IMPACT of the

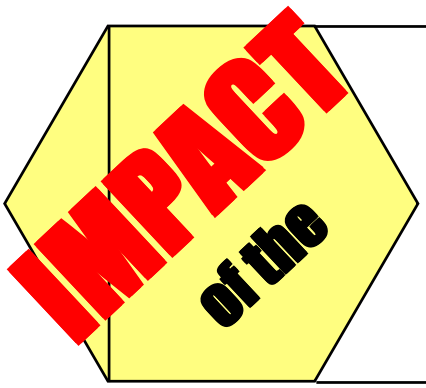
BIRCH LAKE OUTLET DAM on the WATER LEVELS of BIRCH LAKE (11-412) and TEN MILE LAKE (11-413)

Cass County, Minnesota

July 31, 2001

Minnesota
Department of Natural Resources
Waters

October, 2003



BIRCH LAKE OUTLET DAM on the WATER LEVELS of BIRCH LAKE (11-412) and TEN MILE LAKE (11-413)

Cass County, Minnesota

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St. Paul, MN

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I. Introduction

The Birch Lake outlet dam, located in Hackensack, Minnesota, is a small concrete dam used to maintain water levels on Birch Lake (Figure 1). The Birch Lake outlet dam is owned and operated by Cass County and was authorized by a Department of Natural Resources Permit (76-3435). This permit authorized the operation of the dam and defined the conditions of operation.

On July 18, 2001, representatives of Ten Mile Lake Association, Birch Lake Association, Pleasant Lake Association, Cass County and the Minnesota Department of Natural Resources met to discuss concerns related to the Birch Lake outlet dam and water levels on Ten Mile Lake and Birch Lake. At the time of that meeting, Ten Mile Lake water levels were near the highest recorded in 25 years. During the course of that meeting, DNR Waters agreed to conduct a two-year study to investigate the operation of the Birch Lake outlet dam and the effects that dam has on water levels on Ten Mile Lake and Birch Lake. It was also decided that the four-inch stoplog, installed since August 1999, would remain in the Birch Lake outlet dam during the course of the two-year study.

On July 20, 2001, Cass County formally requested that the Birch Lake outlet dam be converted to a fixed crest structure and that the permit be modified to reflect that configuration.

The Primary objective of this study was to:

1. Perform a hydraulic and hydrologic analysis of the Birch Lake outlet dam to determine a non-operable configuration that would approximate the operable configuration as defined by MNDNR Permit 76-3435. This study analyzed several alternative dam configurations.

Secondary objectives of this study were to:

2. Investigate concerns about higher water levels on Ten Mile Lake and determine if the Birch Lake outlet dam affects the water levels of Ten Mile Lake. Address complaints about erosion at Angel Island due to high water levels on Ten Mile Lake.

3. Investigate the feasibility of raising water levels on Birch Lake without negatively impacting water levels on Ten Mile Lake.

4. Address allegations that the Birch Lake outlet dam was constructed at the wrong elevation.

5. Investigate the feasibility of providing fish passage through the Birch Lake outlet dam.

The following constraints were placed on the analyses:

1. Any modifications to the Birch Lake outlet dam to improve water levels on Birch Lake must not adversely affect water levels on Ten Mile Lake.

2. Any modifications to the Birch Lake outlet dam must not significantly change the ordinary high water elevations of either Birch Lake or Ten Mile Lake.

3. Any modifications to the Birch Lake outlet dam must not increase the potential for flooding of properties downstream of Birch Lake.

Birch Lake outlet dam, July 31, 2001.

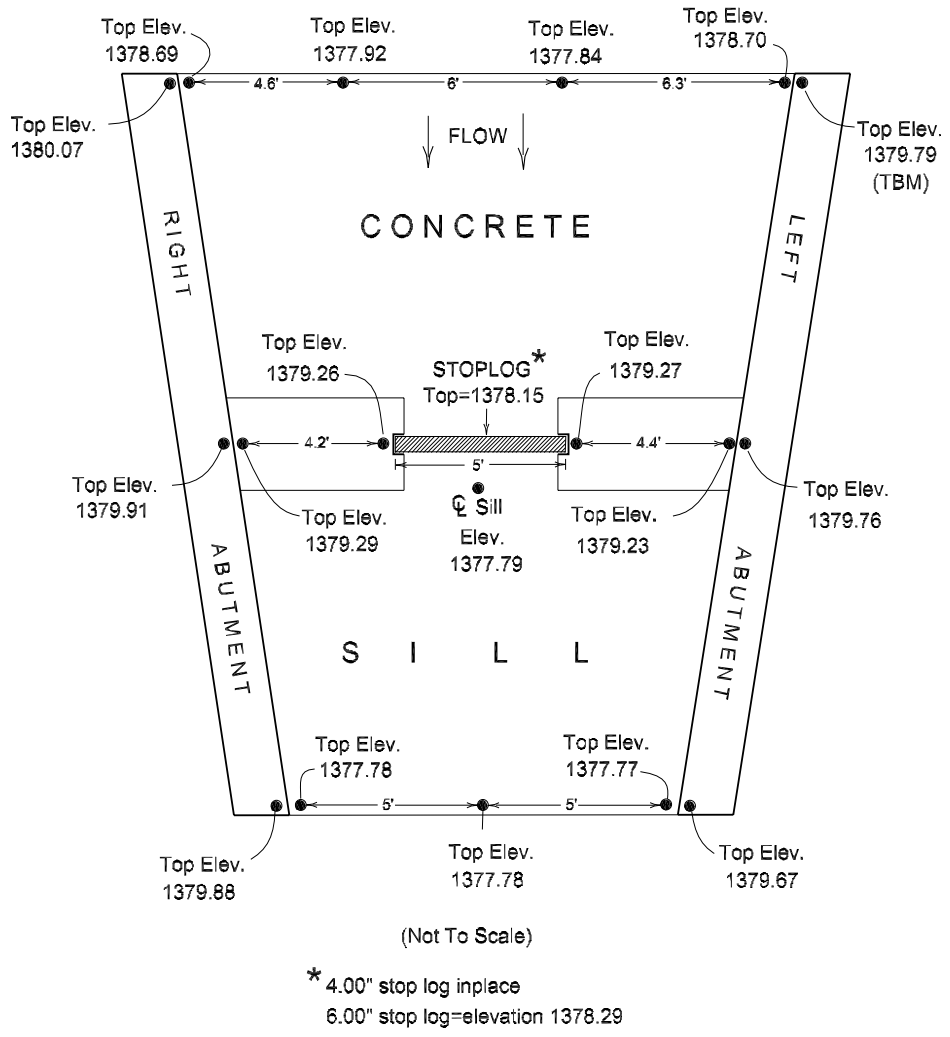


Figure 1. Photograph and plan view of Birch Lake outlet dam; elevations from DNR Waters survey on August 1, 2001.

II. Background Information

A. Hydrologic Setting

Ten Mile Lake and Birch Lake are located in Cass County in north central Minnesota (Figure 2). Both Lakes are part of the Boy River system and are tributary to Leech Lake and the Mississippi River. Ten Mile Lake has a surface area of 7.25 square miles (4640 acres) and a contributing drainage area of 16.3 square miles (10,432 acres). Birch Lake has a surface area of 1.97 square miles (1262 acres) and a direct contributing drainage area of 7.5 square miles (4800 acres). Ten Mile Lake flows into Birch Lake, giving Birch Lake a total contributing drainage area of 23.8 square miles (15,232 acres). As Ten Mile Lake has a larger direct watershed than Birch Lake, a significant portion of the water flowing at the Birch Lake outlet dam are waters that originated in the Ten Mile Lake watershed.

The runout of Birch Lake is normally controlled by the outlet dam. However, during periods of higher water levels, when discharge exceeds 60 cubic feet per second (cfs), outflow is controlled by culverts located approximately 700 feet downstream of the outlet dam.

The runout of Ten Mile Lake is variable. With no stoplog in the Birch Lake outlet dam, the runout of Ten Mile Lake is the high point of the channel bottom under the County Road 6 Bridge. With a four-inch stoplog in the Birch Lake outlet dam, the runout elevation of Ten Mile Lake and Birch Lake are approximately the same. With a six-inch or larger stoplog in the Birch Lake outlet dam, the dam controls the runout of both Birch Lake and Ten Mile Lake. During periods of higher water levels, when outflow from Birch Lake is controlled by the downstream culverts, these culverts also control the outflow of Ten Mile Lake.

During the summer months, when dense vegetation grows in the Boy River between Ten Mile Lake and Birch Lake, the vegetation may control the outflow from Ten Mile Lake. The exact point at which vegetation becomes the hydrologic control for Ten Mile Lake varies from year to year, and is a function of vegetative height and density, the water level of Birch Lake, precipitation, and several other parameters.

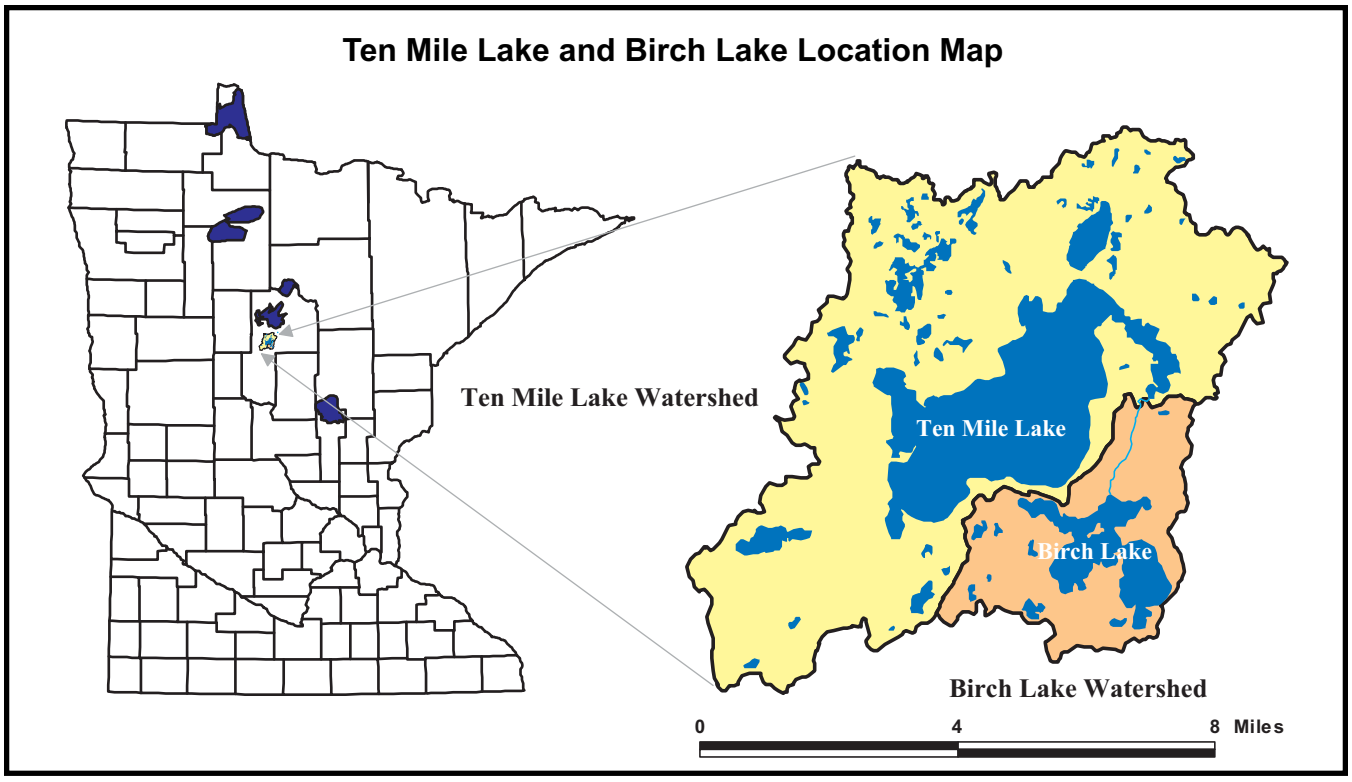


Figure 2. Ten Mile Lake and Birch Lake location map.

B. History of Birch Lake Outlet Dams[1]

Dams have existed at the outlet of Birch Lake in excess of 100 years. The first were timber dams that were used to raise water levels in both lakes so that logs could be floated down from Ten Mile Lake into Birch Lake and to the sawmills and railyard in Hackensack. Real estate agents took advantage of the higher water levels maintained by the early Birch Lake outlet dams to boat up into Ten Mile Lake to sell properties. This ability to boat from Ten Mile Lake to Hackensack was listed as a major selling point for Ten Mile Lake properties

In 1906, a proposal was submitted to the state engineer to combine Birch Lake and Ten Mile Lake into a single lake behind a large concrete dam, with a runout elevation of 1420 feet (project datum), for the purpose of creating a large hydropower reservoir. This project was never constructed.

The first concrete dam was built in 1920. In 1924, the Cass County Board of Commissioners required that the runout of the Birch Lake outlet dam be set at an elevation of 1379.50 feet (datum[2] unknown but MSLD-1912 is assumed; this elevation is equal to 1379.10 feet, NGVD-1929). The first concrete dam, like the timber dams, was used to maintain higher water levels on Birch Lake to allow the passage of boats upstream into Ten Mile Lake. In 1926, a recommendation was made by John T. Stewart, consulting engineer to the Minnesota Game and Fish Department, to lower the Birch Lake outlet dam to 1377.77 (datum unknown, MSLD-1912 assumed). Mr. Stewart concluded as part of his investigation that 1377.77 was the natural runout elevation.

In the early 1920's, dry climatological conditions affected Minnesota, culminating in the severe drought of the 1930's. A lawsuit, contending that the elevation of the Birch Lake outlet dam was withholding water from Pleasant Lake and therefore responsible for lowering lake levels on Pleasant Lake, was heard in United States District Court, Duluth, Minnesota, in 1927. The Court ruled that the lack of water flowing into Pleasant Lake was a result of the ongoing drought and was not related to the elevation of the Birch Lake outlet dam. Shortly after the court decision was issued, the first concrete dam was destroyed by dynamite.

In the spring of 1929, the second dam was constructed. This dam was destroyed by vandalism in the spring of 1930.

In November 1931, a third concrete dam was constructed at the outlet of Birch Lake by the Pleasant Lake Sportsman Association. This dam was destroyed approximately one month later. The dam was rebuilt in the winter of 1932, probably using the same plans.

In 1936, two projects were submitted to the Works Progress Administration, the first to clean the channel of the Boy River between Ten Mile Lake and Birch Lake and the second to build a dam at the outlet of Ten Mile Lake in the vicinity of present day County Road 6. The channel cleaning was done so that water would remain in the channel during periods of no flow, thereby reducing fish mortality. However, there is no evidence that the concrete dam was built at the outlet of Ten Mile Lake as proposed.

In 1958, with the dam in deteriorating condition, funds were requested of the Minnesota Legislature to build a new outlet dam with a 60 foot crest. These funds were not obtained, and the dam was not constructed. In July 1961, the property owner at the Birch Lake outlet dam, Mr. Charles F. Gehl, applied for a permit to repair the dam. Mr. Gehl was informed that no permit was required to repair the dam so long as the repairs did not change the configuration of the dam. Mr. Gehl was also informed that he would need permission from the owner of the dam, Cass County, to do any repairs. The file does not contain any information about what types of repairs were performed, if any, but photos of the structure indicate possible repair to the sidewalls.

1 The history of the Birch Lake outlet dams is derived from DNR Waters files. While these files contain a significant amount of information on the Birch Lake outlet dams, they are not comprehensive. No attempt has been made to research other sources for historical information.

2 The National Geodetic Vertical Datum (NGVD) plane of 1929 is used for most of this report. However, in the early part of the 20th century, other adjustments were used, including the Mean Sea Level Datum (MSLD) of 1912 and assumed datums. Generally, the NGVD-1929 datum plane is 0.40 feet lower than the 1912 datum plane. Therefore, 1379.50 feet MSLD-1912 is equal to 1379.10 feet NVGD-1929. For the remainder of this report, the 1929 datum will be used unless otherwise stated.

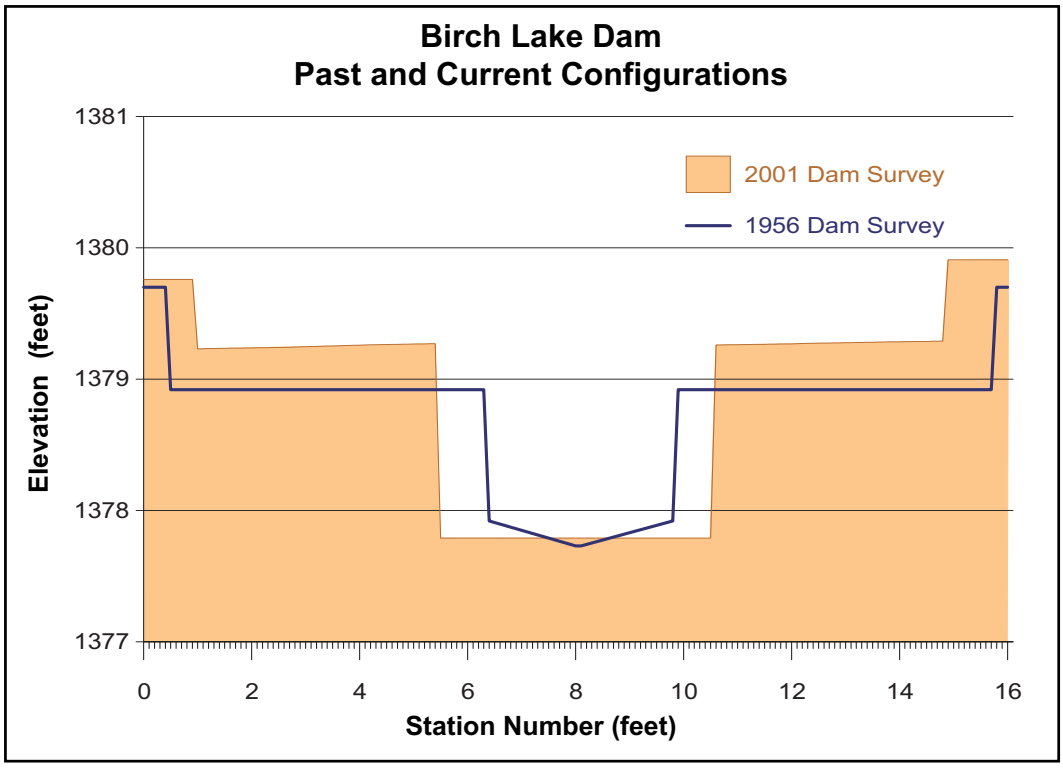


Figure 3. Comparison of existing dam to 1956 configuration.

Figure 3 is a cross-sectional (elevation) view of the fourth Birch Lake outlet dam as surveyed in 1956 and the existing Birch Lake outlet dam as surveyed in 2001.

DNR Waters Permit No. 76-3435

In 1976, Cass County applied for (and was granted) a permit to modify and operate the Birch Lake outlet dam. As part of the 1976 modifications, the dam was widened from 3.5 feet to 5 feet and stoplogs were installed to assist in manipulating water levels. Increasing the width of the dam from 3.5 feet to 5 feet increased the capacity of the dam. Allowing placement of a six-inch stoplog in the dam would slow the decline of lake levels during periods of reduced inflows. In addition, the county requested that the high flow spillways be raised from 1 foot to 1.5 feet above the runout[3]. All modifications were to take place on the existing floor of the dam, using it as the base and retaining the existing sidewalls. A plan for the 1976 modifications and the survey notes from the 1956 survey are reproduced in Appendix A and B, respectively. A copy of the permit, and supporting documentation, is included in Appendix C and D.

The existing Birch Lake outlet dam was constructed as authorized by permit, with the high flow weir being 1.5 feet above the invert of the existing concrete dam. However, there is a conflict with the permit. The permit calls for the high flow weir to be built 1.5 feet above the invert at elevation 1379.42. According to the survey of 1956, an elevation of 1.5 feet above the invert would place the high flow weir at elevation 1379.23. The actual elevation of the high flow weir is 1379.26. Attempts to reconcile the discrepancy between the elevation referred to in the permit and the high flow weir elevation have not been successful. However, during the course of this study, it was determined that there is flow over the high flow weir approximately 2% of the time. Therefore, the impacts of the high flow weir not being constructed to the elevation described in the permit are very small.

The permit also contained an operation plan for the dam. One of the requirements was that in no case shall the stoplog be used when the lake level is above elevation 1378.42. As the elevation of the

3 The runout elevation was surveyed at 1377.73 feet in October, 1956. Establishing the high flow weir 1.5 feet above the runout sets that elevation at 1379.23 feet. A survey of July 2001, obtained an elevation of 1379.25 feet for the left high flow weir and an elevation of 1379.27 feet for the right high flow weir.

Birch Lake outlet dam with the six-inch stoplog in place is 1378.29, the six-inch stoplog could only be used during periods of low or no outflow. The purpose of the six-inch stoplog was to maintain or slow the rate of decline of Birch Lake levels during periods of reduced flows.

Some Birch Lake residents have requested that the six-inch stoplog remain in place continually, while others have requested a higher stoplog be placed into the stoplog bay.

Figure 4 shows three rating curves[4] for three different configurations of the Birch Lake outlet dam. The line starting at elevation 1377.73 (blue) is the rating curve for the original 1932 dam configuration. The line starting at elevation 1378.15 (magenta) is the current dam with the four-inch stoplog installed. The line starting at elevation 1378.35 (red) represents an approximate rating curve if the dam is operated by the conditions stated in the permit.

C. Recorded Lake Levels

Ten Mile Lake

Lake levels on Ten Mile Lake have been recorded since 1973 as part of the Lake Level Minnesota Program. Under this program, a staff gage is installed each spring in the lake and surveyed to a known elevation. The lake gage is then read, usually weekly but more often during rainfall events, by the lake gage reader who then submits the data to DNR Waters for archival.

The highest water level recorded as part of the Lake Level Minnesota program for Ten Mile Lake was 1380.23 on June 14, 2001. However, evidence of higher water levels does exist. During an Ordinary High Water Level (OHWL) investigation performed by DNR Waters in 1982, the surveyors recorded faint stain marks at elevation 1380.4, and the base of an ice ridge at elevation 1380.9.

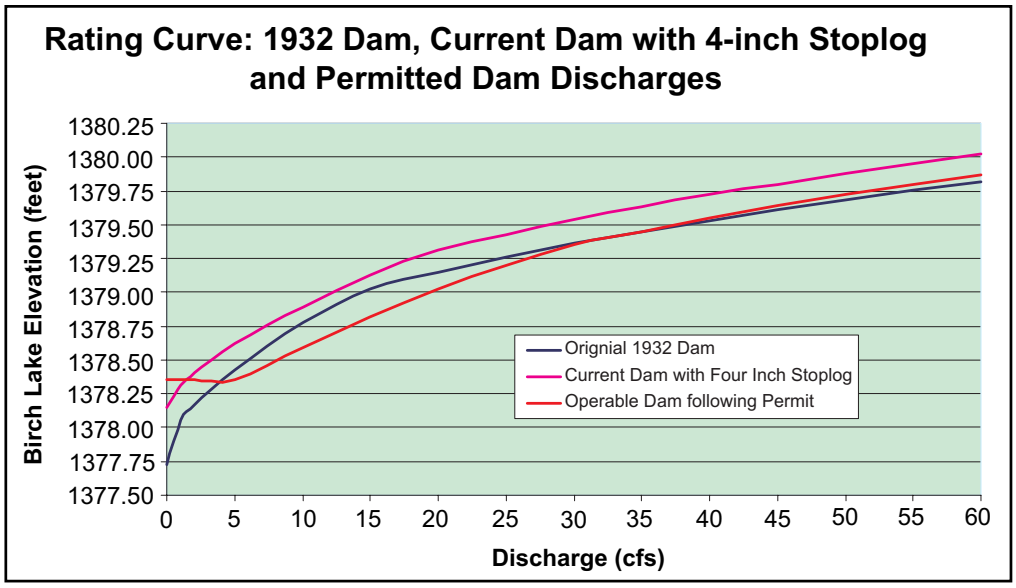


Figure 4. Rating curve for the original dam, current dam and permitted dam.

4 A rating curve is a graph of stage or elevation versus flow or discharge. Rating curves are used to obtain the volume of water flowing past a specific point based on a known water surface elevation.

The lowest water level recorded on Ten Mile Lake was 1376.92, on October 11, 1936, during a survey by the Minnesota Department of Conservation. Historical information available suggests that Ten Mile Lake has fallen significantly lower than this elevation. During the drought of the 1920's and 1930's, Ten Mile Lake residents reported that there were long periods in which there was no outflow from Ten Mile Lake.

Figure 5 shows the historical water levels for Ten Mile Lake and Birch Lake. Water level information on other area lakes, including period of record, number of readings, range, minimum, maximum, and average level are included in Appendix E.

Birch Lake

Lake levels for Birch Lake have been recorded on a regular basis as part of the Lake Level Minnesota Program since 1991. A few additional lake readings have been obtained from other sources and have been added to the database.

Since 1991, the highest water level recorded for Birch Lake was 1380.01 on June 14, 2001. However, an old washline was observed at elevation 1381.1 by a DNR Waters survey crew during an OHWL investigation performed on May 21, 1982. Additional staining was observed at 1380.0 during this same investigation.

Since 1991, the lowest recorded water level was 1377.83 on August 27, 1994. Historically, the level of Birch Lake has been significantly lower. A survey of October 11, 1936, obtained an elevation of 1375.32. Photographs from the 1920's and 30's show water levels approximately four to five feet below the runout elevation of the dam. Unfortunately, there are no reported water levels on the day the photos were taken.

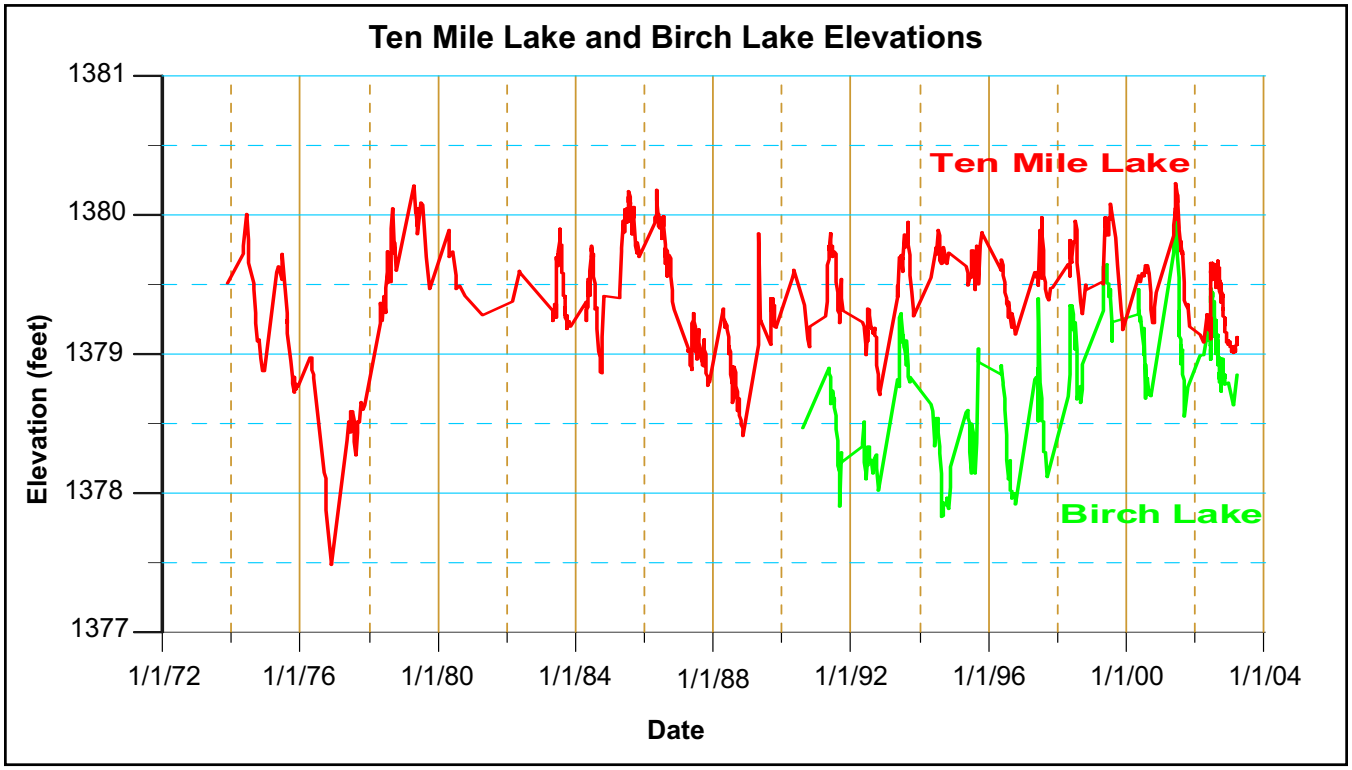


Figure 5. Period of record hydrograph for Ten Mile Lake and Birch Lake. Data from Lake Level Minnesota program.

D. Ordinary High Water Levels

Figure 6 shows the reported annual range of water levels and the average annual level (hatch mark on bar) for Ten Mile Lake and Birch Lake. During the 27-year period of record, water levels for Ten Mile Lake are generally in the 1379 to 1380 range, except for the drought years of 1976-77 and 1987-88.

The ordinary high water level (OHWL) represents an elevation where vegetation changes from predominantly aquatic to predominantly terrestrial. An OHWL is a mark left on the landscape that is a result of long term water levels, usually several decades or longer. Peak water levels of short duration will

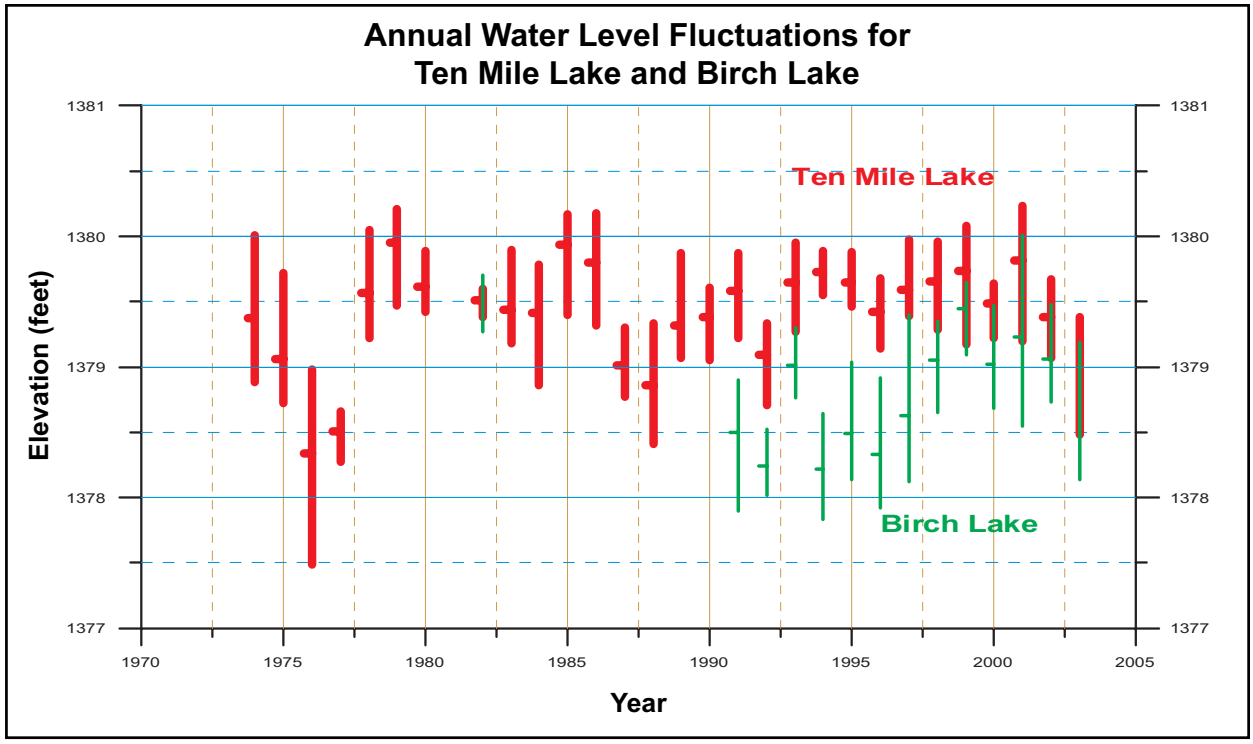


Figure 6. Annual variation in water levels for Ten Mile Lake and Birch Lake. The hatch mark on the bar represents the average annual elevation. Data from Lake Level Minnesota program.

For Birch Lake, the period of record is only 13 years. Water levels for the first seven years (1991 to 1997) generally fall between 1378.00 and 1379.25 feet, while the levels in the past six years (1998 to 2003) generally fall between 1378.50 and 1379.50 feet. This increase in water levels in recent years is likely due to a combination of factors, including increased precipitation, higher ground water levels, changing from an operable dam to a non-operable dam, and raising the runout from 1377.84 to 1378.15 by placing a four-inch stoplog in the dam.

exceed the OHWL. The ordinary high water levels are 1379.9 for Ten Mile Lake and 1379.4 for Birch Lake.

A constraint defined early in this study is that any changes recommended for the Birch Lake outlet dam could not significantly change the OHWL in either lake. Changing the OHWL can result in changes in the vegetation on shoreland properties, increased bank and shoreland erosion and altering of fish and wildlife habitat.

III. Hydrologic and Hydraulic Analysis

A. BACKGROUND INFORMATION

Precipitation

Precipitation data has been recorded at the Leech Lake dam since 1885 and at Walker since 1907. Figure 7 shows the annual precipitation for the Ten Mile Lake area since 1900. Also shown in Figure 7 are the average annual precipitation for the period of record and the 30-year moving average annual precipitation.

The average annual precipitation since 1900 is 25.68 inches. Climatologists use a 30-year period, starting each decade, to denote "average" climatic conditions. The current 30-year period, from 1971 to 2000, had an average precipitation of 27.58 inches. In the last 30 years, since 1973, the average precipitation has increased to 28.20 inches.

Since 1980, the Ten Mile Lake / Birch Lake area has received approximately 56.4 inches (4.70 feet) of rainfall in excess of the long-term (1900-2002) average. Since 1990, the area has received approximately 28.8 inches (2.40 feet) of precipitation in excess of the long-term average.

Evaporation

Evaporation appears to be the largest source of water loss on Ten Mile Lake. During the summer months, evaporation rates approach 0.25 inches per day. On a lake the size of Ten Mile, evaporation of 0.25 inches/day is equivalent to losing almost 50 cubic feet per second (cfs) of water. In comparison, during these same summer months, outflow into the Boy River from Ten Mile Lake is approximately 5 to 10 cfs.

For Birch Lake, the summer evaporation rate of 0.25 inch/day corresponds to a loss of approximately 13 cfs. 13 cfs is also the approximate summer discharge from the Birch Lake outlet dam during the two-year study period. With an inflow of only 5 to 10 cfs from Ten Mile Lake, little inflow from the Birch Lake watershed, and a loss rate of around 26 cfs, the water levels of Birch Lake would be expected to decline.

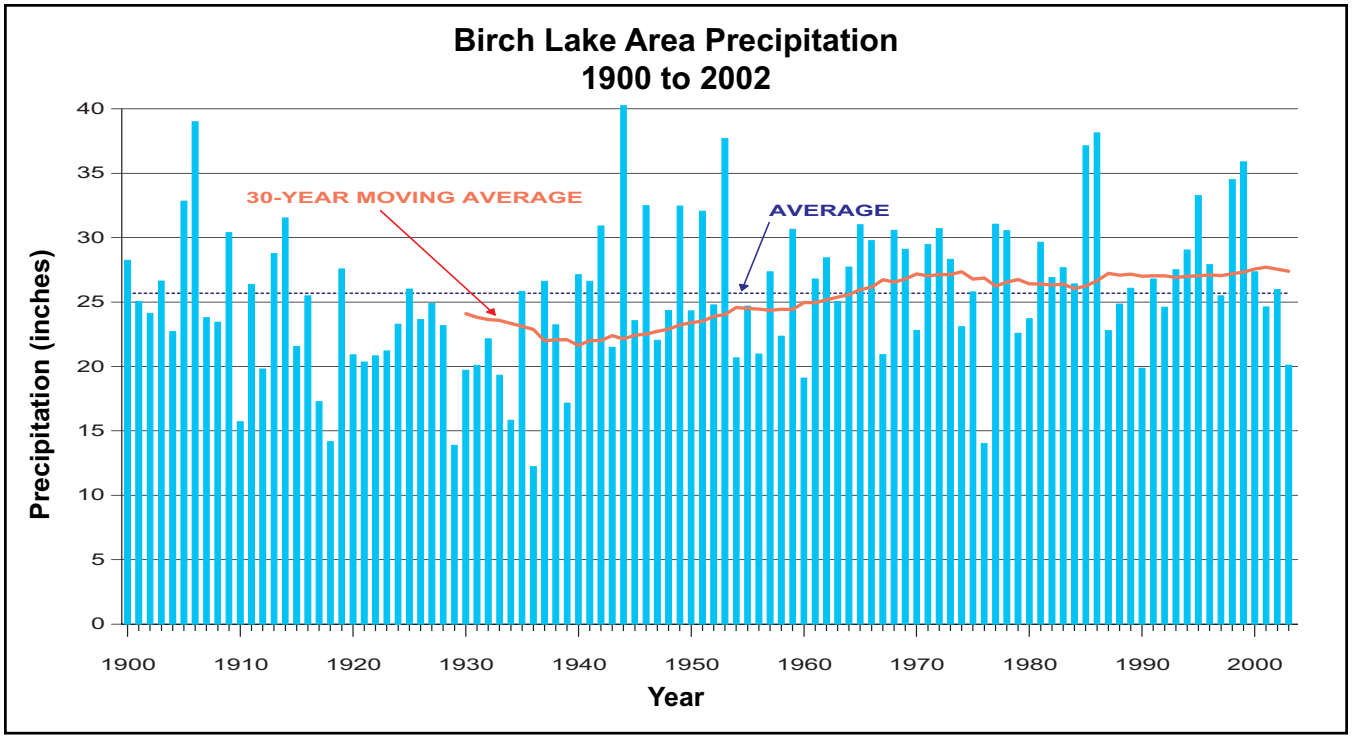


Figure 7. Annual precipitation for the Birch Lake/Ten Mile Lake area, average precipitation since 1900 and the 30-year moving average.

Ground Water

A regional ground water contour map was created for the study area using approximately 150 known water surface elevations. These elevations were imported into the ground water modeling program MLAEM[5], and used to calculate an approximate ground water surface. Figure 8 shows the calculated ground water contours as well as the approximate ground water flow directions for the area.

5 MLAEM, for Multi Layer Analytical Element Model, is a ground water modeling program developed by Professor Otto Strack at the Department of Civil and Geological Engineering, University of Minnesota.

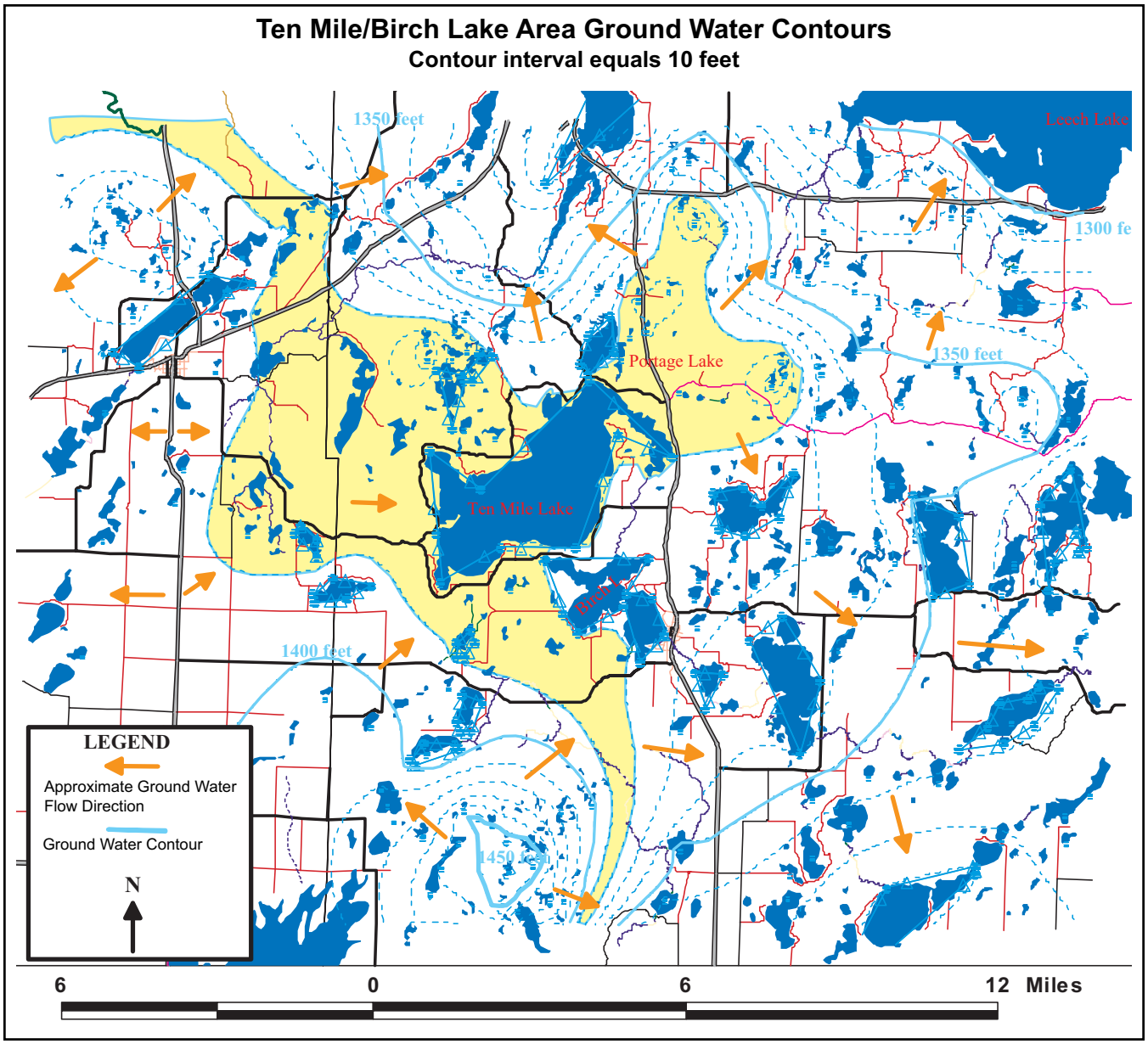


Figure 8. Approximate ground water elevations in the Birch Lake / Ten Mile Lake area.

Ground water enters Ten Mile Lake and Birch Lake predominantly from the west, with some flow coming from the northwest and southwest. Ground water outflows Ten Mile Lake and Birch Lake to the east and northeast. Some ground water, especially at Ten Mile Lake, is also converted to surface water and flows out of the area through the Boy River or evaporates.

Ten Mile Lake and Birch Lake are situated on a "ground water bench"[6] that extends to the northeast from a ground water high located in the southwest. To help identify this bench, the ground water elevation range from 1380 to 1390 is highlighted in yellow. To the southwest, substantially higher ground water levels result in flow toward Ten Mile Lake and Birch Lake, while to the northeast, ground water levels drop rapidly toward Leech Lake.

There are no observation wells in the area around Ten Mile Lake and Birch Lake. However, Portage Lake, a landlocked lake located northeast of Ten Mile Lake, and situated on the ground water bench, can be used to emulate ground water levels. Figure 9 is a graph of the water levels on Portage Lake since 1990. In 1992, the water levels on Portage Lake started rising from an elevation near 1375 feet, to approximately 1380 feet by 2000. The elevation of the ground water bench around Ten Mile Lake and Birch Lake is assumed to follow the levels on Portage Lake. However, Ten Mile Lake and Birch Lake have a surface water outlet. Therefore, as ground water levels adjacent to Ten Mile Lake and Birch Lake rise, some of that ground water is converted to surface water and flows into the Boy River, resulting in increased flows in the Boy River and at the Birch Lake outlet dam. This outflow through the Boy River has prevented the elevations of Ten Mile Lake and Birch Lake from rising like Portage Lake.

North of Ten Mile Lake is the Itasca Moraine, a clay-rich feature of glacial sediments trending east-west that helps sustain the levels on Ten Mile Lake, Birch Lake and Portage Lake. During dry periods, the ground water levels on the bench decline, as do the levels of Ten Mile Lake, Birch Lake and Pleasant Lake.

[6] A ground water bench is an area of low gradient (relatively flat ground water surface) with areas of higher gradient on each side.

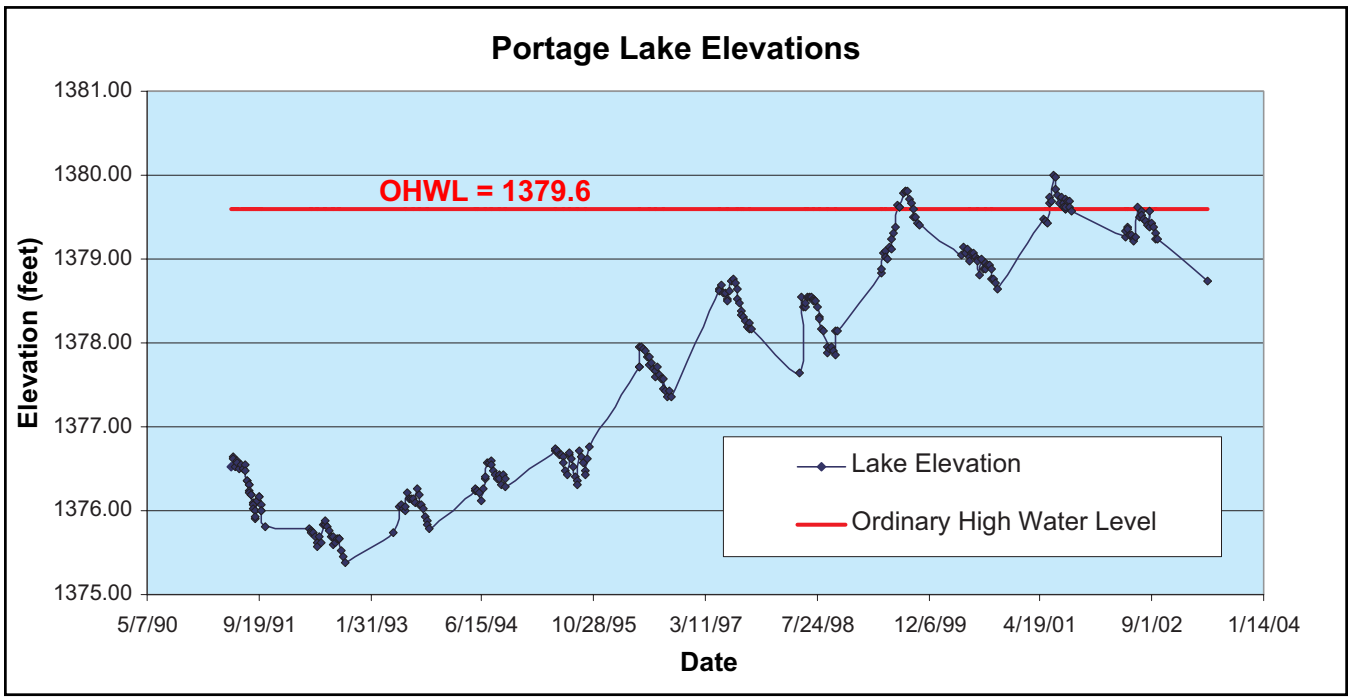


Figure 9. Period of record hydrograph - Portage Lake (11 - 476).

B. DATA COLLECTION

Birch Lake and Ten Mile Lake Dataloggers

To gain a better understanding of the hydraulic[7] and hydrologic response of the Boy River system from Ten Mile Lake through Birch Lake, DNR Waters surveyed the elevations of both lakes, the Boy River channel from Ten Mile Lake to approximately 900 feet downstream of the Birch Lake outlet dam, and numerous cross sections along the course of the river. These cross sections were necessary components of the surface water model that was created.

To accurately model the response of the Birch Lake outlet dam to various precipitation events, dataloggers were installed on each lake on May 5, 2002 and set to record water level elevations every 30-minutes. The datalogger on Ten Mile Lake recorded 30-minute data nearly continuously through July 8, 2003.

The datalogger at Birch Lake also provided 30-minute data. However, during the winter of 2002-03, the datalogger probe produced inaccurate data. As a result, no reliable stage data was obtained for Birch Lake from December 21, 2002 to April 15, 2003. A graph showing all of the datalogger data and observed lake elevations during the course of the study appears in Appendix G.

7 Hydrology refers to the study of water while hydraulics refers to the study of the properties of the earth that control the water, such as channel shape, slope, substrate, roughness, etc.

Stream Flow Measurements and Boy River Stage Information

Approximately every six weeks, staff from DNR Waters recorded the water surface elevations and measured the discharges from Ten Mile Lake and Birch Lake. A table showing the measured water levels and discharges can be found in Appendix F. Figure 10 is a hydrograph of the observed water levels during those visits. This graph shows that Ten Mile Lake and Birch Lake approach a common elevation in late winter and then separate in the spring due to increased runoff from snow melt and spring rains. When the snow melt has passed, and spring rains diminish in volume, the elevation of Birch Lake declines. Ten Mile Lake continues to receive snow melt and precipitation runoff for a longer period of time than Birch Lake due to the larger size of its direct drainage area and the increased distance runoff waters must travel. As a result, the peak stage related to runoff for the two lakes is approximately six weeks apart, with Birch Lake normally peaking in May and Ten Mile Lake peaking in early July.

Stream flow measurements were also made during most site visits. Figure 10 shows a stage and discharge hydrograph for Ten Mile Lake and Birch Lake for the two year study period. The stage and discharge[8] (Figure 10) hydrographs are very similar, as expected.

Ten Mile Lake has no appreciable tributary streams. Water is received into Ten Mile Lake by direct precipitation, runoff from the Ten Mile Lake watershed and ground water flow. During wet periods, several small lakes north and northwest supply additional surface waters to Ten Mile Lake through interflow and near surface ground water flows.

8 While most points on Figure 10 are actual discharge measurements, a few points were obtained from rating curves. Rating curves were used when it was not possible to perform a discharge measurement.

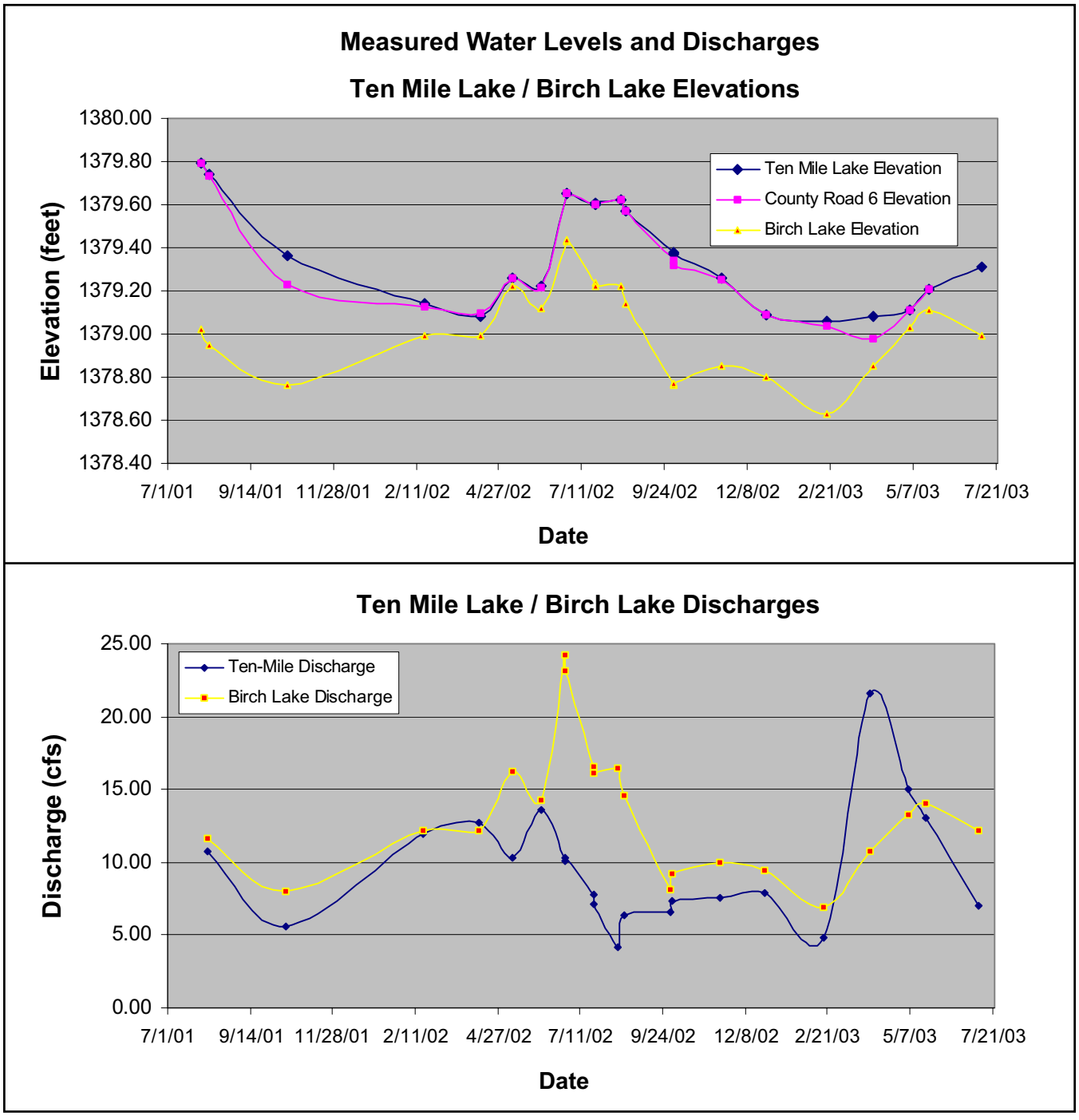


Figure 10. Measured water levels and discharges for Birch Lake and Ten Mile Lake.

Birch Lake receives water from four main sources: 1) direct precipitation on the lake; 2) surface water flowing into Birch Lake from Ten Mile Lake; 3) runoff from the Birch Lake sub-watershed and 4) ground water flow. During the course of this study, it was determined that approximately 70% of the water flowing at the Birch Lake outlet dam is water from the Ten Mile Lake watershed. This "pass through" water is important for maintaining the level of Birch Lake. It was also observed during this study that the level of Birch Lake drops rapidly when these "pass through" waters are interrupted.

The interruption of "pass through" waters was observed on three occasions. In the summers of 2001 and 2002, the Boy River became choked with aquatic vegetation, reducing outflow from Ten Mile Lake. As a result of this vegetation, Ten Mile Lake maintained relatively high summer levels (Figure 10). The vegetation also reduced the volume of water entering Birch Lake causing the level of Birch Lake to fall. As the channel vegetation died off in early autumn, the level of Ten Mile Lake fell and the level of Birch Lake quickly rose due to the increased inflow.

The third interruption of "pass through" waters occurred late in the winter of 2003. In that case, it was observed that the Boy River at County Road 6 had almost completely frozen, and no flow was observed through the ice at the site. However, flows continued out of Birch Lake as open water could be found at the dam. With very little inflow and continued outflow, the level of Birch Lake receded. In early April, as the Boy River started flowing again with the return of warmer weather, the level of Birch Lake rose due to the increased inflows.

The measured discharges from Birch Lake were also used to create a rating curve for the Birch Lake outlet dam (Figure 11). As stated earlier in this report, a rating curve allows a known elevation (water level) to be converted to a discharge (water volume per unit time). By converting level to discharge, it is possible to do a variety of hydraulic and hydrological analyses including mass balance, momentum and energy grade calculations. A rating curve is also important in that it allows for the calibration of computer models using observed discharges. All computer models of the Boy River system were calibrated against the Birch Lake outlet dam rating curve.

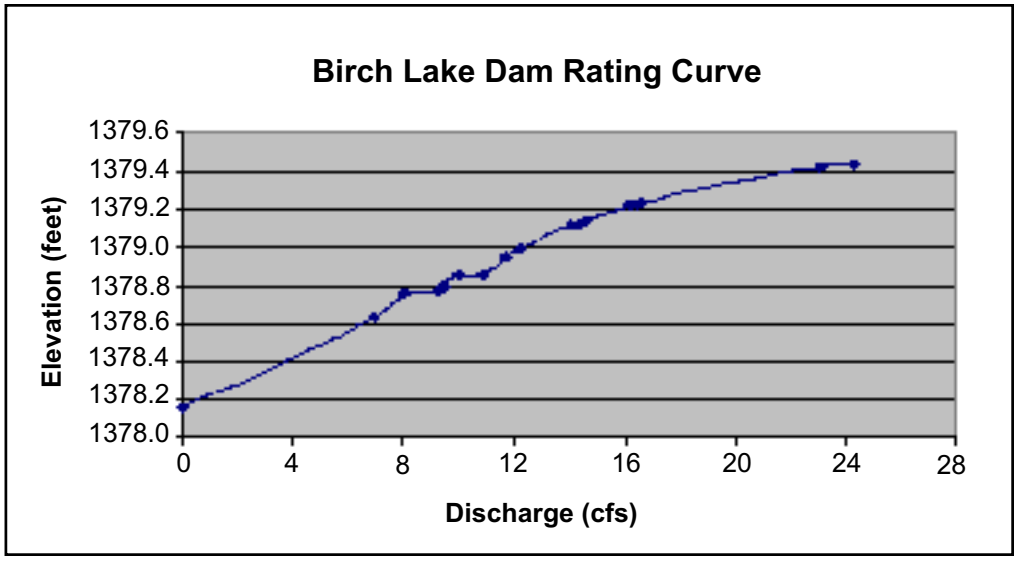


Figure 11. Birch Lake dam rating curve with a four-inch stop log in place.

Computer Modeling

Early in the course of this study, a computer model of the Boy River system was created using the U.S. Army Corps of Engineers modeling program HEC-RAS (for Hydrologic Engineering Center - River Analysis System). A HEC-RAS model was created during the winter of 2001-2002, and then calibrated to the observed water levels found on Birch Lake and Ten Mile Lake and to the discharges observed on the Boy River during the spring of 2002.

As the summer progressed, the observed conditions were compared to the modeled results. Almost immediately, the observed conditions departed from the results predicted by the model. Further investigation showed that the emergent vegetation in the Boy River between Ten Mile Lake and Birch Lake had reduced flows out of Ten Mile Lake and caused Ten Mile Lake level to rise.

would back up from the culverts, causing high tailwater conditions at the dam. High tailwater conditions would reduce the discharge capacity of the dam. To further understand the effects of channel vegetation and the different stoplog elevations of the dam, a second flow model was created and calibrated to a storm observed on June 22, 2002. (The calibration hydrograph is that part of the hydrograph in Appendix G, from June 20 to July 7, 2002.)

The first adjustment to the model was to simulate various friction factors related to channel vegetation in the Boy River between County Road 6 and Birch Lake. Manning's *n* value, a measure of channel roughness (and vegetation), was adjusted from 0.036 for clean channel conditions, to 0.101 for a moderately choked channel, to 0.202 for a completely choked channel. Figure 12 shows the expected elevations on Ten Mile Lake and Birch

	Birch Lake			Ten Mile Lake		
Vegetative Conditions	Low n = 0.036	Moderate n = 0.101	Dense n = 0.202	Low n = 0.036	Moderate n = 0.101	Dense n = 0.202
No stoplog	1379.20	1379.21	1379.21	1379.35	1379.54	1379.91
Four-inch	1379.47	1379.47	1379.47	1379.59	1379.72	1380.01
Six-inch	1379.63	1379.63	1379.63	1379.73	1379.84	1380.08
n = Manning's Roughness Coefficient; Observed Conditions: Four-inch Stoplog n = 0.101						

Figure 12. Modeled and observed peak water levels for Birch Lake and Ten Mile Lake using the storm of June 22, 2002.

The model was continually adjusted to match the changing level and flow conditions. By August, 2002, the model indicated that there was an approximate reduction of 80% in channel capacity due to the growth of channel vegetation. Stream flow measurements of 4.16 cubic feet per second (cfs) and 6.32 cfs were obtained in August 2002. The expected discharges, based on the elevations of Ten Mile Lake and a clean channel configuration, would have been around 40 cfs.

The model also indicated that, at a discharge of 60 cfs, the culverts approximately 700 feet downstream of the Birch Lake outlet dam would become submerged. At flows greater than 60 cfs, water

Lake for the observed conditions (four-inch stoplog), and for the modeled conditions of no stoplog in the dam and a six-inch stoplog in the dam, based on the different vegetative conditions. Figure 12 shows that the expected peak water levels on Birch Lake are a function of the stoplog elevation. The peak storm elevation of Birch Lake will change with stoplog height, as will the peak elevation of Ten Mile Lake. For clean channel conditions, n=0.036, the peak elevation on Birch Lake will increase from 1379.20 for no stoplog to 1379.63 for a six-inch stoplog (a change of 0.43 feet, or approximately 5.22 inches). Different vegetative conditions in the Boy River upstream of Birch Lake have little impact on the peak storm elevation at Birch Lake.

For the same storm and clean channel conditions, Ten Mile Lake would have a peak elevation of 1379.35 for no stoplog and a peak elevation of 1379.73 with a six-inch stoplog installed. This represents an increase in peak elevation of 0.38 feet or 4.60 inches. Clearly, the Birch Lake outlet dam affects the elevation of Ten Mile Lake.

With increasing vegetation, the peak level of Birch Lake is unaffected. However, the peak level on Ten Mile Lake rises even more dramatically, as can be seen when the six-inch stoplog is modeled with dense vegetation (N=0.202). Comparing the elevation of Ten Mile Lake with a clean channel condition and no stoplog to a condition with a six-inch stoplog and dense vegetation results in a peak stage of 1380.08 ft, an increase in almost 9 inches. (Note, the results shown for the four-inch stoplog with moderate vegetation (n=0.101) are both the observed elevations, and the elevations to which the model was calibrated.)

While channel vegetation had no affect on the peak elevation of Birch Lake, the elevation of Birch Lake is affected by the channel vegetation. As seen in Figure 13, vegetation in the Boy River channel upstream of Birch Lake reduces the inflow to Birch Lake during the summer months. The storm event of June 22, 2002 was of sufficient magnitude that the peak was unaffected. However, several days after the storm peak, channel vegetation reduced the inflow into Birch Lake, causing the lake to decline to a lower level. This scenario simulated the interruptions of “pass through” waters observed during the summers of 2001 and 2002.

Figure 13 are two output hydrographs from HEC-RAS and shows the modeled elevations of Ten Mile Lake and Birch Lake based on the three vegetative conditions.

The top of Figure 13 shows the modeled water levels of Ten Mile Lake while the lower graph shows the modeled water levels on Birch Lake. The center line (blue) denoting elevation on each graph is the approximate observed elevation. Referring to the lower graph, the peak Birch Lake elevation on June 25 due to the storm is approximately the same elevation for each of the channel conditions. Channel vegetation had little affect on the peak elevation of Birch Lake.

Note the two lines connecting the two hydrographs; one line labeled “No Channel Vegetation” and the other labeled “Dense Vegetation”. As can be seen on the graphs, when no vegetation exists in the Boy River channel, water quickly flows out of Ten Mile Lake and into Birch Lake. This process maintains a lower level on Ten Mile Lake while sustaining a higher level on Birch Lake. During periods of “Dense Vegetation”, the volume of water flowing out of Ten Mile Lake is reduced, thereby causing the lake level to rise. With less water flowing out of Ten Mile Lake, the elevation of Birch Lake drops.

While the channel vegetation on the Boy River may occasionally have negative impacts on the water levels of Birch Lake and Ten Mile Lake, it also has many positive impacts, including filtering waters coming out of Ten Mile Lake and supplying fish and wildlife habitat for both lakes. Dredging of the channel, which had been done in the past, would have many detrimental affects on both Birch Lake and Ten Mile Lake and could result in significantly lower levels on both lakes.

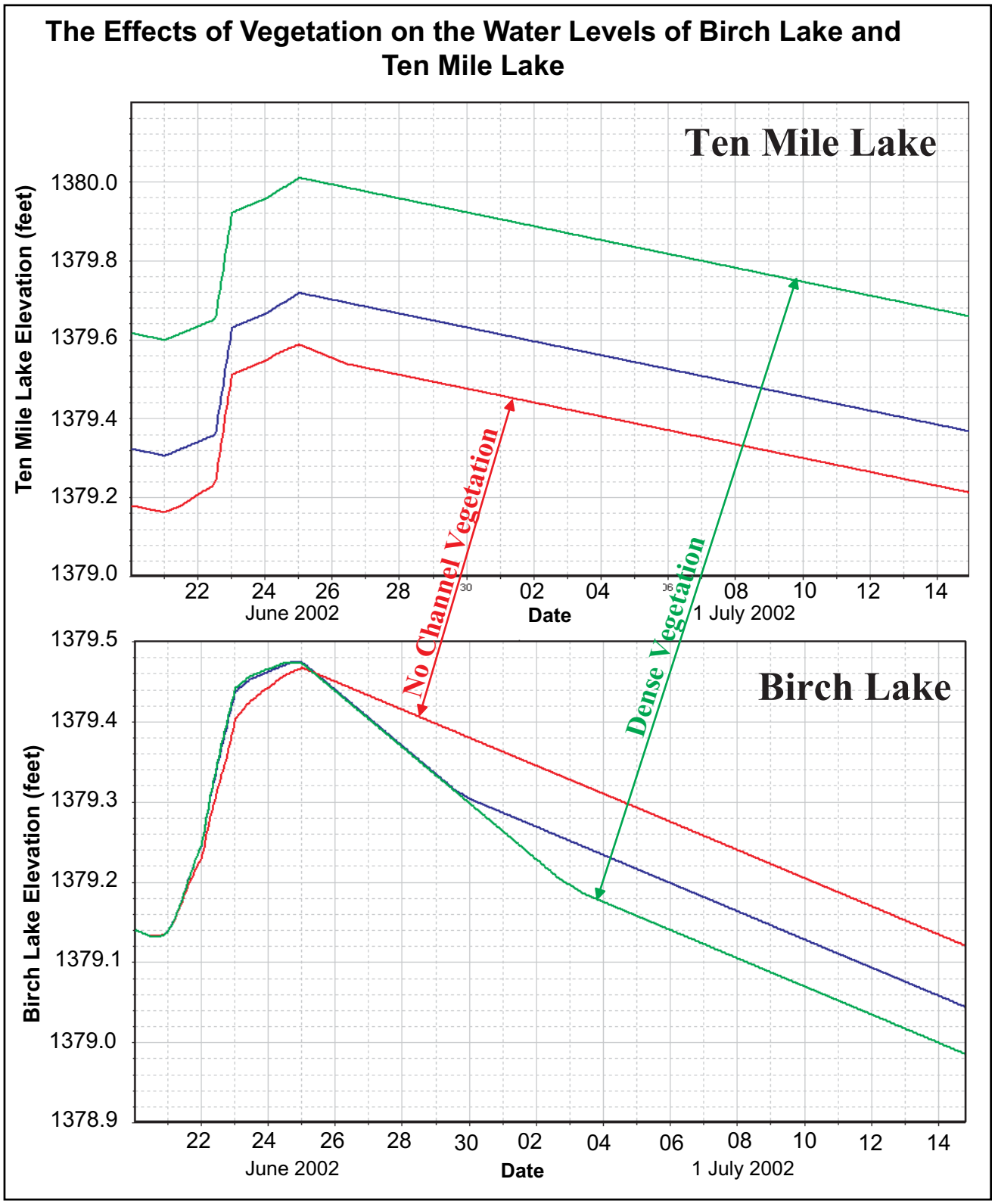


Figure 13. HEC-RAS output showing the expected water of Birch Lake and Ten Mile Lake for three different channel vegetative conditions.

D. Modifications to the Birch Lake Outlet Dam

After review of the original objectives of the study and careful analysis of the hydraulic and hydrologic conditions related to the Boy River system and the Birch Lake dam, a variety of solutions were considered. The solutions were geared towards reducing the outflow capacity of the Birch Lake outlet dam at low flows, so as to slow the rate of decline of the Birch Lake water levels and sustain flow in the Boy River channel downstream of Birch Lake for longer periods of time. Reducing the capacity of the Birch Lake outlet dam during periods of low flow would also reduce the impacts when "pass through" waters from Ten Mile Lake were interrupted.

Computer models were used to simulate a variety of changes to the Birch lake outlet dam to obtain a configuration that had the least impact on each lake. Changes to the Birch Lake outlet dam fell into two categories. The first category consisted of modifications to the size and shape of stoplogs contained within the existing 5-foot stoplog bay. The second category consisted of completely removing the control section[9] of the Birch Lake outlet dam and replacing it with a new structure built on the existing concrete floor. The existing sidewalls, wingwalls and floor would be retained in the new design. In all, approximately 70 different designs and modifications for the Birch Lake outlet dam were modeled.

All changes to the Birch Lake outlet dam had to met the constraints established earlier in this report.

Several different size and shape stoplogs were modeled. Six-inch or larger stoplogs produced very high water levels on Ten Mile Lake during moderate storms. Several different trapezoidal shapes were also modeled in the 5-foot bay, including V-notched weirs of different heights and angles. Due to the small size of the 5-foot bay, the variety of V-notched weirs modeled produced results very similar to the four-inch stoplog. However, a four-inch stoplog is not a desirable solution, as it increases the elevation of Ten Mile Lake during periods of higher flows and does not help alleviate problems created when "pass through" waters are interrupted.

9 The control section is defined as the concrete part of the dam that contains the high flow weir and the 5-foot stoplog bay.

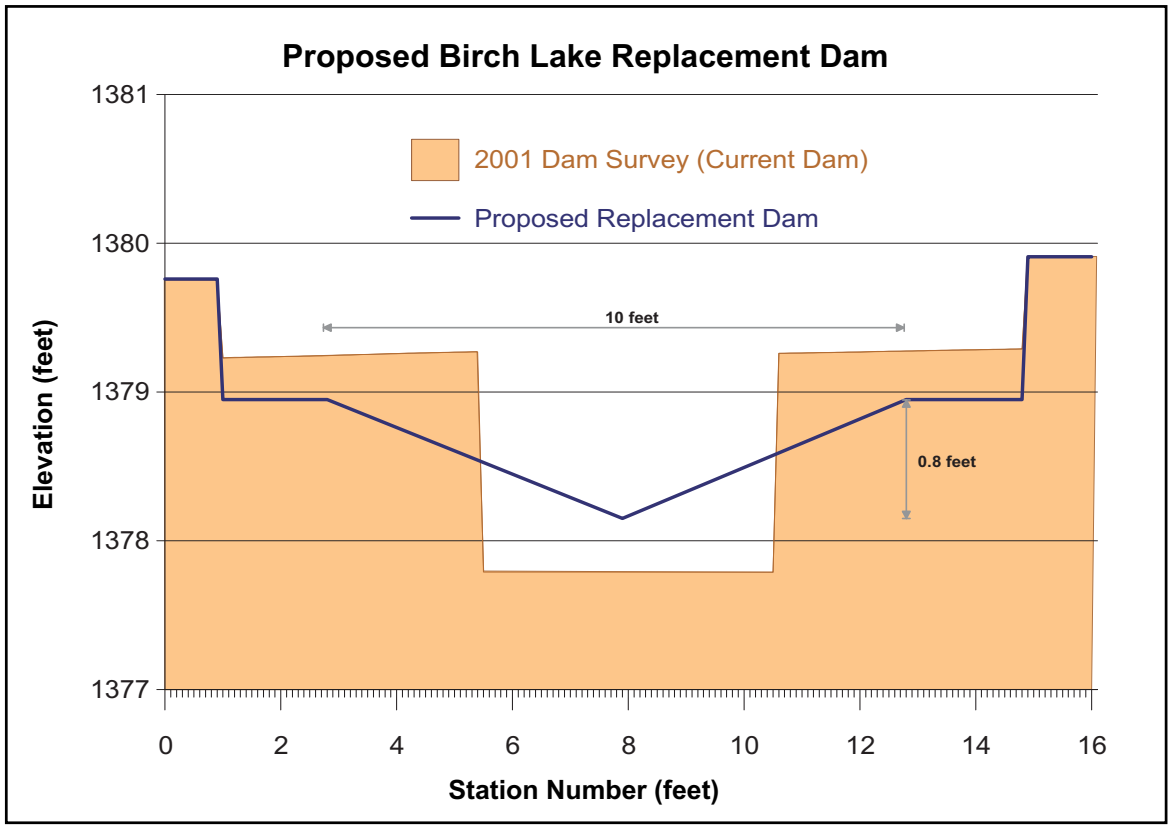


Figure 14. Existing dam (no stoplog) and proposed replacement dam.

Approximately 35 different modifications to the 5-foot stoplog bay were modeled. However, due to the small size of the bay and the height of the high flow weir, these models all produced undesirable water levels on Ten Mile Lake.

Replacing the control section of the outlet dam was also considered. The replacement sections were designed to produce higher lake elevations on Birch Lake at low flows, and to produce results similar to the existing dam with no stoplog at high flows. The replacement structure that best meets these criteria is a V-notched weir with a runout elevation of 1378.15 (same elevations as the four-inch stoplog). At elevation 1378.95 feet, a broad-crested weir exists on each side of the V-notch. The total length of the two broad-crested weirs is approximately 3.6 feet.

Figure 14 shows the existing Birch Lake outlet dam with no stoplog and the proposed replacement V-notched weir. Based on the computer model for this configuration, a discharge of 10 cfs would sustain Birch Lake at elevation of 1379.02 and a discharge of 13 cfs would sustain Birch Lake at an elevation of 1379.10 feet. The existing dam, with the four-inch stoplog, would maintain Birch Lake at elevations of 1378.85 and 1379.02 for these discharges. Following the conditions of the existing permit with no stoplog installed, elevations of 1378.56 and 1378.74 would be expected. Note that 13 cfs was the average flow during the two-year study, while 10 cfs is the estimated long term average annual discharge.

There is no high flow weir in the proposed replacement dam. Based on the configuration of the dam, water is expected to flow over the entire width of the dam approximately 50% of the time, in a normal year.

Figure 15 is a rating curve for the proposed Birch Lake outlet dam. The red line represents the water level of Birch Lake when the Birch Lake outlet dam is operated as defined by the permit. The green line represents the water level of Birch Lake with a four-inch stoplog in the 5-foot stoplog bay (existing conditions). The blue line shows the expected water level for the proposed V-notched weir.

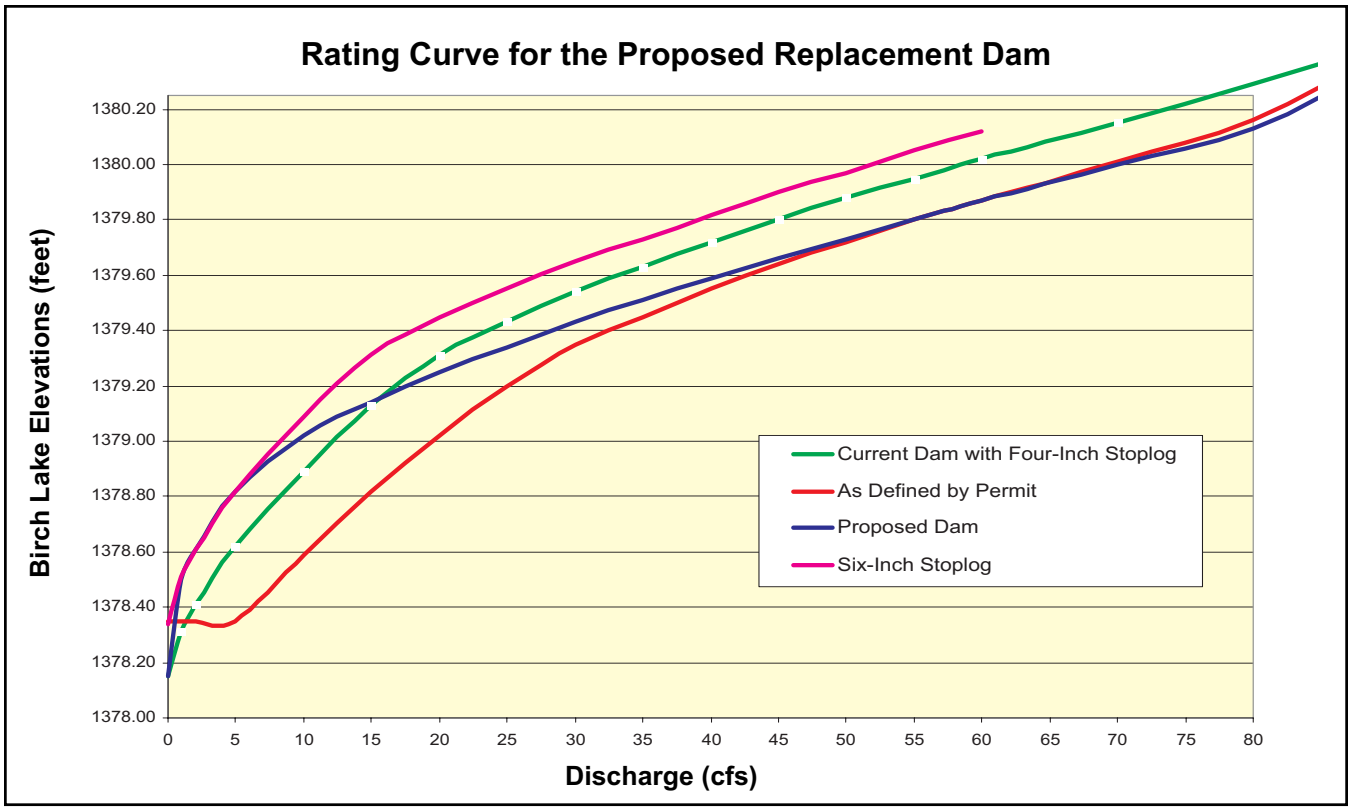


Figure 15. Rating curve of proposed V-notch weir; existing dam, and permit rating curve.

The suggested replacement structure would maintain Birch Lake at levels almost identical to the levels obtained with a six-inch stoplog for discharges from approximately 0.5 to 8 cfs. For discharges less than 0.5 cfs, the lake level would drop to the equivalent of the four-inch stoplog. At discharges above 8 cfs, lake levels would be lower than with the four-inch stoplog but higher than the "no stoplog" configuration defined in the 1976 permit. At flows of 60 cfs or higher, the proposed replacement section would maintain water levels on Birch Lake at approximately the same elevation as the existing dam with no stoplogs in place.

With the reduced capacity at low flows, the interruption of "pass through" waters from Ten Mile Lake would also be reduced on Birch Lake.

The proposed replacement dam would also have benefits for Ten Mile Lake. It would maintain a higher lake level on Ten Mile Lake when flows are low, but would provide a slightly greater capacity when lake levels are high.

E. Fish Passage

Flow velocities were measured on the concrete floor, both upstream and downstream, of the Birch Lake outlet dam. Flow velocities upstream of the dam were consistently around one foot per second.

As water passed through the dam, velocities increased. On the downstream concrete sill, average flow velocities of 9 ft/sec were common at a discharge of 10 cfs. Water depths in this flow regime were approximately one inch on the tailwater floor. According to DNR Ecological Services staff, flow velocities faster than around 2 ft/sec prevent the passage of fish. Considering the tailwater velocities, the only time fish are able to migrate into Birch Lake from the downstream Boy River is during periods of high flow, when the Birch Lake outlet dam is completely submerged and water levels are controlled by the downstream culverts.

Fish migration into Birch Lake can be improved with the placement of obstructions immediately downstream of the control structure to pool water and reduce water velocities. Fish passage at the Birch Lake dam should be re-evaluated if/when the replacement dam is in place.

F. Erosion along Angel Island

There are two mains currents in Ten Mile Lake. The stronger is a result of coriolis forces which, as in most lakes in Minnesota, is clockwise. The larger the water body, the stronger the current.

The second current in Ten Mile Lake is caused by ground water flow. Ground water enters Ten Mile Lake from predominantly the west and flows to the north and east. Figure 16 is an air photo of Ten Mile Lake showing the flow directions of the currents. The ground water current and the coriolis current combine on the western and northern portion of Ten Mile Lake.

Property owners and divers have reported that the currents in Ten Mile Lake are very noticeable. One consequence of these currents is that the sediments found on the western shore are predominantly sands and gravels while silts, clays and very fine organic materials are carried to and deposited on the eastern edge of the lake.

On Angel Island, prior to the construction of the gravel road, currents flowed around the west side of the island. With the construction of the road to the island, currents could no longer flow around the island. Instead, currents are in an easterly direction, along the road to the island, and then to the northeast. Referring again to Figure 16, the air photo shows the deposition of coarse materials along the northeastern corner of the island. The finer sediments remain suspended, with the finest sediments being deposited on the eastern shores of the lake, entering the Boy River channel, where many of these sediments becoming trapped in the channel. A few strategically placed culverts or small bridges in the roadway may reduce the erosion problems on Angel Island.

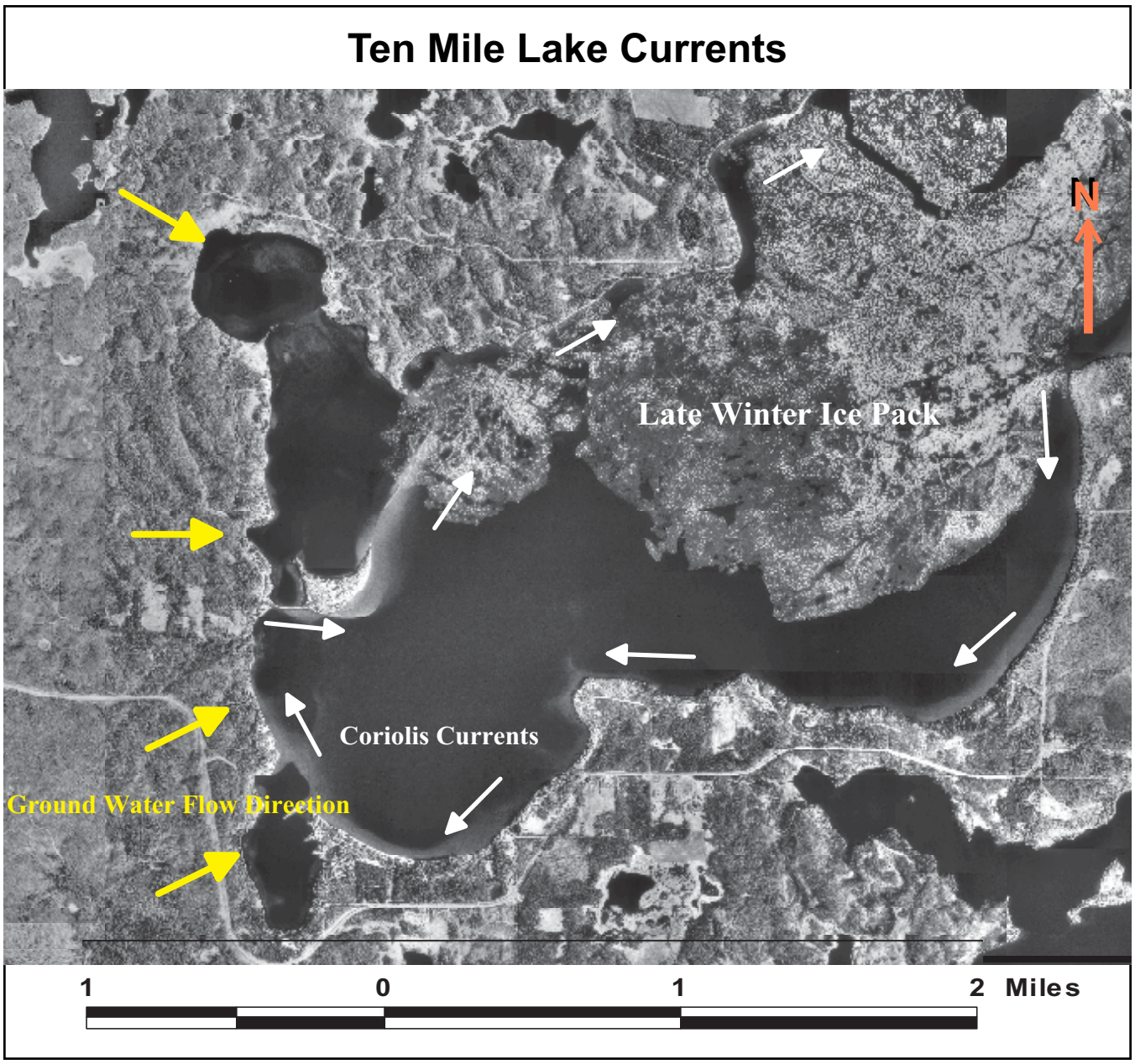


Figure 16. Air photo of Ten Mile Lake showing Angel Island, approximate ground water flow direction, and expected coriolis currents.

IV. Conclusions

1. The Birch Lake outlet dam affects the water levels of Ten Mile Lake under some conditions. Raising the elevation of the existing Birch Lake outlet dam will generally cause higher water levels on Ten Mile Lake.

2. Channel vegetation in the Boy River between Ten Mile Lake and Birch Lake can reduce outflow from Ten Mile Lake during the summer, resulting in lower water levels on Birch Lake and higher levels on Ten Mile Lake.

3. The range of water levels observed on Ten Mile Lake over the past three decades has been relatively small. The difference in elevation between the highest water level and the lowest is only 2.74 feet. Ten Mile Lake is normally between 1379 and 1380 feet, with higher water levels exceeding 1380 (8 times in the past 29 years). The highest water level observed in the last 30 years was 1380.23 on June, 2001.

4. The 1976 changes to the dam were intended to decrease the capacity of the dam for high discharge events and to maintain the level of Birch Lake during periods of low flow with the use of a stoplog. At no time during the two-year study would permit 76-3435 have allowed for the placement of any stoplog in the Birch Lake outlet dam. In fact, based on the permit, no stoplog would have been allowed in the Birch Lake dam for any period since late 1997.

5. The 1976 changes to the Birch Lake outlet dam were completed as authorized, on the floor of the existing dam.

6. Fish passage into Birch Lake and Ten Mile Lake has been reduced by the Birch Lake outlet dam.

7. Replacing the existing Birch Lake outlet dam with a V-notched weir will:

- create higher water levels on both Birch Lake and Ten Mile Lake during periods of reduced precipitation and flow.
- reduce the impacts on Birch Lake when “pass through” waters from Ten Mile Lake are interrupted.
- maintain flows for a longer time period in the Boy River channel downstream of the Birch Lake outlet dam.
- reduce the impacts of stoplog manipulation on the Boy River and on Pleasant Lake.

8. The proposed V-notch weir will not impact the OHWL on either Ten Mile Lake or Birch Lake. However, the proposed V-notch will cause a slight increase in the peak elevations, for storms that produce discharges up to 60 cfs, due to the lower elevation of the broad-crested weir. Larger storms, producing discharges greater than 60 cfs, will generate peaks of equal or slightly less magnitude due to the increased capacity of the dam at high discharges.

V. Recommendations

1. It is recommended that Cass County replace the existing Birch Lake outlet dam with the proposed V-notch structure described in this report. Until such time that the dam can be replaced, the four-inch stoplog should remain in place in the Birch Lake outlet dam.

2. Use of baffles, rock or some other method should be examined to pool water in the tailwater area to reduce flow velocities to allow fish migration through the Birch Lake outlet dam, if it can be done without diminishing the dam's capacity.

VI. References

Strum, Terry W, "Open Channel Hydraulics" 2001, McGraw-Hill Company, Boston

U.S. Army Corps of Engineers, "HEC-RAS - River Analysis System" 2001

U.S. Army Corps of Engineers, "HEC-RAS River Analysis System - Hydraulic Reference Manual, 2002

VII. Acknowledgments

This study and report would not have been possible with out the help and input of several individuals. The input of these individuals has greatly improved the Birch Lake Dam Outlet Study and I am deeply indebted to these individuals for their time, effort and patience.

Dave Ford, Surface Water Engineer, was instrumental in setting up the project and guiding it during its early stages, including early public meetings.

Brett Coleman and *Joe Oschwald* assisted in the field work and data gathering, and supplied many helpful ideas and suggestions.

Mel Sinn, *Bob Potocnik* and *Glen Yakel* spent countless hours reviewing drafts of this document and supplied many needed corrections and recommendations.

Jim Solstad also reviewed the document for technical accuracy, but more importantly, reviewed the results of the computer models and made many necessary recommendations to make the models more accurate.

Numerous residents on Ten Mile Lake and Birch Lake, supplied comments, questions and input during the course of the study. These inputs were occasionally challenging but always helpful. I am especially grateful to *Otelia Schmieg* for allowing access to the Birch Lake outlet dam to perform numerous stream flow measurements as well as the use of her property for the placement of a datalogger. *Sybil Nies* and *Millie Borchert*, lake gage readers for Birch Lake and Ten Mile Lake, supplied many water surface elevations used in this study.

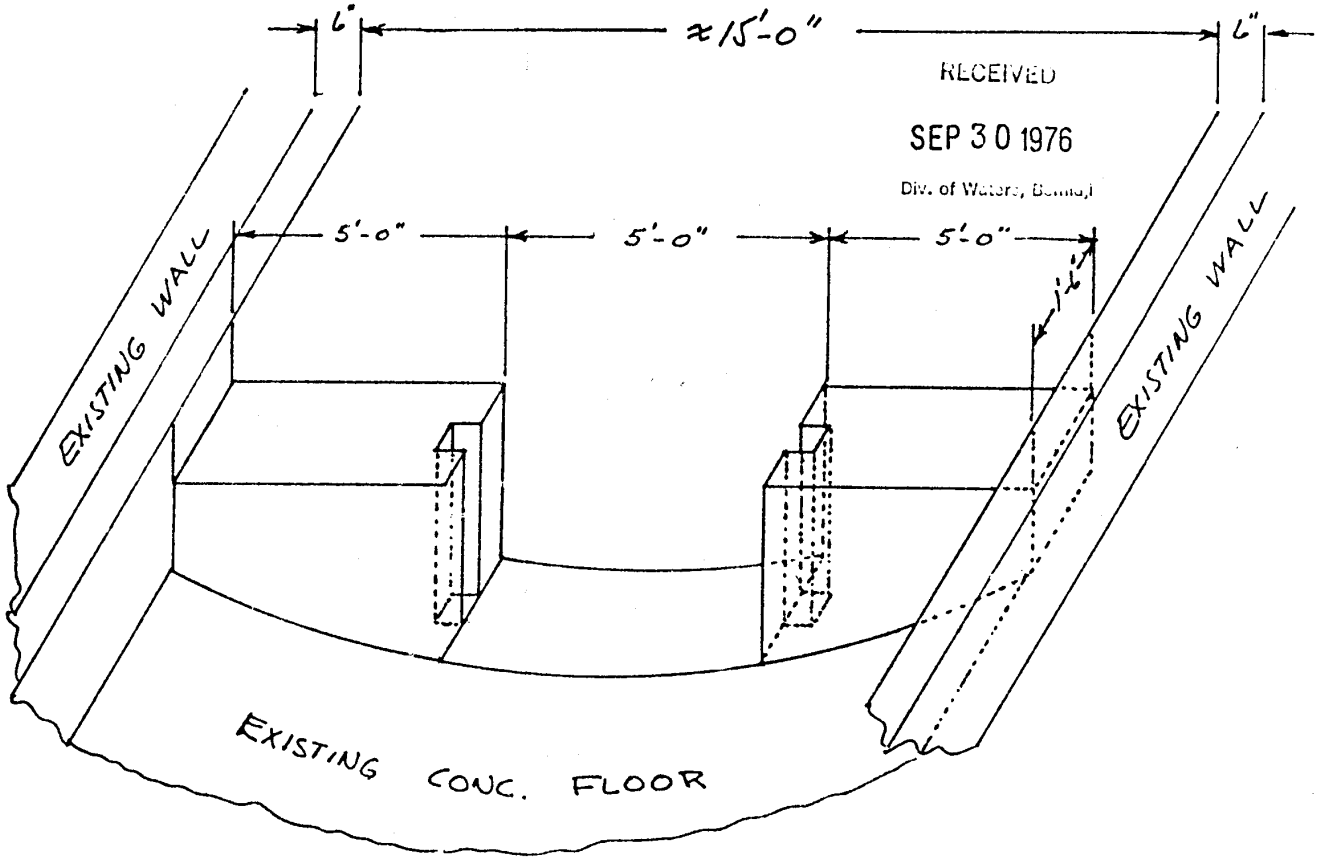
The final layout of this report was done by DNR Waters graphic designer, Jim Zicopula, whose design has greatly improved the look and feel of the report.

Dana Dostert, October 2003

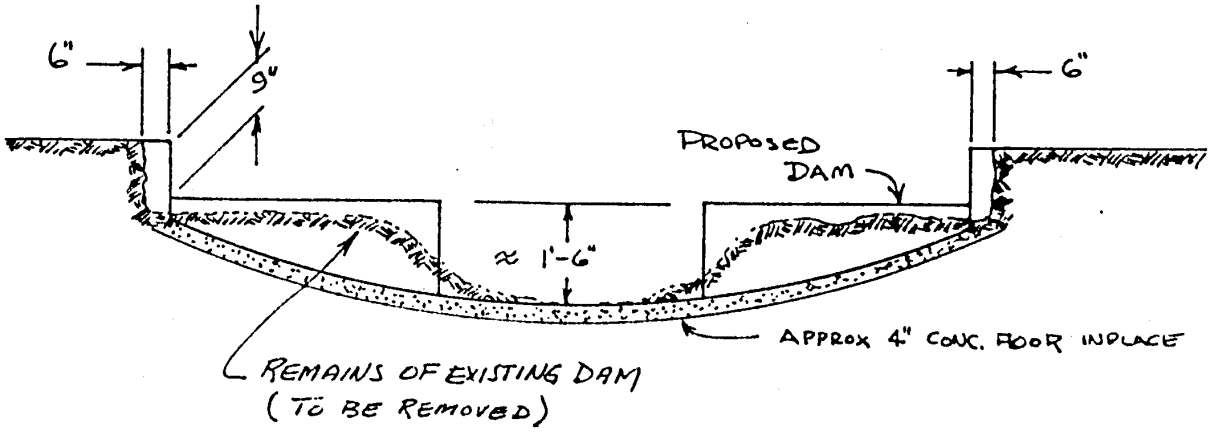
Appendix A - Design sketch for the proposed 1976 Dam Repairs

P.A. 76-3435

PROJECT BIRCH LAKE DAM REPAIR - BOY RIVER DATE 9/27/76

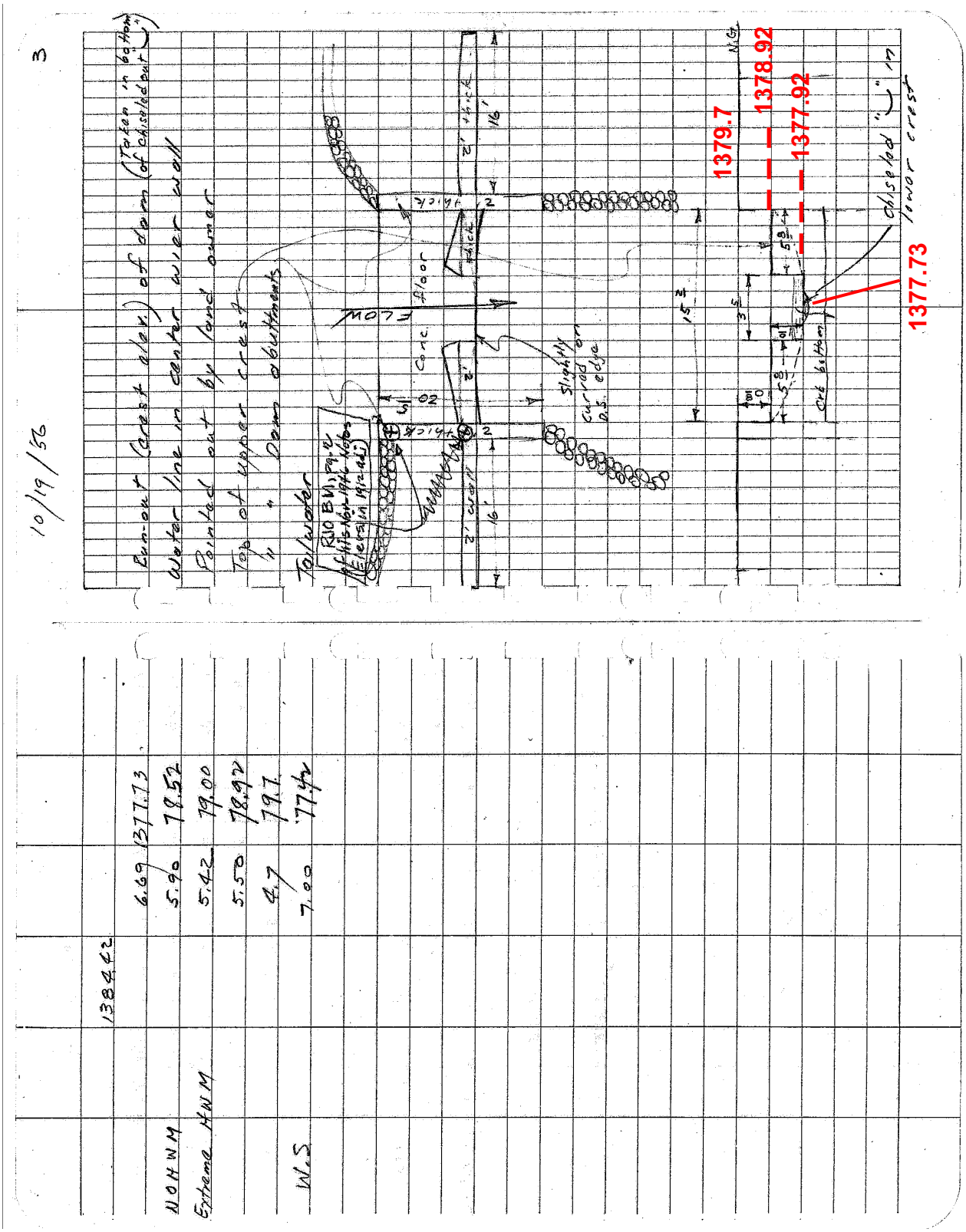


ALL DIMENSIONS SHOWN ARE APPROXIMATE



Appendix B - Birch Lake Outlet Dam Survey Notes - 10/19/1956

(elevations in red added in August 2003)



Appendix C - DNR Waters Permit No. 76-3435

W 70-50
Rev. 11/70

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCE
DIVISION OF WATERS, SOILS AND MINERALS
Centennial Office Building, St. Paul, Minnesota, 55101

P.A. No. 76-3435

IN THE MATTER OF THE APPLICATION OF CASS COUNTY

for a PERMIT TO CHANGE THE COURSE, CURRENT, OR CROSS SECTION of BIRCH LAKE (11-412) & BOY RIVER

CASS County.

PERMIT

Pursuant to Minnesota Statutes, Chapter 105, and on the basis of statements and information contained in the permit application, letters, maps, and plans submitted by the applicant, and other supporting data, all of which are made a part hereof by reference, PERMISSION IS HEREBY GRANTED to James Worcester, Co. Hwy. Engineer whose address for the purpose of notices and other communications pertaining to this permit is Cass County Court House Walker, MN 56484 which address is subject to change by written notice from the permittee.

To Remove existing lake outlet structure and construct a new reinforced concrete weir with top elevation at 1379.42' and being 1.5' high; and having a rectangular notch 5' wide by 1.5' high which may be fitted with one six-inch stop log. The operation of the structure shall be under the guidance of the County Engineer, but in ino case shall the stop log be used when the lake level is above elevation 1378.42'.

PROPERTY DESCRIBED as: Gov't Lot 3, Section 19, T 140N, R 30W

for the purpose of reconstructing outlet structure Cass COUNTY

This permit is granted subject to the following GENERAL and SPECIAL PROVISIONS:

GENERAL PROVISIONS

1. This permit is permissive only and shall not release the permittee from any liability or obligation imposed by Minnesota Statutes, Federal Law or local ordinances relating thereto and shall remain in force subject to all conditions and limitations now or hereafter imposed by law.
2. This permit is not assignable except with the written consent of the Commissioner of Natural Resources.
3. The Director of the Division of Waters, Soils and Minerals shall be notified at least five days in advance of the commencement of the work authorized hereunder and shall be notified of its completion within five days thereafter. The notice of permit issued by the Commissioner shall be kept securely posted in a conspicuous place at the site of operations.
4. No change shall be made, without written permission previously obtained from the Commissioner of Natural Resources, in the hydraulic dimensions, capacity or location of any items of work authorized hereunder.
5. The permittee shall grant access to the site at all reasonable times during and after construction to authorized representatives of the Commissioner of Natural Resources for inspection of the work authorized hereunder
6. This Permit may be terminated by the Commissioner of Natural Resources, without notice, at any time he deems it necessary for the conservation of the water resources of the state, or in the interest of public health and welfare, or for violation of any of the provisions of this permit, unless otherwise provided in the Special Provisions.

SPECIAL PROVISIONS

I. Construction work authorized under this permit shall be completed on or before November 30, 1977. Upon written request to the Commissioner by the Permittee, stating the reason therefore, an extention of time may be obtained.

II. The excavation of soil authorized herein shall not be construed to include the removal of organic matter DOES NOT APPLY unless the area from which such organic matter is removed is impervious or is sealed by the application of bentonite after excavation.

III. In all cases where the doing by the permittee of anything authorized by this permit shall involve the taking, using, or damaging of any property rights or interests of any other person or persons, or of any publicly owned lands or improvements thereon or interests therein, the permittee, before proceeding therewith, shall obtain the written consent of all persons, agencies, or authorities concerned, and shall acquire all property, rights and interests necessary therefor.

IV. This permit is permissive only. No liability shall be imposed upon or incurred by the State of Minnesota or any of its officers, agents or employees, officially or personally, on account of the granting hereof or on account of any damage to any person or property resulting from any act or omission of the permittee or any of its agents, employees, or contractors relating to any matter hereunder. This permit shall not be construed as estopping or limiting any legal claims or right of action of any person other than the state against the permittee, its agents, employees, or contractors, for any damage or injury resulting from any such act or omission, or as estopping or limiting any legal claim or right of action of the state against the permittee, its agents, employees, or contractors for violation of or failure to comply with the provisions of the permit or applicable provisions of law.

V. No material excavated by authority of this permit nor material from any other source except as specified herein, shall be placed on any portion of the bed of said waters which lies below. ORDINARY HIGH WATER LEVEL It shall be the duty of the permittee to determine correctly all pertinent elevations at the site of the work for the purpose of complying with the conditions of this permit

VI. Any extension of the surface of said waters resulting from work authorized by this permit shall become public waters and left open and unobstructed for use by the public

(over)

76-3435

SPECIAL PROVISIONS

VII. Receipt is hereby acknowledge of $ DOES as payment for NOT cubic yards of sand, gravel or rock and APPLY cubic yards of muck and silt, the estimated amount of material to be removed hereunder computed at the rate of ten cents per cubic yard for sand and gravel and two cents per cubic yard for muck and silt.

Permittee agrees by acceptance of this permit as shown by commencement of work authorized hereunder to pay, by certified check, bank or postal money order, made payable to the State Treasurer and delivered to the Director, Division of Waters, Soils and Minerals, Department of Natural Resources, Centennial Office Building, St. Paul, Minnesota 55101, for any material removed from the bed of public waters in excess of that so estimated, at the above rate within thrity days after completion of the work authorized hereunder.

(SEE ATTACHED SHEET FOR SPECIAL PROVISIONS)

cc: Region 1 Administrator
ATTN: Gerald Paul

Carl Mostrom, Mayor
City of Hackensack 56452

Cass Co. Zoning

U.S.C.E.

DATED AT ST. PAUL, MINNESOTA, THIS 21 DAY OF Oct. 19 76

L. D. Spreeman

Division of Waters, Soils and Minerals

WORK IN THE BEDS OF PUBLIC WATERS PERMIT NO. 76-3435

SPECIAL PROVISIONS

(Only the numbered Special Provisions apply to this permit.)

VIII. The permittee shall comply with all rules, regulations, requirements, or standards of the Minnesota Pollution Control Agency and other applicable federal, state, or local agencies.

IX. The use of explosives in any of the waters of the state is prohibited unless the local State Conservation Officer is notified thereof at least 48 hours in advance of the time the work is to be done. (M.S., Sec. 101.42, Subd. 11).

_____ Before construction and after completion of the project authorized, permittee shall suppl the Division of Waters with photographs of the project area.

X. Spoil material shall not be placed on the beds of public waters, and, wherever possible, such material should not be placed anywhere within areas subject to flooding. In the event spoil must be placed within flood plain areas because areas free from flooding are not readily available, the spoil should be placed parallel to the direction of flood flow and/or spread over a large area so as to minimize any possible obstruction to the passage of flood waters.

XI. Upon completion of construction, the bed of the public water shall be restored as nearly as practicable to the original cross-section.

_____ The permittee shall cover or protect all exposed soil resulting from the construction authorized by placing riprap, sod, and/or seed on banks and slopes of said construction for the prevention of soil erosion, sedimentation and lake/stream discoloration.

XII. After the completion of the project authorized, permittee shall supply the Division of Waters with photographs of the project area.

_____ Future maintenance excavation of this project shall not exceed the dimensions herein authorized. Prior to commencing any maintenance excavation, permittee shall advise the Department of Natural Resources of the volume of material to be removed, the manner of removal, and the spoil disposal site(s) proposed. If the Commissioner of Natural Resources determines that a field inspection is necessary prior to approving such maintenance work, the permittee shall submit a check payable to the State Treasurer to cover the actual cost of the inspection, or $25.00, whichever is greater, pursuant to Minnesota Regulations NR 5000, Paragraph (g). Maintenance excavation shall not be commenced until permittee's receipt of the Department's approval.

XIII. This permit does not obviate any requirement for federal assent from the U. S. Corps of Engineers, 1135 U. S. Post Office and Custom House, St. Paul, Minnesota 55101.

_____ Permittee shall seed a strip of land abutting both sides of the ditch to permanent grasses and legumes, these strips to meet one of the following standards:

A. Each strip shall be at least 40 feet wide for the full length of the excavated ditch and shall not be mowed prior to July 15 in any year; or

B. Each strip shall be at least 25 feet wide for the full length of the excavated ditch, provided mowing of these narrower strips shall not be done.

(See reverse side for additional provisions, if any.)

Appendix D - Letter, Gerald Paul to Lawrence Seymour

ADMIN 1000

STATE OF MINNESOTA

4520

DEPARTMENT OF NATURAL RESOURCES

Office Memorandum

TO : Lawrence D. Seymour, Supervisor
Development Section

DATE: Oct. 19, 1976

FROM : Gerald L. Paul, Regional Hydrologist

PHONE: (218) 755-3973

SUBJECT: PROJECT EVALUATION REPORT

PERMIT APPLICATION NO.: 76-3435
PERMIT TYPE: X - Water Level Control
PUBLIC WATER: Birch Lake (11-412)
COUNTY, LOCATION: Cass Co., Sec. 19, T 140N, R 30W
APPLICANT: Cass Co. Engineer

Birch Lake is located on the west side of Hackensack, MN. It has a surface area of 1262 acres per Bulletin 25 and is classified as "General Development, limited" in the Cass County shoreland ordinance. The Boy River enters the lake on the north side and leaves the lake on the southeast side. A low-head outlet structure was built in 1931 at the mouth of the outlet stream. Its dimensions were approximately 15' wide with vertical concrete side walls 1.75' high, and with a concrete weir, 1.0' high, and running across the channel, notched in the center, 3.5' wide x 1.0' high. Over the years, the weir has become chipped and broken, and there has been much local interest to get it repaired. The Ten Mile Lake Association had solicited D.N.R. assistance in 1974 and were advised that the reconstruction work would require a P.A. submitted by a unit of government. Two site inspections were made at that time, one in March and one in April, 1974. The flow depth at the latter time matched the level of stain marks on the upstream channel walls (about 3" below the top of the channel walls).

At present, the lake level is down and there is no flow in the outlet channel (see P.A. photos). The County Engineer has submitted the P.A. and would like to reconstruct the weir to similar dimensions, except it would be 1.5' high instead of 1.0' and would have a 5.0' wide notch instead of 3.5'. He would also like to incorporate stop log control, if permissible.

I have made flow estimates for the present and proposed structures with water surface at 1.5' depth (approximately at O.H.W.). The existing structure would discharge 35.1 cfs, and the proposed one without stop logs would pass 30.6 cfs.

Birch Lake has a small direct watershed, having a ratio drainage area to lake area of about 0.88 and supplemented with the Boy River inflow which carries the run-off of Ten Mile Lake watershed.

Based upon a 6 hr., 100-year storm event, I have made some hasty calculations that a 1.0' jump in lake stage would occur. It has been a past practice to set outlet capacity and/or elevation such that the flood volume on the lake could be drawn down in a 30-day period, assuming constant discharge at O.H.W. level. With these conditions

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imposed upon the proposed structure, a head of 1.15' would have to be maintained. Since the notch is only 1.5' with top at O.H.W., only one 4" stop log could be used continuously. Or, alternatively, one 6" stop log could be used and left in place until the lake stage was 6" above the bottom of the notch. This would always allow the storage space for the 1.0' lake stage bounce.

By te.ephone conversation with John Egan, it was determined that the bottom of notch elevation is at 1377.92'. Then the elevation of the estimated O.H.W. is 1379.42', and the level of the lake when the stop log should be removed is at 1378.42'.

RECOMMENDATION: Issue permit for structure as proposed in P.A.; allow use of stop log control, specifying use of only one 6" log to be removed under rising lake stage conditions when water level reaches its crest (1378.42') or may be inserted under falling lake stage conditions when level is at or below elevation 1378.42. Assign operational responsibility to the County Highway Engineer.

Enclosed is a typed final permit draft prepared in the regional office.

GLP/pc

Appendix E - Water Level and Related Information for Selected Lakes

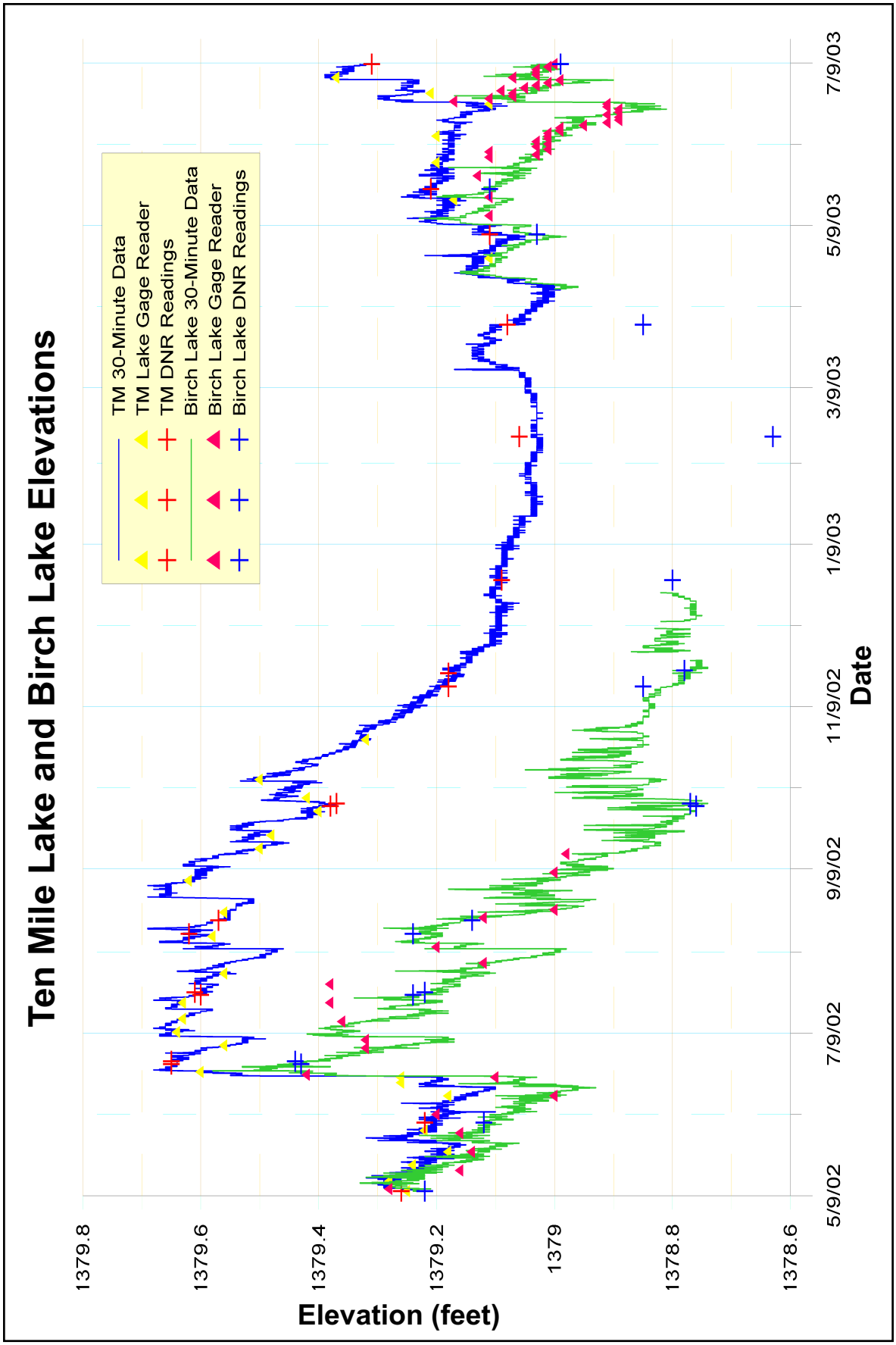
The table below is a summary of water level and related information for Ten Mile, Birch and other lakes located in the vicinity of the project area.

Lake	Period of Record	Number of Readings	Maximum Elevation Observed	Minimum Elevation Observed	Average	Range	Ordinary High Water Elevation
Williams (Hubbard Co)	12/14/87 to 9/30/96	2911	1383.02	1380.42	1381.50	2.66	NA
Ten Mile	11/12/73 to 5/5/03	1326	1380.23	1377.49	1379.39	2.74	1379.90
Birch	10/19/56 to 5/27/2003	785	1380.00	1377.83	1378.90	2.18	1379.40
Portage	5/16/91 to 5/7/03	309	1380.00	1375.38	1377.70	4.62	1379.60
Stoney	1/11/88 to 5/7/03	482	1375.36	1370.93	1372.52	4.43	1375.80
Pleasant	9/12/78 to 5/5/03	126	1362.82	1360.17	1361.83	2.65	1362.60
Webb	3/15/65 to 5/7/03	54	1349.66	1344.74	1348.55	4.92	1352.10
Leech	1/1/65 to 4/3/03	13973	1296.09	1292.69	1294.33	3.40	1294.90

Appendix F - Measured Elevations and Discharges

Ten Mile/Birch Lake Elevation and Discharge Measurements					Estimated Discharge	
Date	Ten Mile Lake Elevation (ft.)	County Road 6 Elevation (ft.)	County Road 6 Discharge (cfs)	Birch Lake Elevation (ft.)	Birch Lake Dam Discharge (cfs)	Lake L Difference
8/1/2001	1379.79	1379.79		1379.02		-0.77
8/7/2001	1379.74	1379.73	10.72	1378.95	11.66	-0.79
10/17/2001	1379.36	1379.23	5.60	1378.76	7.99	-0.60
2/19/2002	1379.14	1379.13	12.00	1378.99	12.20	-0.15
4/10/2002	1379.08	1379.10	12.70	1378.99	12.20	-0.09
5/10/2002	1379.26	1379.26	10.30	1379.22	16.20	-0.04
6/5/2002	1379.22	1379.22	13.60	1379.12	14.30	-0.10
6/27/2002	1379.65	1379.65	10.12	1379.43	24.25	-0.22
6/28/2002	1379.65	1379.65	10.30	1379.44	23.10	-0.21
7/23/2002	1379.60	1379.60	7.81	1379.24	16.60	-0.36
7/24/2002	1379.61	1379.60	7.09	1379.22	16.10	-0.39
8/15/2002	1379.62	1379.62	4.16	1379.22	16.50	-0.40
8/20/2002	1379.57	1379.57	6.32	1379.14	14.60	-0.43
10/2/2002	1379.38	1379.34	6.55	1378.76	8.06	-0.62
10/3/2002	1379.37	1379.32	7.37	1378.77	9.20	-0.60
11/15/2002	1379.26	1379.25	7.62	1378.85	9.98	-0.41
12/26/2002	1379.09	1379.09	7.90	1378.80	9.45	-0.29
2/18/2003	1379.06	1379.04	4.80	1378.63	6.95	-0.43
4/1/2003	1379.08	1378.98	21.60	1378.85	10.80	-0.23
5/5/2003	1379.11	1379.11	15.00	1379.03	13.22	-0.08
5/22/2003	1379.21	1379.21	13.00	1379.11	14.00	-0.10

Appendix G - Ten Mile Lake and Birch Lake Study Hydrograph



Appendix H - Historical Photographs of the Birch Lake Outlet Dam

10/3/1927

7/20/1944

8/4/1954

8/1/1962

8/8/1990

This information is available in an alternative format upon request

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