Hydraulic Design Feasibility Analysis

Little Round Lake Dam

Sawyer County, Wisconsin

SEH No. A-SAWYE0802.00

November 2007

November 1, 2007

RE: Little Round Lake Dam
Hydraulic Design Feasibility Analysis
Sawyer County, Wisconsin
SEH No. A-SAWYE0802.00

Mr. Dale Olson
Sawyer County Conservationist
Land and Water Department
P.O. Box 89
Hayward, WI 54843

Dear Mr. Olson:

Short Elliott Hendrickson Inc. (SEH®) has prepared the enclosed Hydraulic Design Feasibility Analysis of the Little Round Lake Dam for the Sawyer County Land and Water Conservation Department and Sawyer County Board of Supervisors. The recommendations in this report take into account the needs and regulations of the County, Round Lake Association, State of Wisconsin, Lac Courte Oreilles Tribe, and other interested parties.

Please contact us with any comments, questions, or concerns you have about the enclosed information. If we can be of additional assistance in the structural design or implementation of any changes in the controls as a result of this work, please do not hesitate to ask.

Sincerely,

Bernard N. Lenz, PE
Project Manager

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Hydraulic Design Feasibility Analysis

Little Round Lake Dam
Sawyer County, Wisconsin

Prepared for:
Sawyer County
Hayward, Wisconsin

Prepared by:
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Bernard N. Lenz, PE — PE Number — 11/1/07 Date
Project Manager

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Little Round Lake Dam

Prepared for Sawyer County

1.0 Introduction

1.1 Project Description

Sawyer County, Wisconsin previously retained Short Elliott Hendrickson Inc. (SEH®) to determine Regional Flood Elevations (RFEs) and the hydraulic controls in the Round Lake Chain of Lakes. (Round Lake, Little Round Lake, Osprey Lake, and Osprey Creek). It was determined that the boards currently used controlled the water surface on Round Lake for all flows when they are in place at 1345 feet. However, since base flow is required to be passed, the boards must be removed from the current structure when the Little Round Lake elevation is below 1345 feet and the boards prevent base flow in Osprey Creek from being passed. Boards cannot legally be replaced again until flow is sufficient such that by placing the boards the County would not retain more than 25% of the flow, depriving the downstream system of base flows. (IE- Round and Little Round Lakes must reach an elevation of over 1345 feet before boards can be placed.)

Often, by the time flows are sufficient that boards legally be placed, the elevations of Little Round and Round Lake are can be high enough that boards are no longer desirable, or if placed, boards would need to be removed shortly there after. As a result, the County has been able to place boards in the dam very infrequently.

The SEH studies determined that with boards removed, control in the system a low flow is dependent on backwater effects of the downstream beaver dams and the Little Round Lake dam constriction. The backwater effects of the current County Road NN culverts and embankment become part of the control at flows of approximately 78 cfs and above; just under the 100-year RFE flow rate of approximately 100 cfs.

To maximize the amount of water leaving Round and Little Round Lake during times of high lake levels, thus increasing the rate that available storage is returned to the system and minimizing the chance of flooding, it was recommended by SEH in that previous study that the beaver dams be removed, a clear channel maintained, and that the Little Round Lake Dam constriction be eliminated by increasing the hydraulic capacity of the structure to the capacity of the downstream waterway.

Subsequent to that recommendation, members of the Round Lake Task Force determined that it is not acceptable, nor feasible to remove beavers and maintain a clear channel. However, the SEH studies showed that increasing the hydraulic capacity of the Little Round Lake Dam at Carlson Road without removal of the beaver dams or lowering of County Road NN culverts would result in an increase in the RFE elevations of Osprey Lake and thus the State of Wisconsin would require flood easements be obtained before permitting such a structure. Such easements would be unfeasible to obtain.

The previous study by SEH also determined that the current low water control of Round Lake is dependent on the beaver dams rather than the dam sill when boards are removed. The elevation difference between the beaver dam control and the boards is only 0.6 inches. A structural low water control would be needed at the dam to maintain the Round Lake elevations near the 1345 foot elevation only if the current beaver dams are leaking, fail, or were removed. The SEH study suggested a structural low flow control would be more reliable than the beaver dam and that a notch in the weir designed to provide "run of the river" low flows, thus avoiding the "stealing" of water from Osprey Lake and the downstream watershed during low flow periods, could be added to the design.

During prolong drought, the lakes elevations drop below the beaver dam and below the sill, thus no flow occurs between the Round Lakes and Osprey Lake during extremely dry periods. No change in the control at the Little Round Lake dam would allow the lakes to maintain elevation when there is drought and thus no flow from the upstream watershed is available to maintain lake levels.

Since the County Road NN culverts contribute to backwater at flows of 78 cfs, a flow below the 100-year event, the State of Wisconsin administrative rules require that the County Road NN culverts either be lowered, and their capacity be increased so their hydraulic capacity is that of the natural channel for all flow up to and including the 100-year event. Alternately, the culverts could be permitted as a dam, requiring a dam failure analysis and possible flood easements.

As a result of these considerations, SEH has been asked to design, model, and recommend modification to the County Round NN culvert placement such that the culverts no longer contribute to the backwater effects of Osprey Creek at flows up to and including the 100-year event flow. In addition, SEH has been asked to design, model, and evaluate what can be done at the Little Round Lake control structure to increase the capacity of the structure by the amount of increased capacity associated with lowering the County Road NN culverts or alter the current structural control to pass base flow in the event the County Road NN culverts are not lowered. All scenarios assume the beaver dams in Osprey Creek remain.

Two design changes at the Little Round Lake Dam were evaluated in this report and include:

- Lower County Road NN culverts and replace the current box and control structure and
- Modify the current control structure.

The impact on the RFE of all lakes and the change in the relation of lake stage to flow through the full range of likely flows is also evaluated for each design and compared to current conditions.

The lakes and flowages within the study area support recreation and tourism activities important to Sawyer County and the State of Wisconsin as well as hold cultural significance to the Lac-Courte-Oreilles Tribe. Development around the lakes includes a mix of traditional seasonal cabins, undeveloped shoreline, and vacation homes including lands in private, public, and Tribal ownership. There has been a long history of high and low water extremes in the system and associated concerns with both. Subsequent reports and public outreach sessions have given the Task Force an understanding of the controls and associated lake elevations as well as how these relate to local concerns about water elevations. The designs evaluated in this feasibility report are based on informed decisions made by the Round Lake Task Force. The designs evaluated in this report considers current water law Wisconsin Administrative Code requirements and the level of acceptance of the County, Tribe, State, and lake residents to the consequences of manipulating hydraulic controls in this system.

SEH previously completed a Regional Flood Elevation (RFE) assessment for a system of eleven water bodies located at the headwaters of the Couderay River, including the Round Chain of Lakes; subsequently a report that evaluated the hydraulic controls in the Round, Little Round, Osprey Lake, and Osprey Creek system was completed. The models developed for those two studies were used to design the hydraulic controls and assess the feasibility of the proposed structure in this feasibility analysis.

1.2 Purpose

The purpose of this study is to provide Sawyer County and the Round Lake Task Force with hydraulic designs and an evaluation of the feasibility of replacing or revising the hydraulic controls in the Osprey, Little Round, and Round Lake chain of Lakes.

1.3 The Round Lake System

The Round Lake System includes Round Lake, Little Round Lake, Osprey Lake, and Osprey Creek. Figure one is a map of the study area. Round Lake is the headwaters of the system but can receive water from another watershed. Water can flow from Tiger Cat Flowage, an impoundment of North Fork Chief River created in 1937, to Round Lake through a series of diversion canals and impoundments. Due to concerns with the biologic integrity of the two systems, the diversion is not in use and the County has submitted an application to the State of Wisconsin for a permit to permanently abandon this diversion.

Round Lake is directly connected to Little Round Lake, separated only by the bridge opening under the roadway of CTH B. Water flows freely between Round Lake and Little Round Lake under the CTH B Bridge. This connection performs no hydraulic control of the system, thus, the water surface of the two lakes is nearly always the same.

The outlet of Little Round Lake is controlled by the Little Round Lake Dam, also known as the Carlson Road Dam, and located in the northwest quarter of Section 1, Township 40 North, Range 8 West, Town of Hayward. The Little Round Lake Dam consists of a wooden bridge structure with wooden wing walls and a wooden sill. The physical constriction and two five-foot stop log bays provide the hydraulic control of the structure. Little Round Lake Dam has a history of having a stop log in place at a weir elevation of approximately 1345 feet. The actual sill elevation is approximately 1343.7 feet, but is overlain by a considerable amount of sediment.

A channel approximately 1,800 feet long extends from the Little Round Lake Dam downstream to Osprey Lake. Osprey Lake was formerly know as Squaw Lake and appears by that name on some maps and historic references. About the first 300 feet of the channel is dredged, with a stream width of 20 to 25 feet; the remainder of the channel is a narrow stream that meanders through a thick growth of cattails and other wetland plants. This is considered to be a man-made connection between the lakes.

The historical natural connection between the lakes is located at the southeastern corner of Little Round Lake and connects to the north side of Osprey Lake through a wide wetland area. The physical restrictions in the second channel and limited head differential prohibit any substantial flow from passing through this secondary channel.

Osprey Lake drains to Osprey Creek, a meandering channel through wetlands that eventually reaches Lake Lac-Courte-Oreilles. The stream channel distance of Osprey Creek from Osprey Lake to Lac-Courte-Oreilles is approximately five miles. There are two roadway crossings of Osprey Creek: twin 48-inch culvert pipes at County Road NN and a set of four culvert pipes at CTH E (twin 30-inch pipes and a 54-inch and 60-inch pipe installed side-by-side). Two large beaver dams between Osprey Lake and County Road NN were identified, surveyed and included in the hydraulic models. Numerous less permanent beaver dams come and go throughout this low gradient, heavily wooded reach. Photos of the hydraulic controls in the system are found in the photo log in Appendix A.

2.0 Previous Studies and Information

Preliminary models developed by Northern Wisconsin Based Engineers (NWBE) and its subcontractor, Carthel Engineering, LLC to perform a RFE assessment were used by SEH as a basis for the RFE Determination Study. In doing the study the original models were modified extensively by SEH and supplemented with additional survey data. The final models and associated reports were submitted to WDNR on December 29, 2006 and Regional Flood Elevations were approved by the State of Wisconsin on May 7th, 2007 for all three lakes evaluated in this study. These approved RFEs are shown in Table 1.

Table 1
Round Lake, Little Round Lake, and Osprey Lake Regional Flood Elevations

	Regional Flood Elevation
Round Lake	1346.98
Little Round Lake	1346.97
Osprey Lake	1346.53

The SEH models from the RFE determination were used in a second study to evaluate the Hydraulic Controls of Round Lake, Little Round Lake, Osprey Lake, and Osprey Creek. Table 2 shows the results of this second study.

Table 2
Round Lake Hydraulic Controls – Lake Elevation and Associated Flow

Hydraulic Control	Lake Elevation (feet)	Associated Flow (cfs)
Boards in Little Round Dam		
Boards	1345 and up	0-80 and up
No Boards in Little Round Dam and Beaver Dam Intact		
Backwater from Osprey Lake caused by beaver dam	1344.80 to 1345.15	0-9
Backwater from beaver dam and Little Round Lake Dam constriction	1345.15 to 1346.51	9-78
Backwater from County Road NN culverts and Little Round Lake Dam Constriction	1346.51 and up	78 and up
No Boards in Little Round Dam and Beaver Dam Removed		
Riffle in Osprey Creek 135 feet downstream of Little Round Lake Dam	1344.05 (approximately 4.2 inches above sill)	0
Osprey Creek downstream of Little Round Dam and Little Round Lake Dam constriction influence of dam opening constriction is insignificant (<0.05 feet) below 1345 feet	1344.05 to 1345.30	0-31
Combined Osprey Creek channel, dam constriction, and backwater from County Road NN culverts	1345.30 and up	31-80 and up

3.0 Analysis Methodology

The U.S. Army Corps of Engineers Hydrologic Engineering Center HEC-RAS (Hydrologic Engineering Center River Analysis System) version 3.1.3, was used for hydraulic design and evaluation in this study. The software is available for download at the Army Corps HEC website.

The models used in this study were modified from those created and used in the previous two studies, discussed in Section 2.0.

4.0 County Road NN Culverts

4.1 Hydraulic Control

The existing County Road NN culverts are placed at an elevation that is above the natural channel profile thru the reach, making them part of the hydraulic control of flow through this portion of the system at flows above 78 cubic feet per second (cfs). The existing HEC-RAS model was modified to reflect the hydraulic characteristics of the reach at County Road NN if the culverts and all culvert embankments were removed. This is considered to be the natural channel profile.

This natural channel profile was used to determine the flow that the County Road NN culvert would need to pass in order to not back up water into Osprey Lake and not be considered a dam. The HEC-RAS model was then used to design the modifications to the culverts and embankment such that the County Road NN crossing no longer acts as a control during flows less than the 1-year event, which is 100.5 cfs.

The current culverts are placed nearly flat with inverts at 1342.2 to 1342.3 feet. The natural channel elevation at the culverts is about 1341.0 feet, or about 1.2 feet lower than the current culvert inverts. The analysis shows that the current culverts can be reused if lowered to the following elevations.

- Upstream Inverts = 1340.7 feet
- Downstream invert = 1340.6 feet

At these design elevations, the HEC RAS model showed the culverts and embankments are not part of the control for flow below 100.5 cfs -the 100-year flow at this reach. A drawing of the modified reach profile are shown in Figure 2.

Figure 3 shows the stage verse flow relation for the current County Road NN culvert placement, the proposed modification to the County Road NN culvert placement, and for the natural channel through this reach. The effects of the Osprey Lake backwater from these scenarios on Round and Little Round lakes is shown in Figure 4.

Under their current placement, the County Road NN culverts become part of the control at flows of 78 cfs. This is below the 100-year flood flow of 100.5 cfs. If the County Road NN culverts are lowered as proposed, the culverts will not become part of the hydraulic control until flows are above the 100-year event, thus they would no longer be a factor to limiting water passage for flows below the 100-year event. The beaver dams and the Osprey Creek channel will control all flow up to the 100-year event after County Road NN culverts are lowered.

4.2 Regional Flood Elevation

By lowering the County Road NN culverts, more water is allowed to pass through the system and the 100-year flood elevation of the upstream reach and lakes (Osprey, Round, and Little Round) is lowered. This additional water does not affect the flood elevation of the downstream Lac Courte Oreilles Lake because the Osprey Creek river reach dampens the effect of this increased flow and the timing of drainage in the system. Table 3 shows

the Regional Flood Elevations of the lakes with the alterations made to the stream reach containing the County Road NN culverts.

Table 3
Impact of lowering County Road NN Culverts on 100-Year Flood Elevations (RFE Model)

Lake	Round Lake	Little Round Lake	Osprey Lake
Starting Water Surface Elevation for RFE Determination	1346.15	1346.15	1345.86
USGS Topo Map "Normal" Water Surface Elevation	1346	1346	1344
Approved 100 -Year RFE	1346.98	1346.97	1346.53
100-Year Event w/County Road NN Culverts Removed (as Natural Channel) -Beaver dams remain	1346.98	1346.97	1346.49
100-Year Event w/County Road NN Culverts Lowered - Beaver dams remain	1346.98	1346.97	1346.49

5.0 Replace Little Round Lake Crossing and Control Structure

5.1 Hydraulic Control

Lowering the County Road NN culverts such that they no longer retain water at flows below the capacity of the natural channel, and are capable of passing flows up to the 100-year event will allow the capacity of the Little Round Lake Dam structure to be incremented without exceeding Osprey Lake's RFE. SEH evaluated the amount that the hydraulic capacity of the Little Round Lake Structure can be increased by widening the structure, assuming the County Road NN culvert crossing is lowered. Subsequently, the elevation that the low water control can then be raised was determined. Both changes consider the requirement of not raising the previously determined Regional Flood Elevations in Round, Little, Round and Osprey Lakes.

Figure 5 is an artist rendition of the proposed replacement box and control structure at the Little Round Lake Dam at Carlson Road. The proposed structure is a 6 x 10 foot concrete box, giving the opening additional flow capacity compared to the old wooden box with twin five foot openings. The low water control is designed to be outside of the box entrance and upstream 6 feet, allowing for the control to be longer than the width of the box. A railing is provided above the box as access to remove or add boards and to clear debris from the weir from above.

Overall the new control structure is 16 feet long with 12 feet of weir. Three feet, or 25 percent of the weir is comprised of a vee notch weir that will allow for the passage of base flow. The vee shape of this weir means flow rates will increase as the upstream lake elevation rises. The bottom of the notch will be set at the current sill elevation while the top is set at the normal elevation of the top of the present boards when in place (1345 feet). When the lake elevations drop, less water will be passed downstream. As Round and Little Round Lake elevations rise and the lake elevations reach the top of the vee, the full 12 feet of weir will be available to pass flow. In the event of extreme wet periods and excessive run-off, the board can be removed, allowing for the full use of the increased capacity of the new box culvert.

Figure 6 shows the stage verse flow relation for the current Little Round Lake control structure and for the proposed new control structure design, each with boards in and out. The effects of the change in Osprey Lake backwater due to the lowering of the County Road NN culverts is included in the new design and relations shown.

The proposed design increases the Round Lake elevations as compare to the current condition without boards; however, because of the need for the base flow notch, the elevations are lower than those with the full weir at 1345 feet. The difference in lake elevation between the proposed design and the current conditions at the sill represents the water that can be stored by having the vee notch to pass base flow as compared to having boards out and the dam at the sill until flows are sufficient to add boards without restricting base flow. A change of 0.01 feet in the Round and Little Round lake surface elevation provides enough additional storage to maintain a 17.7 cfs flow for 24 hours. The difference in storage provide by having the proposed design at a flow of 17.7 cfs is 0.12 feet, enough for about 12 days of a 17.7 cfs base flow and 12 days of a higher Round and Little Round Lake elevations.

Because of the longer weir design and the lowering of the County Road NN culverts constriction, the proposed structure can pass more flow than the current dam could with all the board removed (at sill) for flows over 91 cfs with boards in place at 1345 feet. When the boards are removed, the increased capacity becomes significant for flow of 34 cfs and above. Although the RFE analysis shows the weir elevation can be raised to 1345.5 feet without changing the RFE, this board elevation impacts the low to middle range flow and is not desirable.

5.2 Regional Flood Elevation

Increasing the capacity of the Little Round Lake Dam structure without altering the downstream reach can not be permitted without flood easements, as doing so would raise the Osprey Lake 100-year flood elevation. It has been determined that the beaver dams in the reach will remain, leaving the County Road NN culverts the remaining control that can be altered. By lowering the County Road NN culverts, more water is allowed to pass through the system and the 100-year flood elevation at upstream lakes (Osprey, Round, and Little Round) would be lowered. Thus additional water can be passed thru the Little Round Lake Dam at Carlson Road without surpassing the State approved RFE of the downstream Osprey Lake.

This was achieved in the proposed SEH design by replacing the existing wooden box at Carlson Road with a larger capacity concrete box and modifying the weir structure by increasing it's length to 12 feet. With the additional capacity added to the Little Round Lake Dam the 100-year flood elevation of Round and Little Round Lakes are slightly lowered and the 100-year flood elevation of Osprey Lake is increased back to the State approved RFE. If the capacity of the Dam were increase more than what is proposed the 100 –year flood elevations of Osprey Lake would be increased beyond the RFE elevation.

Additionally, with the added capacity of the structure the weir elevation can be increased. The elevation that the low water control can be raised without exceeding the upstream lakes RFE was determined to be 1345.5 feet. If the boards are placed in the control structure at elevations beyond 1345.5 feet, the RFE of the upstream lakes would be exceeded. Table 4 shows the regional flood elevations with the new box culvert and control structure in place at the Little Round Lake Dam and alterations made to the stream reach containing the County Road NN culverts.

Table 4
Impact of New Round Lake Control Structure on 100-Year Flood Elevations (RFE Model)

Lake	Round Lake	Little Round Lake	Osprey Lake
Starting Water Surface Elevation for RFE Determination	1346.15	1346.15	1345.86
USGS Topo Map "Normal" Water Surface Elevation	1346	1346	1344
Approved 100 -Year RFE	1346.98	1346.97	1346.53
100-Year RFE w/new structure and boards in place at 1345.00*	1346.98	1346.97	1346.53
100-Year RFE w/new structure and boards in place at 1345.50*	1346.98	1346.97	1346.49
100-Year RFE w/new structure and boards removed*	1346.97	1346.97	1346.54

* Assumes County Road NN culverts are lowered as indicated in Section 4.1

6.0 Alter Little Round Lake Control Structure

6.1 Hydraulic Control

If the County Road NN culverts are not lowered, additional control at the Little Round Lake Dam can be achieved by altering the board configuration. Currently, when the Little Round Lake elevation falls below the top of the controlling board, legally, the boards must be removed and base flow allowed to pass. A new board configuration was designed by SEH that has 25% of the dam face available to pass flow with board in place at a Little Round Lake elevation of 1345.0 feet, and allows only base flow to pass at lake elevations below 1345.0 feet and until the sill elevation is reached. (Once sill elevation is reached the lake elevations are dependant on the availability of water from upstream sources.) This configuration allows low flows to pass without the need to open the entire width of the structure to meet base flow requirements and thus more water will be retained during flows between the sill elevation of 1343.7 and the elevation of the board top (1345.0), allowing lake elevations to remain higher for slightly longer periods during drought, with the severity of the drought being the controlling factor.

Figure 6 shows the stage to flow relation for the current Little Round Lake control structure and for the proposed new control structure, each with board in and boards out. The effect of the modified weir is lower lake elevations than the full weir in place at 1345 feet and higher than the dam at the sill for all flows. By adding the notch, the board can be in place at all low flows and the additional storage provided by doing so will extend the period of base

flow and increased water surface elevations of the lake as discussed in Section 5.1. However, at medium and high flows the dam constriction will result in higher lake elevation than the structure proposed in Section 5.1. Section 8 of this report compares both designs.

6.2 Regional Flood Elevation

This proposed modification to the control structure at the Little Round Lake Dam does not affect the flow capacity of the structure at high flows, thus flood elevation of Round, Little Round, and Osprey Lakes do not change as long as the top of the new board tops remains at the 1345 foot elevation.

If the County Road NN culverts are lowered, reducing backwater effect at the Little Round Lake Dam and effectively increasing its capacity, the elevation of the altered board configuration could be raised to 1345.3 feet without impacting the flood elevations of Round or Little Round Lakes. Raising the boards above 1345.30 feet would cause the RFE of the upstream lakes to be exceeded. Table 5 shows the regional flood elevations with the modified control structure at the Little Round Lake Dam with and without alterations made to the stream reach containing the County Road NN culverts.

Table 5
Impact Modified Round Lake Control Structure on 100-Year Flood Elevations (RFE Model)

Lake	Round Lake	Little Round Lake	Osprey Lake
Starting Water Surface Elevation for RFE Determination	1346.15	1346.15	1345.86
USGS Topo Map "Normal" Water Surface Elevation	1346	1346	1344
Approved 100 -Year RFE	1346.98	1346.97	1346.53
100 -Year Event w/modified boards in place at 1345.00	1346.98	1346.97	1346.53
100 -Year Event w/modified boards in place at 1345.00 and County Road NN lowered	1346.98	1346.97	1346.50
100 -Year Event w/modified boards in place at 1345.30 and County Road NN lowered	1346.98	1346.97	1346.48

7.0 Cost Estimate

An opinion of probable cost (OPC) for the structural design and construction of the proposed changes was evaluated by SEH. These OPC's include materials, construction, design, and typical permitting costs. Permitting cost of this structure could be significantly higher than a typical structure due to the complexity of the issues associated with the structure. Factors beyond the control of the County; specifically the level of public acceptance of the proposed change, will be reflected in the public comment process, the result permit requirements, and thus cost. A permitting cost estimate beyond typical was not made. Costs associated with roadway replacement are not included in the OPC's and would be minimal if restoration is to be the same as the current road surface.

Table 6
Opinion of Probable Cost of New and Modified Control Structures

OPC #1: Replace Structure with New Box and Control Structure	
Concrete Box (6' height by 10' width at 50' long)	$75,000
Integrated Approach Apron and Weir Structure	$25,000
Embankment	$10,000
Coffer Dam and Construction Flow Bypass	$10,000
Access Railings and Beam Guard	$ 2,500
Contingencies (10%)	$12,250
	$134,750
OPC #2: Keep Existing Box and Modify Present Control Structure	
Remove and Replace Structural Control	$22,000
Contingencies (10%)	$ 2,200
	$24,200

8.0 Comparison of Hydraulic Function

Figure 8 compares the stage to flow relation of the current structure and the proposed designs. Table 7 compares the RFE of the same. Since the beaver dams remain for all scenarios and are the low water control at zero flow, all scenarios begin at the elevation of the lowest point of the beaver dam (1344.95 feet). The board configuration plays a minor role in the lake elevation at these low flows because the beaver dams are controlling. However, the boards provide a control if the beaver dams fail, leak, or are removed. The proposed change of a notch in the weir to provide base flow is significant because it allows the board to remain in place at all low flows. Using today as an example, Little Round Lake is below the sill of the Carlson Road dam. With a structure containing a vee notch weir in place, if it were to rain enough that the lake rose above the sill elevation the vee weir would immediately begin to restrict a portion of the available flow while still providing Osprey Creek base flow (25% is required to pass by law). The water that was retained would go into storage, raising the upstream lake elevations. If a period of dry weather returned, this stored water would then drain out of the upstream lakes and provide an extended period of base flow to Osprey Creek. This is a win-win scenario, as the lake would have a longer period of time before extreme low water levels were reached, and Osprey Creek would have an extended period of time with increased base flows. When an extended period of wetness returns, eventually storage would no longer be required. The longer weir would gradually increase flows as upstream lake elevations rose. If necessary, the full weir could be opened to increase capacity.

Table 7
Comparison of Proposed Designs and other Controls on 100-Year Flood Elevations (RFE)

Lake	Round Lake	Little Round Lake	Osprey Lake
Current Conditions			
Starting Water Surface Elevation for RFE Determination	1346.15	1346.15	1345.86
USGS Topo Map "Normal" Water Surface Elevation	1346	1346	1344
Proposed 100 -Year RFE	1346.98	1346.97	1346.53
100-Year Event w/Dam at Sill (no boards or sediment)	1346.97	1346.97	1346.59
With Changes to Reach			
100-Year Event w/Beaver Dams In Place and NN Culverts Removed	1346.97	1346.97	1346.49
100-Year Event w/Beaver Dams Removed and NN Culverts Removed	1346.97	1346.97	1346.14
100-Year Event w/Dam at Sill, Beaver Dams Removed and NN Culverts Removed	1346.96	1346.95	1346.21
100-Year Event w/Carlson Road Dam Gone, Beaver Dams Gone, and NN Culverts Removed (Clear Channel to Osprey Creek)	1346.95	1346.93	1346.34
With a New Structure			
100-Year RFE w/New Structure and Boards In Place at 1345.00*	1346.98	1346.97	1346.53
100-Year RFE w/New Structure and Boards In Place at 1345.50*	1346.98	1346.97	1346.49
100-Year RFE w/New Structure and Boards Removed*	1346.97	1346.97	1346.54
With Modification to Existing Boards			
100-Year Event w/Modified Boards In Place at 1345.00	1346.98	1346.97	1346.53
100-Year Event w/Modified Boards In Place at 1345.00 and NN Lowered	1346.98	1346.97	1346.50
100-Year Event w/Modified Boards In place at 1345.30 and NN Lowered	1346.98	1346.97	1346.48

9.0 Recommendations and Conclusions

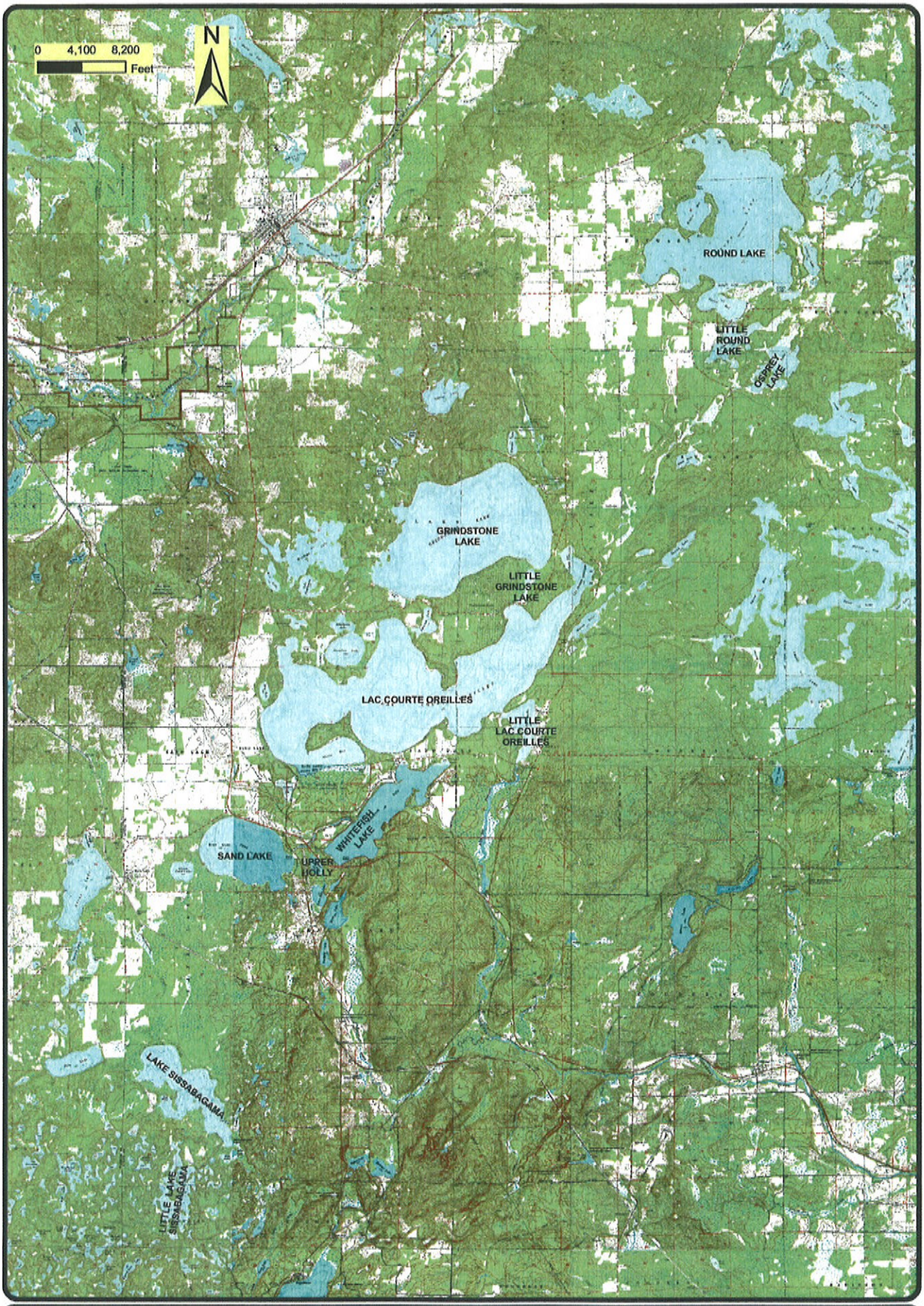
Historic lake water surface elevations summaries, previously prepared by others, are found in the appendixes to this report. Historically, boards have been place at around the 1345 foot mark. Water surface elevations within the range of 1344.5 feet to 1345.25 on Round and Little Round Lake are generally not of concern as documented by the lack of measurement made at these elevations. Outside this range the level of concern goes up. The 1941 PSC order indicates a range of 1344.75 to 1345 feet is desirable. On July 25, the Round Lake Property Owners Association made a formal proposal requesting the County consider an operation range of 1344.15 feet to 1345.65 feet for Round and Little Round Lakes.

Extremes in lake elevations in the chain are also common as evidenced by the record of historical lake levels. Lake elevations have been recorded on Round Lake as high as 1351.09 feet at the turn of the century and as low as 1340.51 feet during the dust bowl era of 1929-34. The recent Historical High Watermark for Round Lake is considered to be 1346.15 feet and the lake was recorded at a low point of 1343.62 feet in 1976. It was again several inches below the dam sill (1346.7 feet) in the summer of 2007. These extremes are associated with longer term climatic extremes (drought and extended wet periods). The historical record also indicates some of the higher flows maybe associated with reduced capacity of Osprey Creek downstream of County Road NN. Less information is available for the historic levels of Osprey Lake, but Osprey Lake elevation is generally considered to be as, or more, variable than Round and Little Round Lake elevations.

If County Road NN culverts are lowered, the proposed new box culvert with the control structure on the approach apron is the best design to allow the lakes to be maintained closest to the preferred elevations. The weir and boards control structure at 1345.0 feet will allow for low water control in the event the beaver dams down stream were to fail or leak while still passing base flows as required. The added capacity of the new box and wider control structure allows additional water can pass and still maintains the RFE of both the upstream and downstream lakes. It allows for greater relief of flooding when necessary.

If the County Road NN culverts can not be lowered, the board configuration on the box structure should be modified to provide a vee notch weir for low water control. The condition of the current structure should be considered prior to modifying the control for the structure. Given the condition of the current wooden box, a new box may need to be installed prior to modifying the low water control. If the County Road NN Culverts are not lowered the new box would need to have the same hydraulic capacity as the current box or RFE elevations will be exceeded either upstream (if replaced with less capacity) or downstream (if replaced with more capacity).

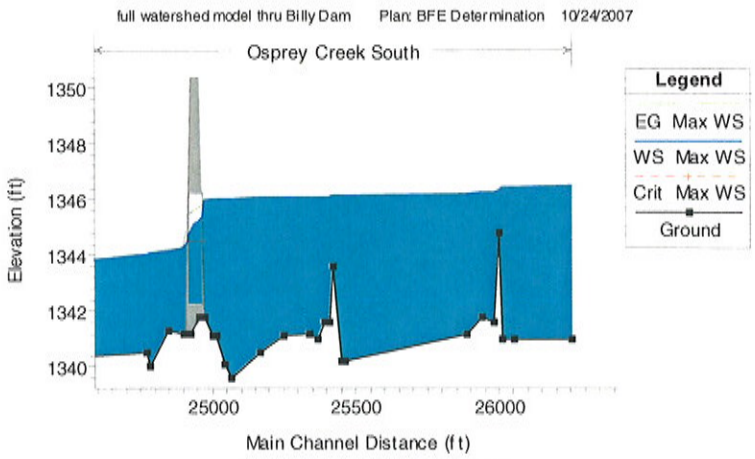
Figures



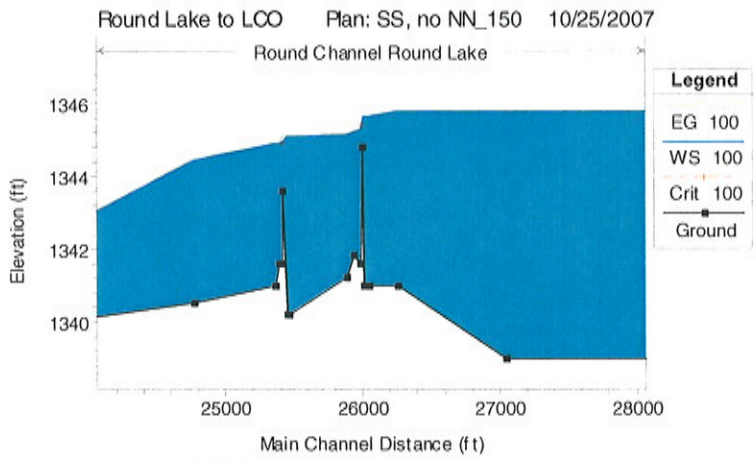
REVISIONS	DATE

FIGURE 1
STUDY AREA

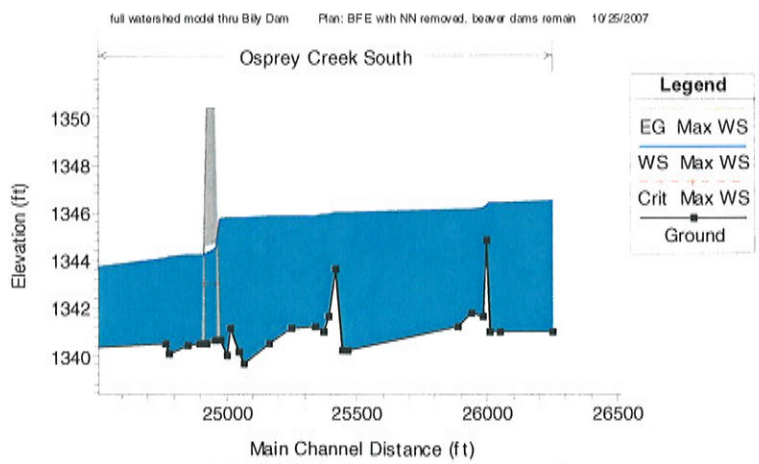
Map Created
12/18/2006



Current Conditions



CTH NN Culverts Removed



CTH NN Culvert Lowered

Figure 2. Cross Section Modification at County NN Culverts

Figure 3. Model Results of Osprey Lake Hydraulic Controls - CTH NN Modification

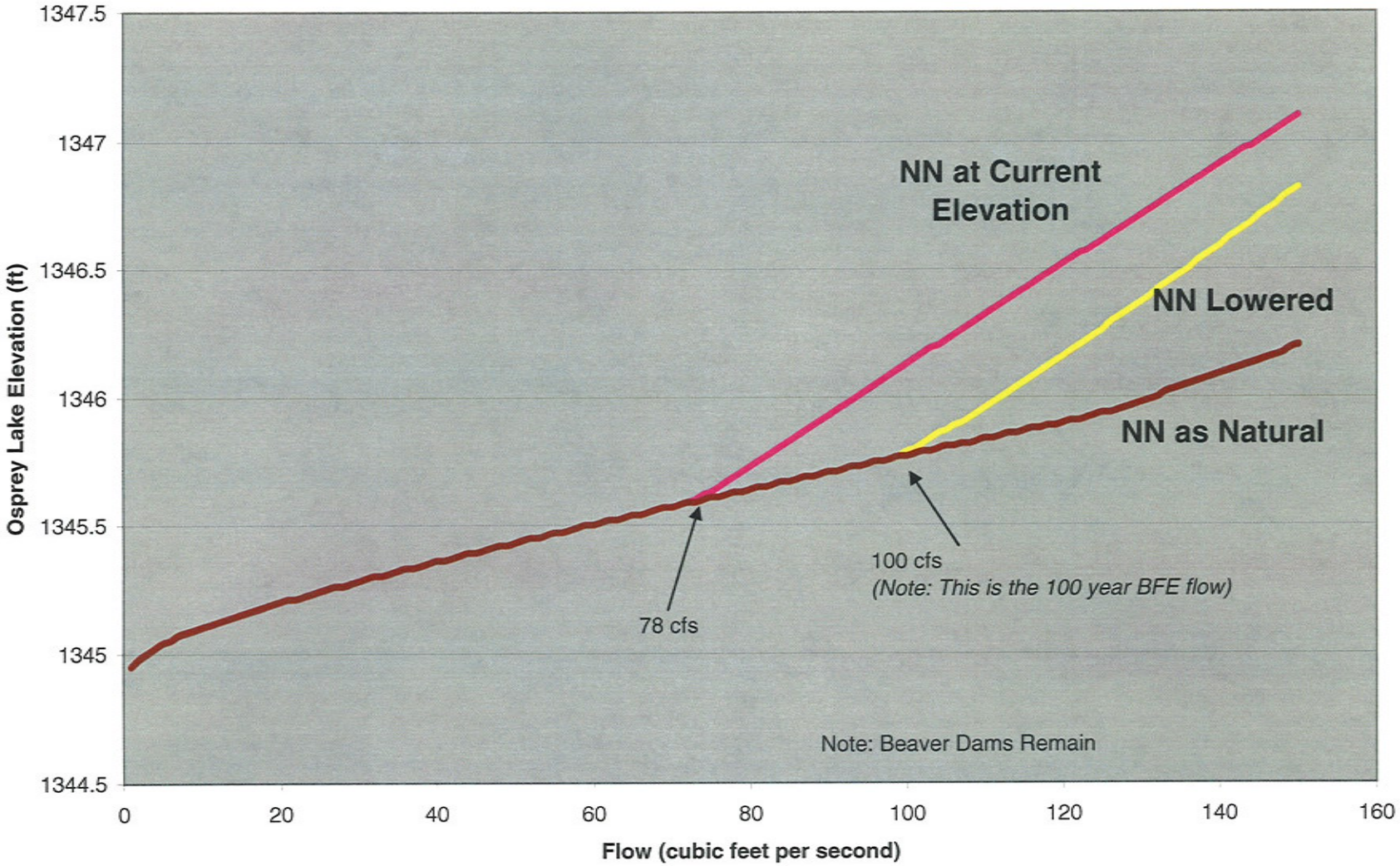


Figure 4. Model Results of Round and Little Round Lake Controls - CTH NN Modification

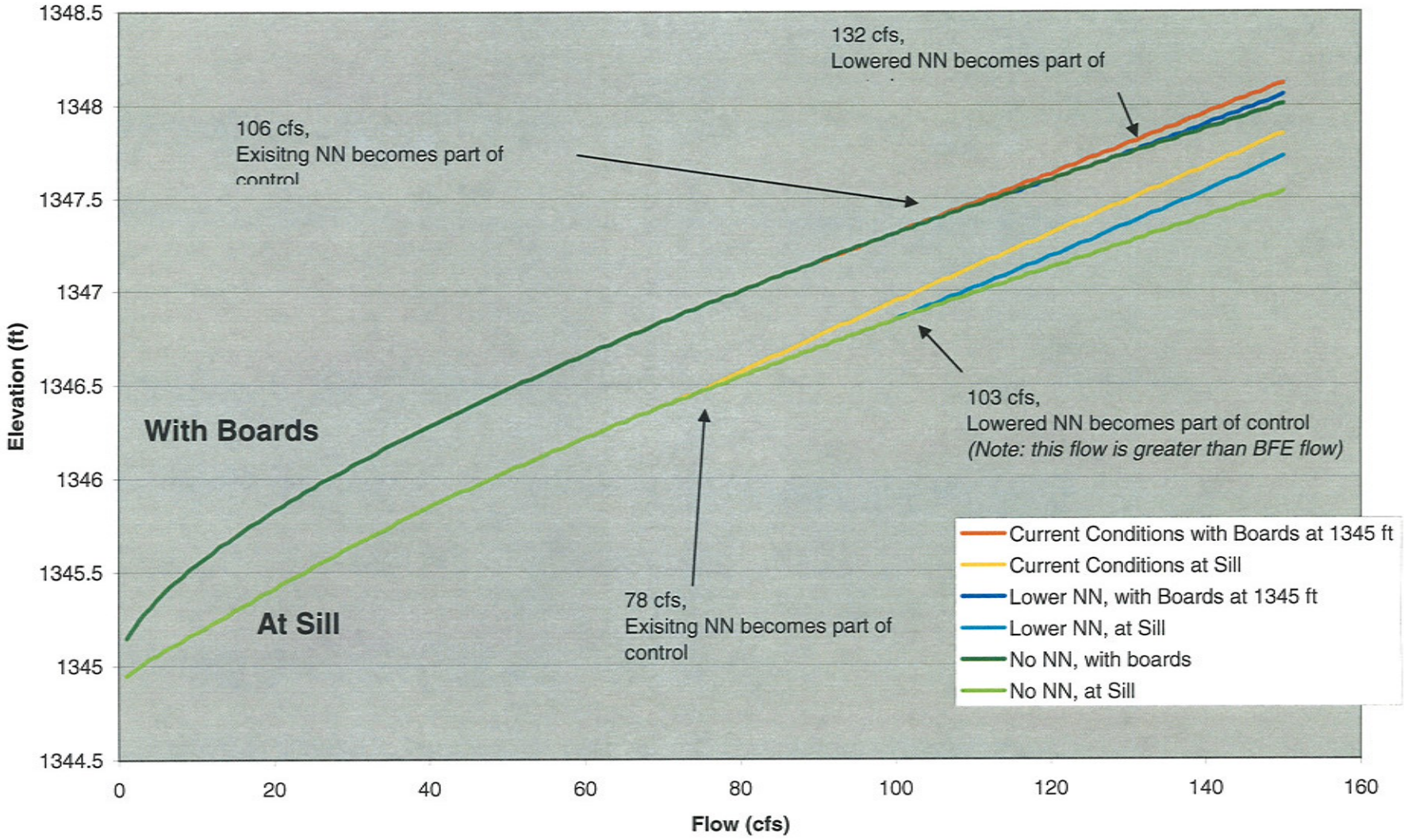


Figure 5. Artist Rendition of Proposed New Little Round Lake Control Structure

Figure 6. Model Results of Round and Little Round Lake Hydraulic Controls - New Little Round Lake Control Structure

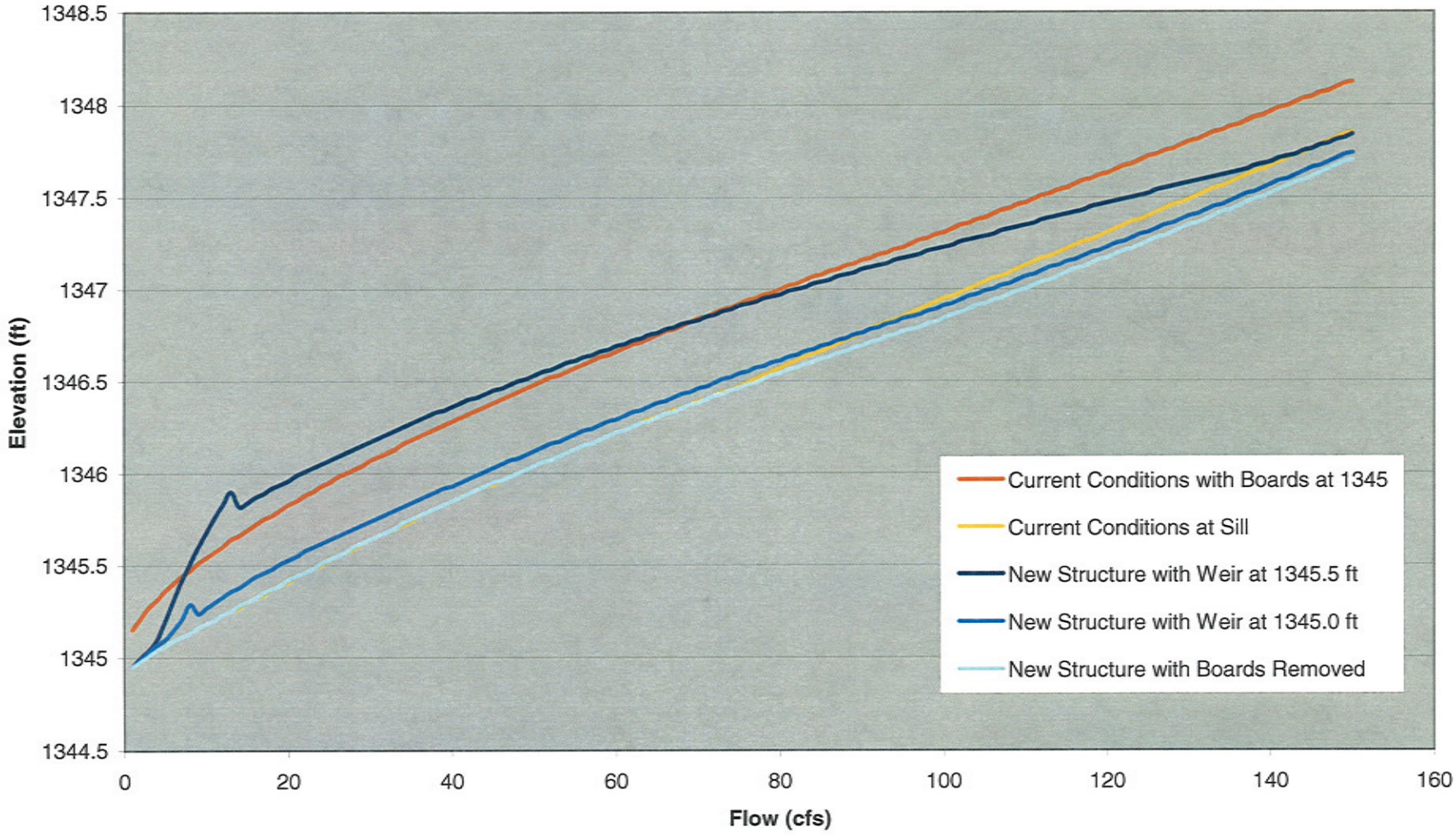


Figure 7. Model Results of Round and Little Round Lake Hydraulic Controls- Modified Little Round Lake Control Structure

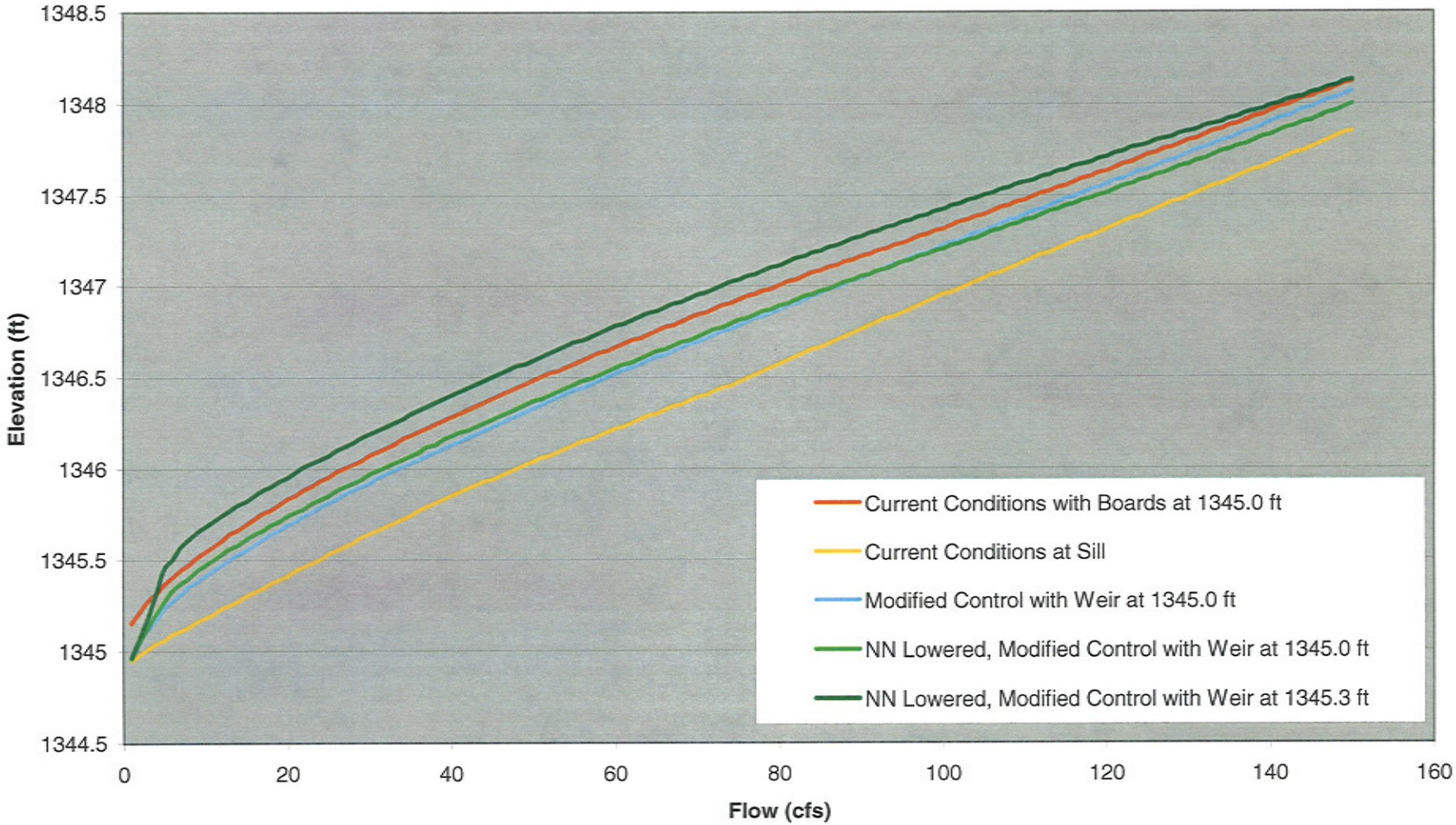
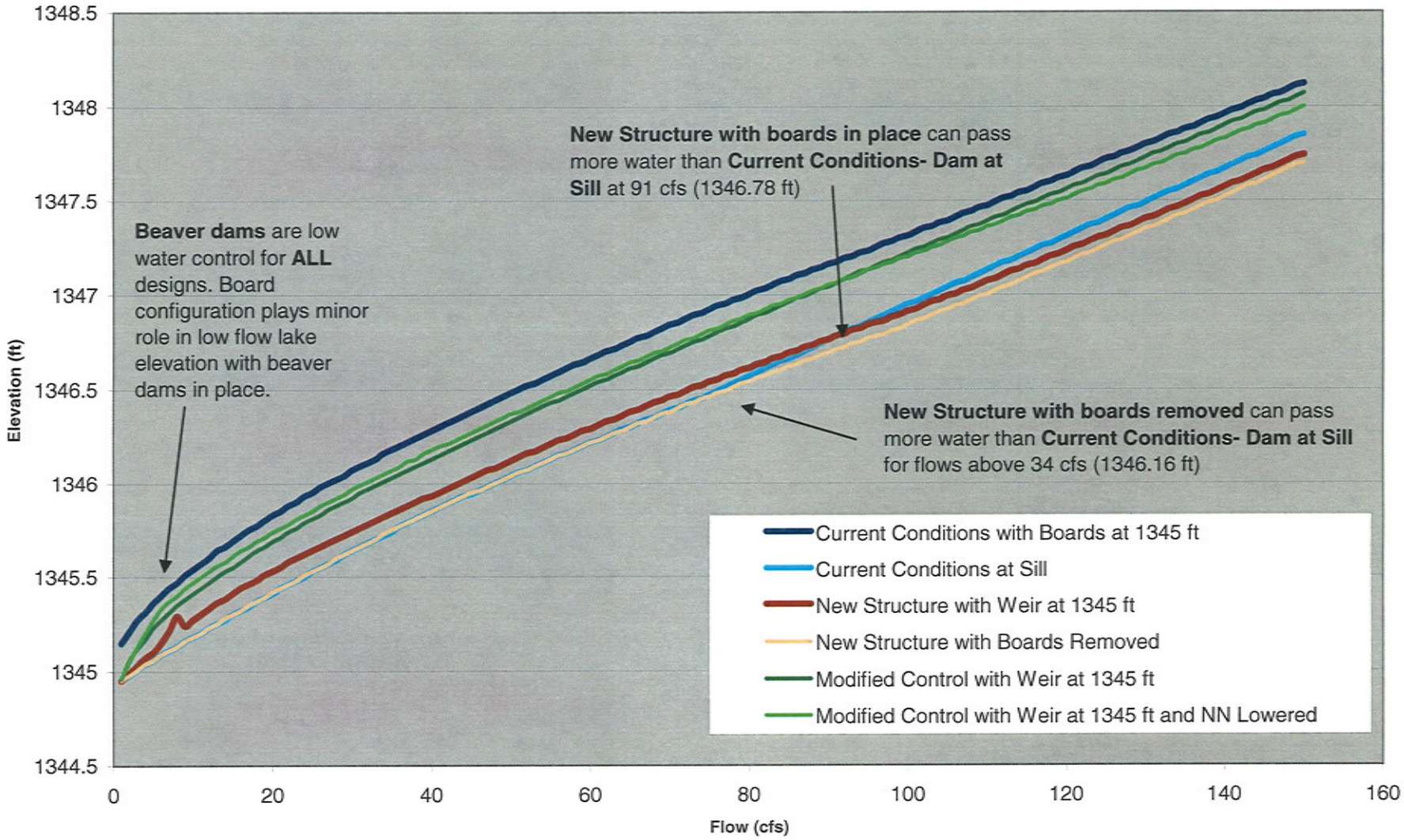


Figure 8. Comparision of Designs Hydraulic Function



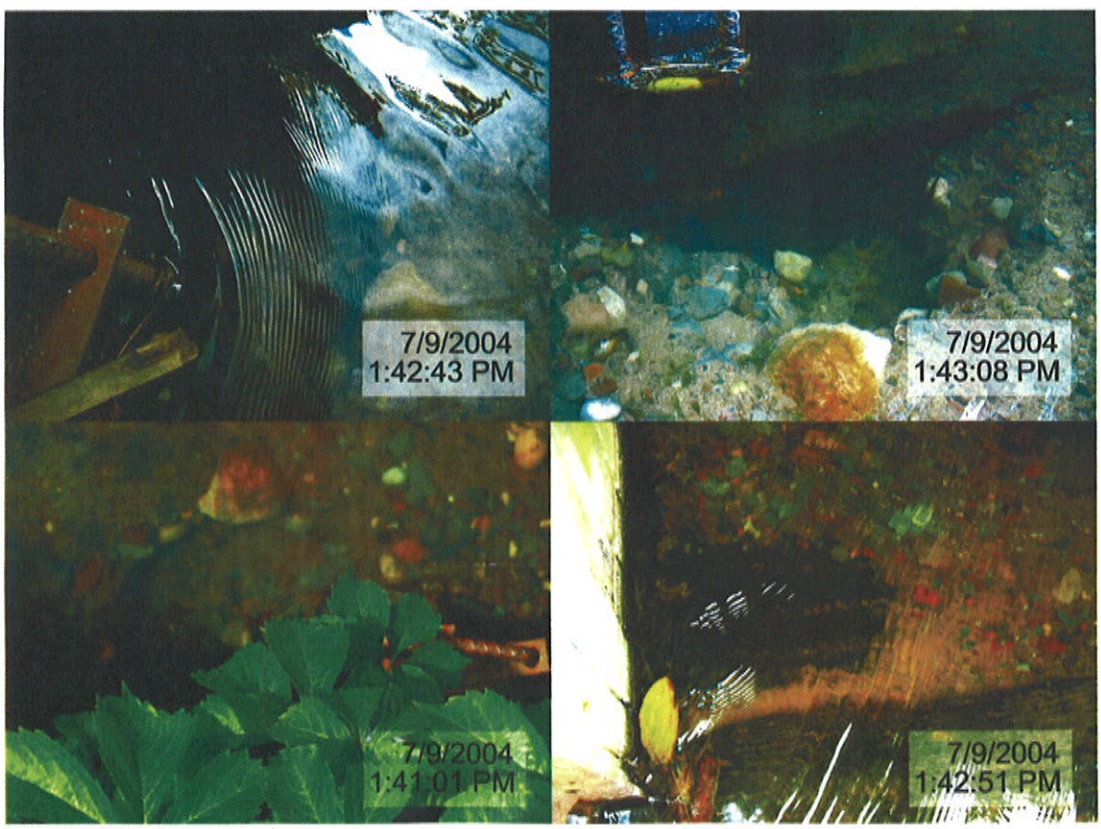
Appendix A

Photo Log

Upstream face of CTH B bridge between Round Lake and Little Round Lake
November 2006

Downstream side of CTH B bridge
November 2006

Upstream face of Little Round Lake Dam (note gage on right wingwall)
November 2006



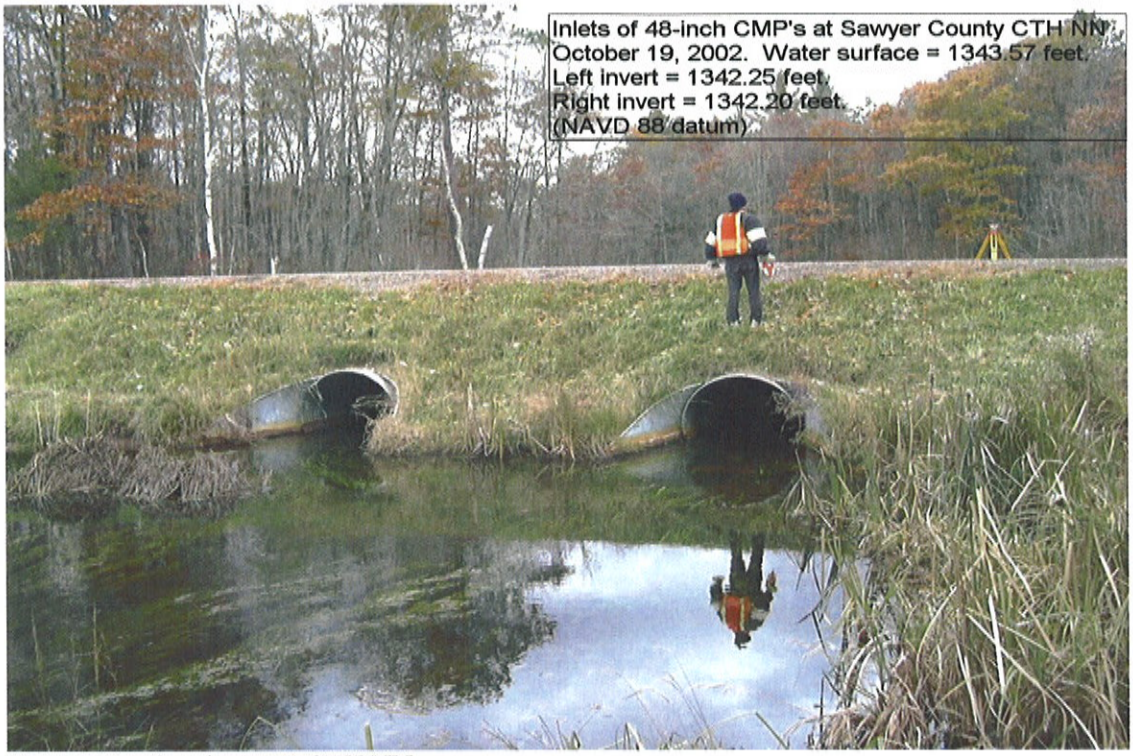
Sill of Little Round Lake Dam

Osprey Creek channel looking downstream from Little Round Lake Dam
Spring 2002

Beaver dam in Osprey Creek between Osprey Lake and CTH NN culverts

Looking upstream from right (north) side of beaver/debris dam at Osprey Lake outlet
October 2002

Osprey Creek looking downstream from CTH NN
October 2002



Osprey Creek culverts at CTH NN
October 2002

CTH NN roadway at Osprey Creek
November 2006

Osprey Creek looking downstream of CTH NN culverts
October 2002

Osprey Creek at old Snowmobile Bridge (near Green Lake)
November 2006

Appendix B

Historical Recorded Lake Elevations from RFE Study

Summary of Round Lake Water Levels

Date	NAVD88 Elevation (feet)	Comments
1896	1350.59	
1900	1351.09	
1906	1344.92	
1921	1348.09	
1922	1345.19	
1926	1341.19	
1929	1344.53	
1933	1340.51	
1934	1341.34	
10/30/1935	1340.51	
6/26/1941	1344.55	On east shore with strong inshore west wind
7/29/1941	1344.7	
12/2/1941	1345.75	
1/24/1942	1345.95	
4/7/1942	1346.35	
5/29/1942	1346.7	
6/7/1942	1347	
6/14/1943	1346.15	Obstructions . . . marshes, snags, beaver dams
6/29/1944	1346.15	
7/31/1945	1346.15	Diversion dam O.K.
11/19/1946	1345.27	
5/7/1947	1346	Water coming in from Tiger Cat Flowage
6/26/1947	1345.85	
12/2/1947	1358.79	Tiger Cat Flowage Dam
12/2/1947	1345.05	Top of ice at Round Lake
12/2/1947	1346.15	High water mark at Round Lake
9/8/1958	1345.7	
7/16/1959	1345.12	
5/13/1960	1345.48	Referred to 879-B benchmark
6/7/1961	1345.45	Referred to 1127-A benchmark
6/16/1965	1345.09	
7/21/1966	1345.53	at CTH B
7/21/1966	1351.44	BM 1127-D
7/7/1967	1345.94	
4/25/1968	1345.56	
10/26/1968	1345.71	
11/17/1969	1344.98	
8/18/1970	1344.93	
8/2/1972	1345.5	
4/16/1974	1344.99	
7/2/1974	1345.1	
11/11/1976	1343.62	
4/5/1977	1344.07	
7/24/1978	1345.34	
8/24/1978	1345.31	
6/21/1979	1345.38	
6/22/1981	1345.35	
6/15/1989	1344.54	
5/4/1990	1343.93	
3/31/1992	1345.55	
4/20/2001	1345.53	
6/3/2002	1345.45	
6/28/2002	1345.57	
10/19/2002	1345.39	No stoplogs
8/10/2003	1345.305	
5/7/2004	1345.04	3-4 inch rain within last two weeks
6/30/2004	1345.1	
7/5/2004	1345.02	
12/17/2004	1344.84	
2/17/2005	1344.86	

Appendix C

Historical Lake Elevations from Round Lake Association

Carlson Dam

9-21-2007 → recd from Al Reinemann

	8/25/01	77.10
	spring of 02	78.15
Down .80	6/1/02	77.60
4 months	7/1/02	77.45
	8/24/02	77.35
	8/22/03	76.9
	7/13/06	76.45
	7/19/06	76.35
	7/25/06	76.20
	7/30/06	76.50
Down .50	8/5/06	76.65
6 1/2 weeks	9/22/06	76.15

Aug 01 to spring of 02 up 1.05

spring 02 to Aug 02 Down .80

Aug 06 to Sept 06 Down .50