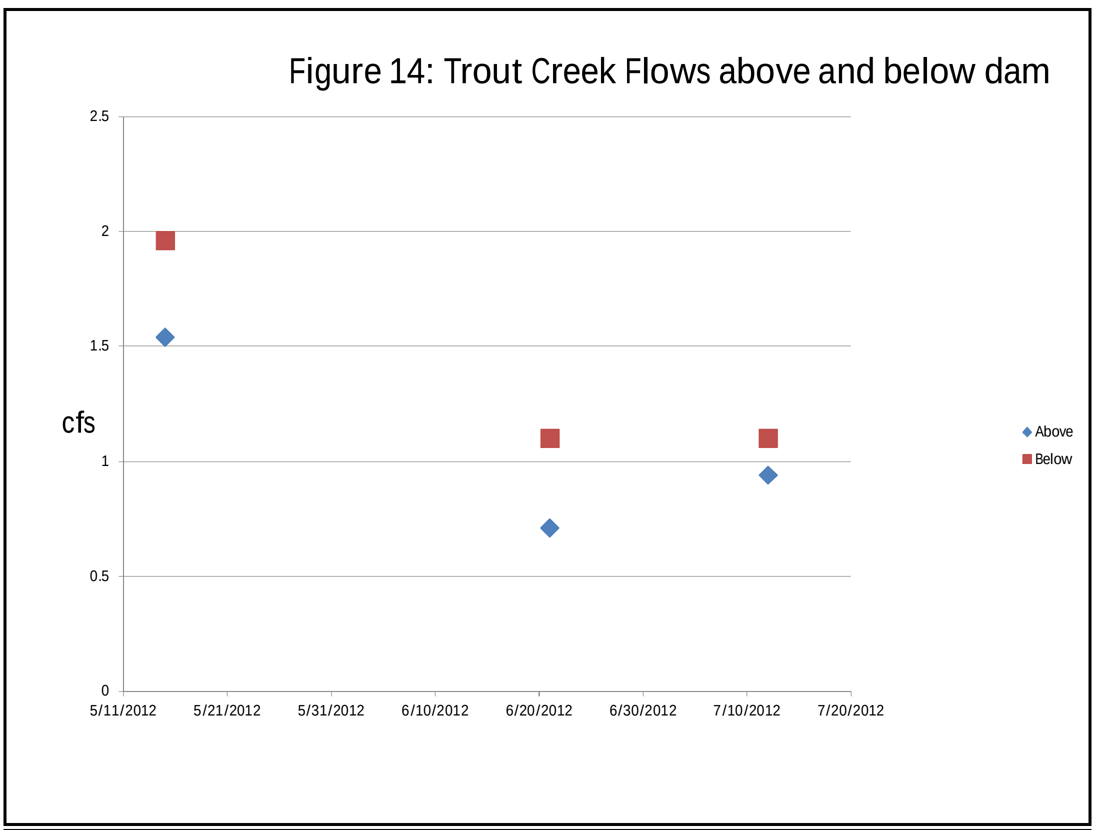


Figure 14: Trout Creek Flows above and below dam
cfs
2.5
2
1.5
1
0.5
0
5/11/2012
5/21/2012
5/31/2012
6/10/2012
6/20/2012
6/30/2012
7/10/2012
7/20/2012
Above
Below

Other biological observations: Wildlife sightings in the lake included Canada geese, mallard ducks, Great blue heron, green frog, and snapping turtle. No Threatened or Endangered species were observed during the surveys.

References

Agrecol Environmental Consulting LLC. 2010. Birch Lake Management Plan.

Cheetham, R.N.Jr. and R.F. Wilke. 1976. Sedimentation in Birch Lake, Iowa County, Wisconsin. Wisconsin Proceedings of the Third Federal Inter-agency Sediment Conference. PB-245 100.

Hilsenhoff, W.L. 1988, Rapid Field Assessment of Organic Pollution with a Family-level Biotic Index. The Great Lakes Entomologist.

Lyons, J, L. Wang and T. Simonson. 1996. Development and Validation of an Index of Biotic Integrity for Coldwater Streams in Wisconsin. North American Journal of Fisheries Management, 16:241-256.

WDNR. 1995. Impoundment Effects on Trout Creek, Iowa Co. Wisconsin.

WDNR. 2001. Coldwater Habitat Evaluation Final Report.

APPENDIX C

PRELIMINARY ALTERNATIVES MATRIX

Conceptual Diversion Alternatives Matrix

Birch Lake Restoration Project – Phase II

	Diversion Objective	Type of Diversion	Size of Pipe/Channel/Berm	Channel/Pipe Conveyance	Performance (% Sediment diverted from Lake)	Cost
Alternative 1	Divert up to 1-year flood event	Channel	• 5' wide channel bottom • 3H:1V sideslopes • 8' wide berm • 3.3' high berm (above normal water surface) • 110' 24" outlet pipe	• Slope = 0.26% • Mannings n = 0.035	58%	$250,000
Alternative 2	Divert up to 1-year flood event	Pipe	• 8' wide embankment over pipe (2' above normal water level surface) • 1250' long 24" diversion pipe from diversion structure to dam outlet structure	• Slope = 0.26% • Mannings n = 0.012	58%	$320,000
Alternative 3	Divert up to 2-year flood event	Channel	• 5' wide channel bottom • 3H:1V sideslopes • 8' wide berm • 4.3' high berm • 110' 48" outlet pipe	• Slope = 0.26% • Mannings n = 0.035	74%	$320,000
Alternative 4	Divert up to 2-year flood event	Pipe	• 8' wide embankment over pipe (2' above normal water level surface) • 1250' long 48" diversion pipe from diversion structure to dam outlet structure	• Slope = 0.26% • Mannings n = 0.012	74%	$400,000
Alternative 5	Divert up to 5-year flood event	Channel	• 5' wide channel bottom • 3H:1V sideslopes • 8' wide berm • 5.8' high berm • 110' 60" outlet pipe	• Slope = 0.26% • Mannings n = 0.035	79%	$420,000
Alternative 6	• Divert up to 5-year flood event	Pipe	• 8' wide embankment over pipe (2' above normal water level surface) • 1250' long 60" diversion pipe from diversion structure to dam outlet structure	• Slope = 0.26% • Mannings n = 0.012	79%	$520,000

APPENDIX D
PRELIMINARY COST ESTIMATES

PRELIMINARY COST ESTIMATE					
BIRCH LAKE BASE FLOW BYPASS					
13-Mar-13					
Alternative 1 - Channel option diverting up to the 1-year event (30 cfs)					
		Estimated		**Unit**	**Total**
Item #	**Item Description**	**Quantity**		**Price**	**Price**
1	Mobilization, Bonds & Insurance	1	LS	$ 5,000.00	$ 5,000.00
2	Clearing and grubbing	1	LS	$ 5,000.00	$ 5,000.00
3	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
4	Diversion berm fill	8300	CY	$ 10.00	$ 83,000.00
5	Swale outlet structure	1	EA	$ 3,000.00	$ 3,000.00
6	24-inch outlet piping	115	LF	$ 75.00	$ 8,625.00
7	Connect to existing lake outlet structure	1	LS	$ 3,500.00	$ 3,500.00
8	Flow Diversion Structure	1	LS	$ 12,000.00	$ 12,000.00
9	RipRap	200	CY	$ 50.00	$ 10,000.00
10	Site Stabilization	1	LS	$ 35,000.00	$ 35,000.00
11	Berm access boardwalk	1	LS	$ 15,000.00	$ 15,000.00
				Construction Subtotal	$ 182,625.00
				Contingencies	$ 27,393.75
				Engineering	$ 36,525.00
				Total Estimate	**$ 246,543.75**

PRELIMINARY COST ESTIMATE							
BIRCH LAKE BASE FLOW BYPASS							
13-Mar-13							
Alternative 2 - Pipe option diverting up to the 1-year event							
		Estimated		**Unit**		**Total**	
Item #	**Item Description**	**Quantity**		**Price**		**Price**	
1	Mobilization, Bonds & Insurance	1	LS	$	5,000.00	$	5,000.00
2	Clearing and grubbing	1	LS	$	5,000.00	$	5,000.00
3	Erosion Control	1	LS	$	2,500.00	$	2,500.00
4	Fill over pipe	3000	CY	$	8.00	$	24,000.00
5	Swale outlet structure	1	EA	$	3,000.00	$	3,000.00
6	30-inch rcp storm sewer	1250	LF	$	95.00	$	118,750.00
7	Connect to existing lake outlet structure	1	LS	$	3,500.00	$	3,500.00
8	Manholes	2	EA	$	2,500.00	$	5,000.00
9	Flow Diversion Structure	1	LS	$	12,000.00	$	12,000.00
10	RipRap	300	CY	$	50.00	$	15,000.00
11	Site Stabilization	1	LS	$	25,000.00	$	25,000.00
12	Berm access boardwalk	1	LS	$	15,000.00	$	15,000.00
				Construction Subtotal		$	233,750.00
				Contingencies		$	35,062.50
				Engineering		$	46,750.00
				Total Estimate		**$**	**315,562.50**

PRELIMINARY COST ESTIMATE					
BIRCH LAKE BASE FLOW BYPASS					
13-Mar-13					
Alternative 3 - Channel option diverting up to the 2-year event (100 cfs)					
		Estimated		**Unit**	**Total**
Item #	**Item Description**	**Quantity**		**Price**	**Price**
1	Mobilization, Bonds & Insurance	1	LS	$ 5,000.00	$ 5,000.00
2	Clearing and grubbing	1	LS	$ 5,000.00	$ 5,000.00
3	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
4	Diversion berm fill	12000	CY	$ 10.00	$ 120,000.00
5	Swale outlet structure	1	EA	$ 4,000.00	$ 4,000.00
6	48-inch outlet piping	115	LF	$ 120.00	$ 13,800.00
7	Connect to existing lake outlet structure	1	LS	$ 5,000.00	$ 5,000.00
8	Flow Diversion Structure	1	LS	$ 12,000.00	$ 12,000.00
9	RipRap	300	CY	$ 50.00	$ 15,000.00
10	Site Stabilization	1	LS	$ 40,000.00	$ 40,000.00
11	Berm access boardwalk	1	LS	$ 15,000.00	$ 15,000.00
				Construction Subtotal	$ 237,300.00
				Contingencies	$ 35,595.00
				Engineering	$ 47,460.00
				Total Estimate	**$ 320,355.00**

PRELIMINARY COST ESTIMATE					
BIRCH LAKE BASE FLOW BYPASS					
13-Mar-13					
Alternative 4 - Pipe option diverting up to the 2-year event					
		Estimated		**Unit**	**Total**
Item #	**Item Description**	**Quantity**		**Price**	**Price**
1	Mobilization, Bonds & Insurance	1	LS	$ 5,000.00	$ 5,000.00
2	Clearing and grubbing	1	LS	$ 5,000.00	$ 5,000.00
3	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
4	Fill over pipe	3000	CY	$ 8.00	$ 24,000.00
5	Swale outlet structure	1	EA	$ 3,000.00	$ 3,000.00
6	48-inch outlet piping	1250	LF	$ 140.00	$ 175,000.00
7	Connect to existing lake outlet structure	1	LS	$ 3,500.00	$ 3,500.00
8	Manholes	2	EA	$ 3,000.00	$ 6,000.00
9	Flow Diversion Structure	1	LS	$ 12,000.00	$ 12,000.00
10	RipRap	300	CY	$ 50.00	$ 15,000.00
11	Site Stabilization	1	LS	$ 25,000.00	$ 25,000.00
12	Berm access boardwalk	1	LS	$ 15,000.00	$ 15,000.00
				Construction Subtotal	$ 291,000.00
				Contingencies	$ 43,650.00
				Engineering	$ 58,200.00
				Total Estimate	**$ 392,850.00**

PRELIMINARY COST ESTIMATE					
BIRCH LAKE BASE FLOW BYPASS					
13-Mar-13					
Alternative 5 - Channel option diverting up to the 5-year event					
		Estimated		**Unit**	**Total**
Item #	**Item Description**	**Quantity**		**Price**	**Price**
1	Mobilization, Bonds & Insurance	1	LS	$ 5,000.00	$ 5,000.00
2	Clearing and grubbing	1	LS	$ 5,000.00	$ 5,000.00
3	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
4	Diversion berm fill	15300	CY	$ 10.00	$ 153,000.00
5	Swale outlet structure	1	EA	$ 5,000.00	$ 5,000.00
6	60-inch outlet piping	115	LF	$ 150.00	$ 17,250.00
7	Connect to existing lake outlet structure	1	LS	$ 7,500.00	$ 7,500.00
8	Flow Diversion Structure	1	LS	$ 12,000.00	$ 12,000.00
9	RipRap	600	CY	$ 50.00	$ 30,000.00
10	Site Stabilization	1	LS	$ 50,000.00	$ 50,000.00
11	Berm access boardwalk	1	LS	$ 15,000.00	$ 15,000.00
				Construction Subtotal	$ 302,250.00
				Contingencies	$ 45,337.50
				Engineering	$ 60,450.00
				Total Estimate	**$ 408,037.50**

PRELIMINARY COST ESTIMATE					
BIRCH LAKE BASE FLOW BYPASS					
13-Mar-13					
Alternative 6 - Pipe option diverting up to the 5-year event					
		Estimated		Unit	Total
Item #	**Item Description**	**Quantity**		**Price**	**Price**
1	Mobilization, Bonds & Insurance	1	LS	$ 5,000.00	$ 5,000.00
2	Clearing and grubbing	1	LS	$ 5,000.00	$ 5,000.00
3	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
4	Fill over pipe	3000	CY	$ 8.00	$ 24,000.00
5	Swale outlet structure	1	EA	$ 3,000.00	$ 3,000.00
6	60-inch outlet piping	1250	LF	$ 200.00	$ 250,000.00
7	Connect to existing lake outlet structure	1	LS	$ 3,500.00	$ 3,500.00
8	Manholes	2	EA	$ 8,000.00	$ 16,000.00
9	Flow Diversion Structure	1	LS	$ 12,000.00	$ 12,000.00
10	RipRap	300	CY	$ 50.00	$ 15,000.00
11	Site Stabilization	1	LS	$ 25,000.00	$ 25,000.00
12	Berm access boardwalk	1	LS	$ 15,000.00	$ 15,000.00
				Construction Subtotal	$ 376,000.00
				Contingencies	$ 56,400.00
				Engineering	$ 75,200.00
				Total Estimate	**$ 507,600.00**

PRELIMINARY COST ESTIMATE					
BIRCH LAKE BASE FLOW BYPASS					
13-Mar-13					
Lake Dredging and Park Improvements					
		Estimated		**Unit**	**Total**
Item #	**Item Description**	**Quantity**		**Price**	**Price**
11	Sediment Removal	5000	CY	$ 6.00	$ 30,000.00
	Engineering and Contingency				$ 10,000.00
				Total	**$ 40,000.00**
12	Channel Dredging	8000	CY	$ 8.00	$ 64,000.00
	Engineering and Contingency				$ 22,000.00
				Total	**$ 66,000.00**
13	Delta Dredging	5000	CY	$ 8.00	$ 40,000.00
	Engineering and Contingency				$ 14,000.00
				Total	**$ 54,000.00**
14	Accessible Fishing Pier	1	LS	$ 45,000.00	$ 45,000.00
	Engineering and Contingency				$ 15,000.00
				Total	**$ 60,000.00**
15	Ballfield Enhancements	1	LS	$ 25,000.00	$ 25,000.00
	Engineering and Contingency				$ 9,000.00
				Total	**$ 34,000.00**