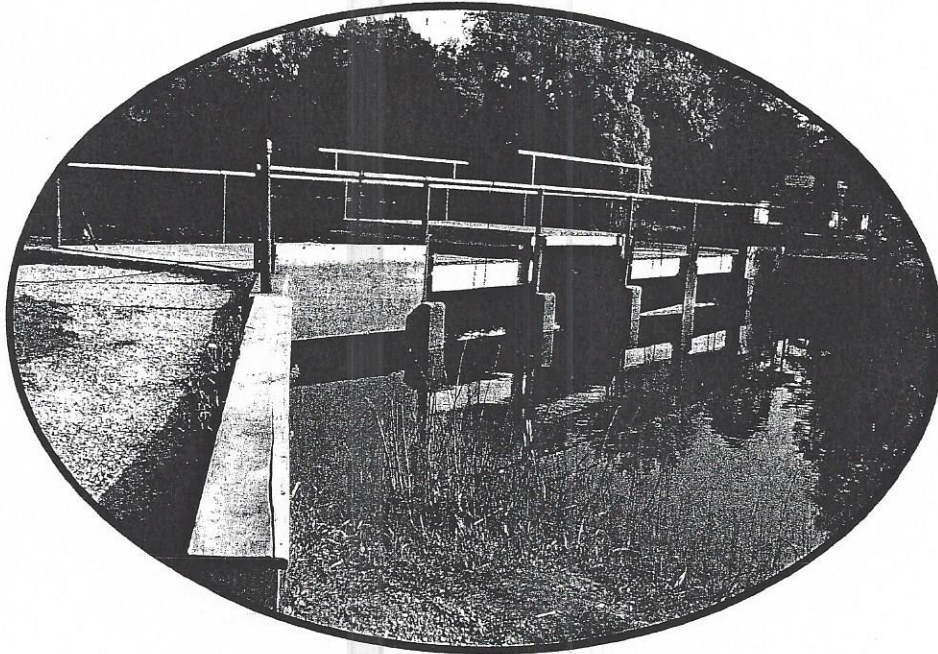


# Houghton Lake Level Control Structure 2010 Engineering Report

State Identification No.: 2014  
NW Quarter of Section 10, T23N, R04W  
Lake Township, Roscommon County, Michigan  
Located on the Muskegon River  
Per Part 307, Act 451 of 1994



**Prepared for:**

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Date of Report: December 14, 2010  
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**TABLE OF CONTENTS**

<b>I. SUMMARY .....</b>	<b>2</b>
<b>II. BACKGROUND.....</b>	<b>3</b>
<b>III. INSPECTION.....</b>	<b>6</b>
A. Top Deck and Railing .....	7
B. Center Piers .....	7
C. Wing Walls and Abutment Walls.....	7
D. Gates and Operational Features.....	7
E. Apron Concrete .....	8
<b>IV. LAKE LEVEL.....</b>	<b>8</b>
<b>V. HYDRAULICS.....</b>	<b>10</b>
<b>VI. RECOMMENDATIONS.....</b>	<b>13</b>
A. Findings of Structural Inspection .....	13
B. Gate System Improvements .....	13
C. Gages.....	14
D. Operation Guidelines.....	15
1. Summer Level (NGVD 1138.10).....	15
2. Winter Level (NGVD 1137.60).....	17
3. Adjusting Lake Level.....	18
<b>VII. PLANNING LEVEL COST ESTIMATE .....</b>	<b>18</b>
<b>APPENDIX A .....</b>	<b>19</b>
<b>APPENDIX B.....</b>	<b>21</b>
<b>APPENDIX C .....</b>	<b>29</b>
<b>APPENDIX D .....</b>	<b>31</b>
<b>APPENDIX E.....</b>	<b>33</b>

## I. SUMMARY

The Roscommon County Board of Commissioners has commissioned Spicer Group to complete an engineering analysis of the Houghton Lake Level Control Structure (LCS). Spicer Group has prepared this report to summarize the conclusions and recommendations of the engineering analysis. This report should be adopted as a guideline for the County related to needed improvements, maintenance and operational changes for the Houghton Lake LCS.

The scope services, as requested by the County, that were completed by Spicer Group and summarized in this report include:

- Inspection of the existing lake level control structure (LCS) and development of recommendations to address deficiencies observed.
- Calculation of the hydraulic capacity of the LCS and development of recommendations to address deficiencies determined.
- Analyze historical lake level data and, based on that data, develop recommendation regarding operation of the LCS related to maintaining established legal lake levels.
- Preparation of initial planning level costs to implement recommendations.

The general conclusions of the analysis are outlined in this paragraph. Improvements to the operational features and procedures of the LCS are needed. Repairs to a damaged pier on the structure should be made. Scour protection in targeted locations should be added. The overall structural condition of the LCS is good. The hydraulic capacity of the LCS is adequate, relative to the downstream river capacity. The recorded lake levels, on average, are above the established legal lake levels each month of the year.

It is recommended that motorized gates be installed, a new stop log system be installed, the damaged pier be repaired, targeted scour protection be added and the monitoring system be improved. The planning level cost estimate for these items is \$670,000. This estimate includes five (5) new motorized slide gates, one (1) new stop log system, new metal decking and rails, new lake level control sensors, new electrical and internet service, concrete repairs and scour protection. It also budgets for engineering, permitting and administration of construction costs.

It is recommended to modify the operational features and procedures to improve the ability to maintain the lake level closer to the established legal lake level. This requires increasing the discharge from the lake with the objective to lower, on average, lake levels to be more consistent with the legally established levels.

The conclusions and recommendations of this report are based on the county operating to the currently ordered and established lake levels. Should, in the future, revisions to be legal lake level be desired for consideration, an analysis to determine the feasibility should be completed in conjunction with proceedings in accordance with Part 307 of Public Act 451 of 1994.

The following sections of this report outline this engineering analysis and the formulation of the conclusions and recommendations.

## II. BACKGROUND

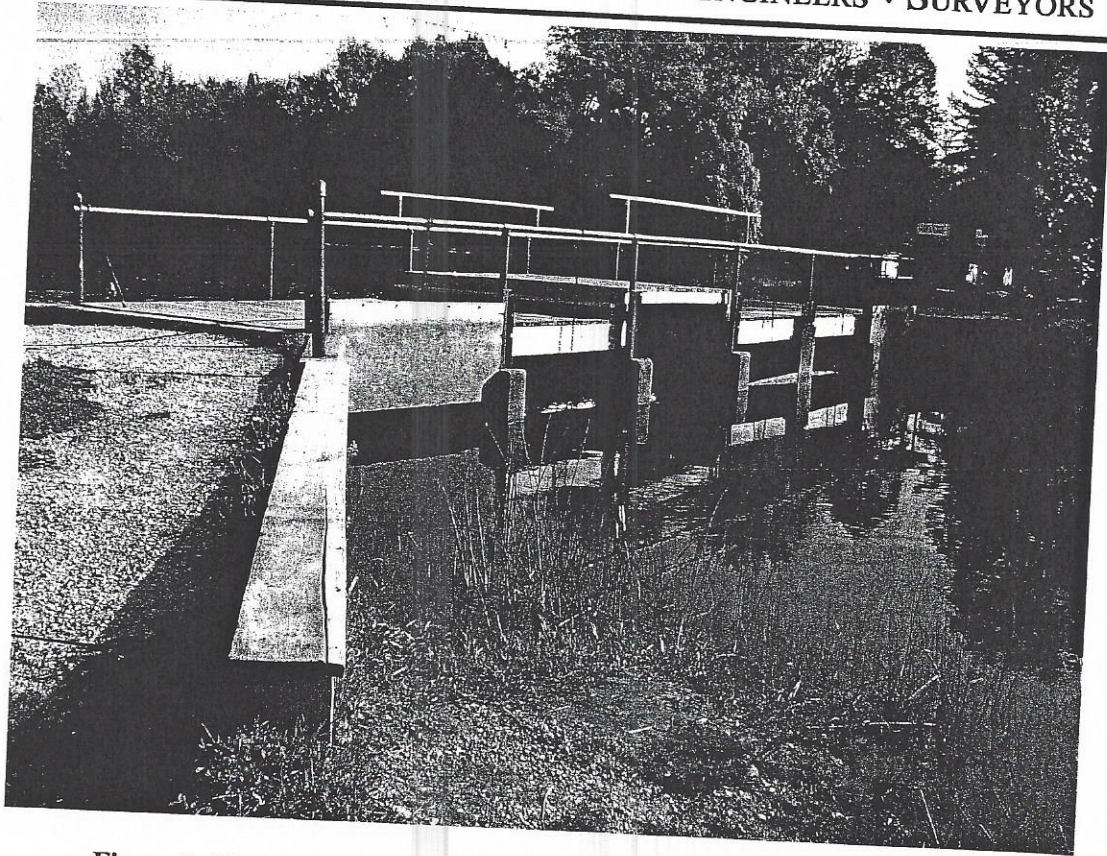
This section outlines Spicer Group's understanding of the background and history of the LCS. The understanding is based on records and information that was provided by Roscommon County.

The legal lake level in Houghton Lake is dictated by an order issued in 1982 by a Roscommon Circuit Court, in accordance with Part 307. The legally established summer level is 1138.1 feet and the winter level is 1137.6 feet. Also, there is a prior court order from 1962 establishing the legal summer level. The 1982 order does not specify the elevation datum but since the order precedes 1988, it is assumed the elevations are NGVD '29.

In accordance with Part 307, Roscommon County is responsible for the operation, maintenance, and improvement of the LCS. The purpose of this analysis and report is to provide the county with conclusions and recommendation consistent with their responsibilities.

The Houghton Lake Level Control Structure (LCS) was constructed in 1938. According to a 1954 report by the Michigan Department of Conservation Engineering and Architecture, the current concrete structure was constructed to replace a logging era wooden structure. An original engineering plan set of the structure has not been provided. It appears that the LCS was constructed with concrete abutments, wing walls and concrete piers to form six (6) bays which water could flow through. The underlying foundation design is not clear at the present time, but is assumed adequate as the structure is in good condition given its age. Water flow was regulated through the bays using a combination of stop logs and vertical slide gates. It is believed that the LCS as currently existing has not had significant structural modification since its construction.

Figure 1 shows a picture of the existing LCS. A more detailed drawing of the LCS is shown in Appendix A. The LCS consists of a wooden deck covering six (6) bays with nominal seven (7) foot spans. Flow through five (5) of these openings is controlled by wooden vertical slide gates. Some of these five (5) bays also have stop logs in them. One (1) bay is controlled exclusively by a system of stop logs.



**Figure 1: Upstream face of the Houghton Lake Level Control Structure**

Operation of the LCS is entirely manual. Vertical wooden slide gates are hoisted out of the water by hand and secured in an open position by chaining the gates to the structure's hand rail.

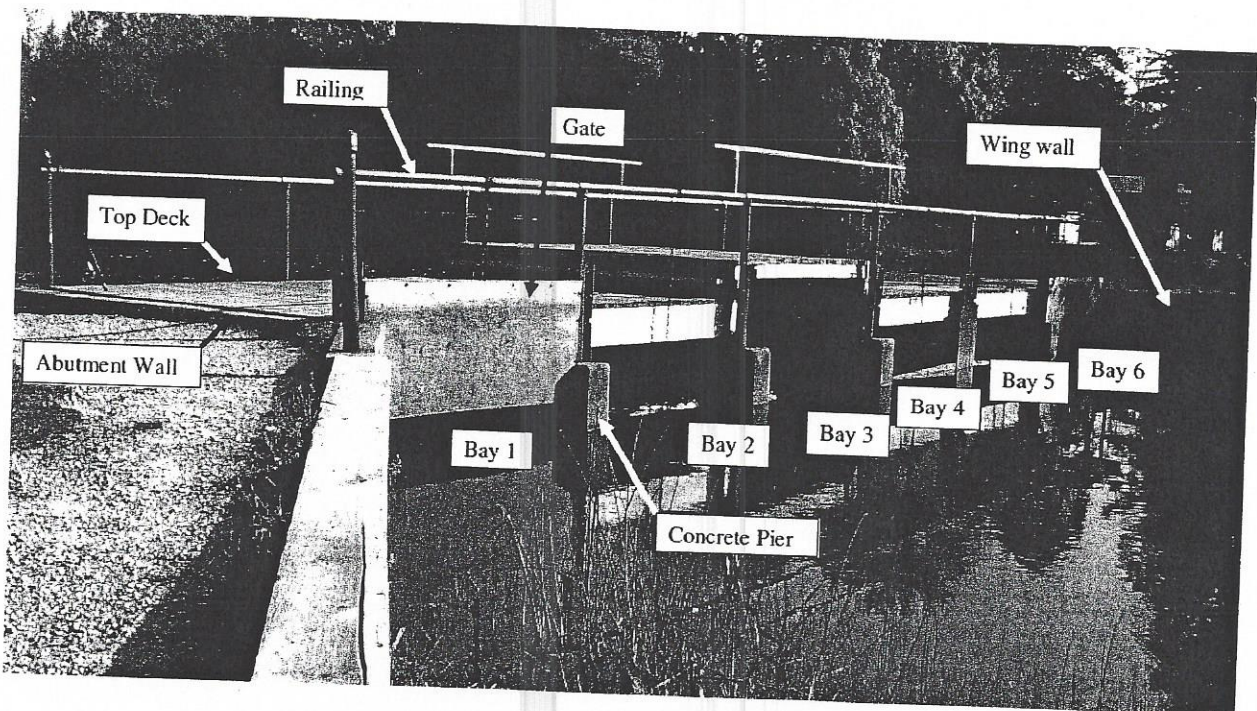
A comprehensive study of the LCS was completed by Ayres, Lewis, Norris and May Consulting Engineers in 1969. The structural configuration of the LCS at that time is similar to present day. The report concluded that the LCS provides adequate capacity and the report recommended that the gate system of the LCS be improved. Several of the findings and conclusions of the 1969 report, specifically with respect to downstream Muskegon River, were assumed as and used for this current report (as completion of study of the downstream river system was beyond current scope). The 1969 study concluded that the peak flow capacity of the Muskegon River is less than the capacity of the LCS, thus the river is the controlling element during high flow conditions.

The county has completed regular inspections of the LCS structure and has performed minor maintenance and repairs over the years.

Recently, the Board of Commissioners has received public comments related to the lake levels of Houghton Lake. This prompted the Board of Commissioner to have this evaluation completed.

### III. INSPECTION

A thorough visual inspection of the Houghton Lake LCS was completed by Spicer Group on July 27, 2010. This inspection included a visual surface inspection and an underwater inspection. A diver was employed to do an underwater visual inspection of the structure. A detailed drawing of the findings of the inspections and associated photographs are shown in Appendix B. A labeled overview of the structure is shown in Figure 2.



**Figure 2: Components of Houghton Lake LCS from upstream face.**

*A. Top Deck and Railing*

The deck is constructed of treated wood deck and is in generally good condition. The steel pipe railing has some rusting but is considered in sound condition.

*B. Center Piers*

The nose of the pier dividing Bays 4 and 5 is missing and has been replaced by a steel plate. Additionally, the upstream end of this pier has several large cracks and areas of spalled concrete. Cracks and areas of concrete spalling are found on both sides of this pier. Also, reinforcing steel has been exposed in sections this pier.

Minor concrete spalling was reported on the upstream pier nose between Bays 2 and 3.

Generally, the condition of the concrete center piers is considered good with the exception of the pier between bay 4 and 5, as explained above.

*C. Wing Walls and Abutment Walls*

Wing walls and abutment walls appear to be in good condition with only minor areas of spalled concrete. Rebar is not presently exposed.

*D. Gates and Operational Features*

The gates and operational features are in poor condition. Gates are constructed of plywood framed with steel. Gates are held open by affixing a chain to the structure's handrail. The operation of these gates is labor intensive and susceptible to tampering. The gate guide between Bays 4 and 5 has broken off with the pier nose. It has been replaced with a steel plate. In several of the bays, stop logs are used in conjunction with sluice gates to control lake level. In Bay 6, these stop logs do not appear to sit flush with the bottom sill.



*E. Apron Concrete*

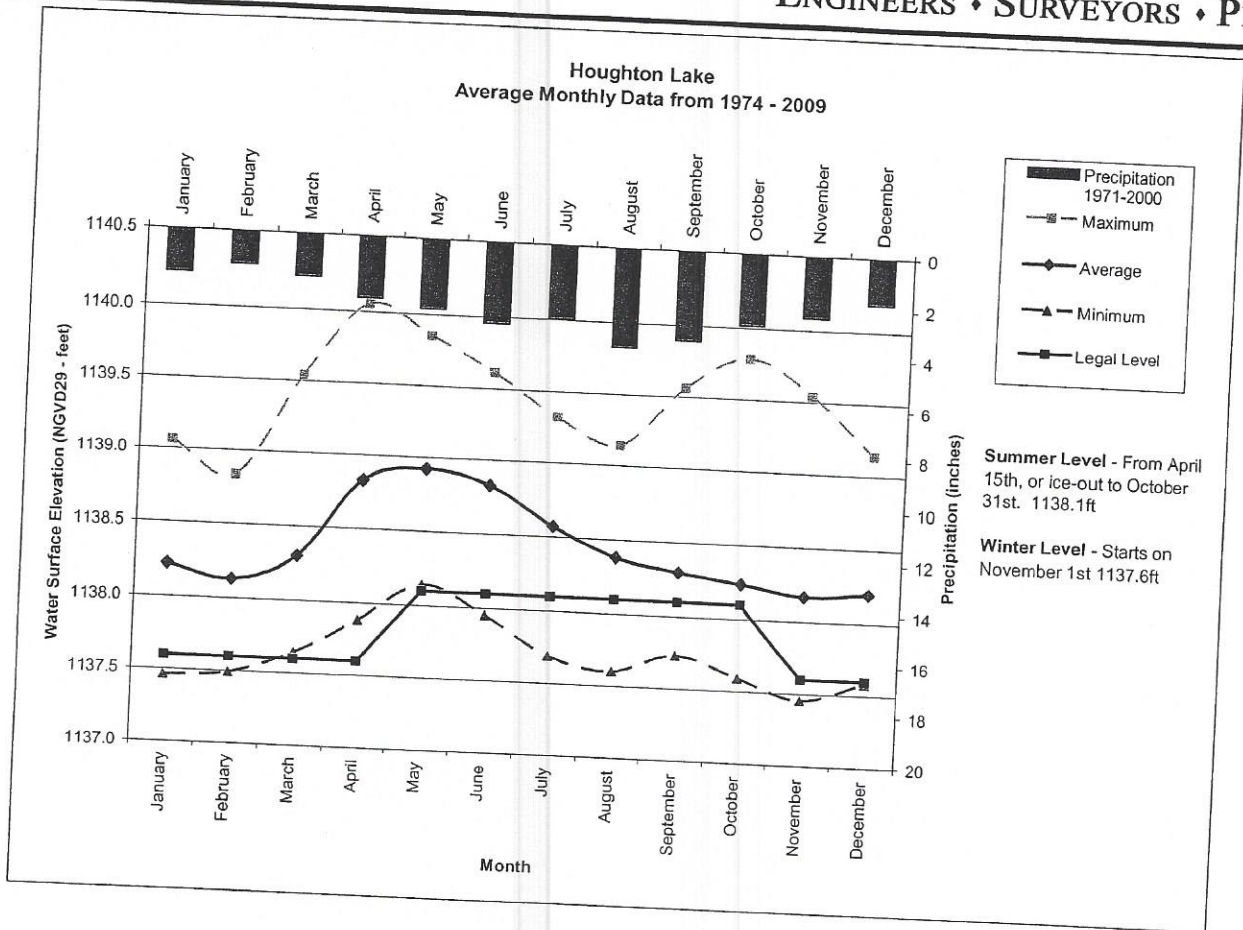
The concrete apron slab underneath the structure is in fair condition. Some scour has occurred along the downstream edge of the apron. In one location between Bays 4 and 5, the scour has begun to undermine the apron slab. Some scour has begun to occur along the upstream side of the apron as well however, undermining was not observed.

**IV. LAKE LEVEL**

In 1982, a court order established the legal level of Houghton Lake at 1138.1 feet for summer months and 1137.6 feet between November 1 and April 15, or ice-out, whichever occurs first. The 1982 order amended the previous 1962 order for which only a legal summer lake level was set at 1138.1 feet.

Lake level data were obtained from USGS gage # 442400084472801. For the period of record from 1974 to 2009, the lake level average was 0.1 to 0.8 feet above the legal level during summer months and 0.5 to 0.7 feet above the legal level during winter months. This comparison is shown below in Figure 3.

Average monthly precipitation data shown in this graph was collected by the Michigan State University Climatologist's Office using a gage located near Houghton Lake for the years of 1971 through 2000.



**Figure 3: USGS gage data for Houghton Lake**

The highest lake level recorded in this period was 1.95 feet above the legal level as measured in April of 1985. The second highest was 1.68 feet above the legal lake level as measured in May of 1986. Rainfall records from a NOAA gage at the Roscommon Airport indicates that 2.4 and 3.2 inches of rain, respectively, occurred in the months of the indicated years. Records of operation at the LCS for these periods have not been evaluated and likely do not exist.

Records indicate that lake levels have fluctuated up to 2.5 feet. Fluctuation of lake level above the legal lake level is a likely indicator of limited hydraulic capacity of the Muskegon River. Additional discussion regarding the hydraulic capacity of the system is provided in the Hydraulics section of the report.

Records indicate, on average, the lake is maintained above the legal level. This could be attributed to many factors including limited downstream river capacity, operation procedures or difficulties, and/or public input regarding the level. Roscommon County is responsible for maintaining the lake level, on average, at legal level, bearing in mind that fluctuation will occur and it is not feasible to maintain the lake at the exact level continuously or consistently. Also, if the downstream river does not have adequate flow capacity, the ability to operate the lake level during large runoff events is diminished.

#### V. HYDRAULICS

An assessment and basic calculation of hydraulic capacity of the Houghton Lake LCS was completed. In performing the assessment, Spicer Group first reviewed the previous study, being the 1969 report. The 1969 report indicates that the channel between Houghton Lake and the Reedsburg Pond has a peak flow capacity less than that of the LCS. The report recommended that channel improvements be made to increase flow capacity of the river. Such improvements are not believed to have been constructed. It is assumed that the finding of the 1969 study is still applicable in the conclusion that the capacity of the LCS is adequate and overall peak capacity is limited by the Muskegon River. This is expressed graphically in Figure 4.

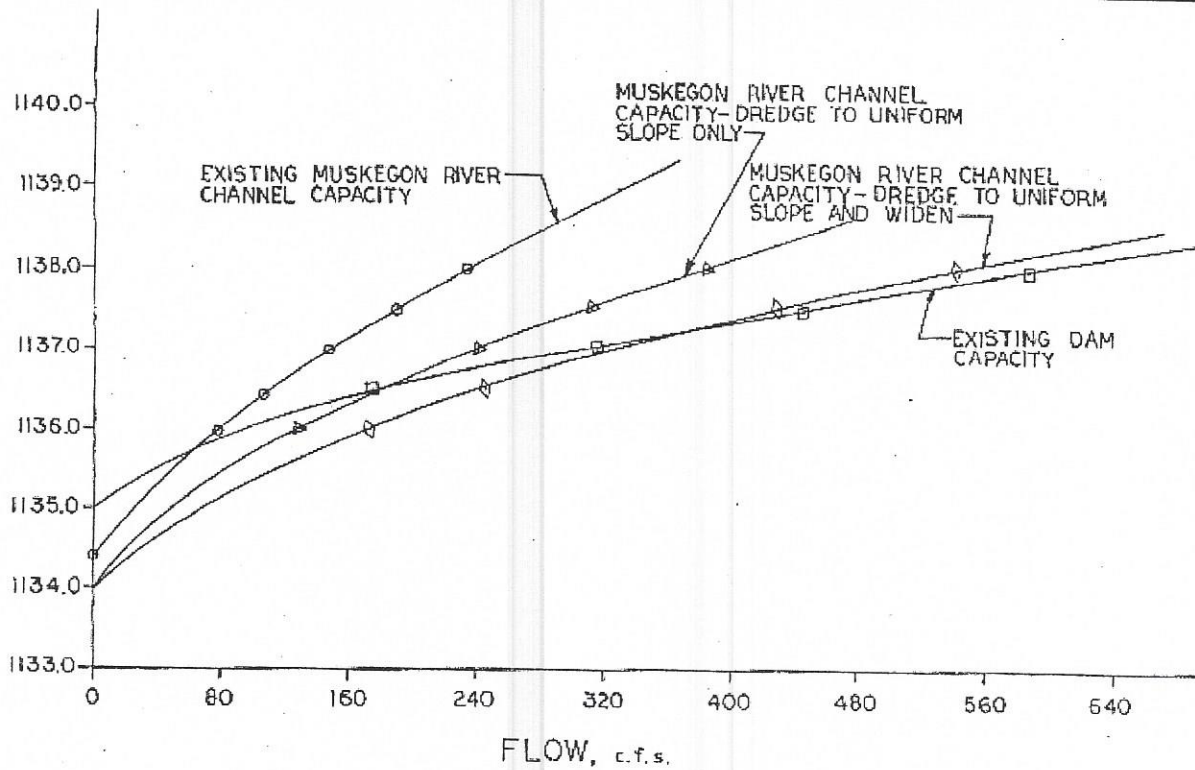


Figure 4: Houghton Lake Outlet System Capacity (Ayres, Lewis, Norris & May, 1969).

A discharge request filed with the Michigan Department of Natural Resources and Environment (MDNRE) on June 9, 2010, reported a 100-year peak flow at the Houghton Lake LCS of 950 cfs. Based on conversation with the MDNRE staff, this flow rate was determined by interpolating flow data from the downstream river gauging station at USGS gage #04121000. The station is located below the Reedsburg Dam. Flow information was also provided in the 1969 report. This report stated the 25-year design storm produces an average inflow to Houghton Lake 1,525 cfs over a 96-hour period. This flow rate, if stored entirely within the lake would be enough to raise the lake by approximately 0.6 feet (1.8 inches/day). This rise would be lessened by the amount of discharge leaving the lake via the Houghton Lake LCS. It is noted that the obtained flow rates were developed without gage data collected in close proximity to the LCS.

A hydraulic calculation was completed using Culvertmaster software, assuming the 100-year design flow rate of 950 cfs as provided by the MDNRE. The calculation was completed assuming that all stop logs were removed and gates opened. Under these conditions, the hydraulic characteristics of the LCS were considered similar to a series of six (6) parallel barrels of six (6) foot by six (6) foot box culverts. Within these parameters, it was calculated that the LCS would pass MDNRE 100-year design at its highest recorded level of 1140.05 feet if the downstream tailwater was at 1139.00 feet. In this condition, approximately one (1) foot of head is required. This calculation is shown in Appendix C. By interpolating Figure 4 at the calculated tailwater elevation, the river can only convey 320 cfs.

Based on this, it is predicted that the LCS has adequate capacity to convey the flow at a rate greater than the river can accept. Based on this, providing additional capacity to the LSC is of no benefit.

It is predicted that fluctuation in lake levels during large runoff events should be expected due limited capacity. The extremes of these fluctuations may be tempered to by enhanced operation of LCS, such as opening gates to allow more water to discharge downstream and drawing lake levels down during dry weather conditions.

It is highly recommended that gages should be installed upstream and downstream of the LCS and the flow and level data be collected and used to refine flow rate calculations and better formulate operational procedures at the LCS.

## VI. RECOMMENDATIONS

The following sections outline specific recommendations for the Houghton Lake LCS. These have been developed to make operation of the structure more simple and efficient and to address specific concerns identified in the inspection of the structure. Also, operation guidelines for the LCS are provided.

### *A. Findings of Structural Inspection*

The general finding is the LCS is in good structural conditional. The pier nose between Bays 4 and 5 has been damaged and is in poor condition and should be repaired within the next five (5) years. The small scour hole under the downstream portion of the apron slab should be addressed at the same time.

### *B. Gate System Improvements*

The gate system and operational features of the LCS are in poor condition. The present structure utilizes a system of manually operated stop logs and slide gates. During large storm events, it may become difficult, hazardous, or impossible to remove stop logs and lift gates to allow storm flows to pass. Installation of new motorized gates with electronic controls is recommended to improve the operation of the LCS. Improvements to the gates will allow the LCS to operate more precisely and quickly during storm events. A new stop log system including a hoist to lift stop logs efficiently is recommended. Spicer Group has prepared a concept design drawing for this proposed system of gates and stop logs. The drawing is included in Appendix D.

To enable easier maintenance of proposed gates in the future, it is recommended that existing stop log channels will remain in place on the upstream side of the structure and new channels will be cut in the piers on the downstream side. If maintenance is needed on any of the gates, stop logs can be used to dewater a bay and allow maintenance access.

During an inspection of the Houghton Lake LCS, it was noted that recreational use of the LCS structure, mainly fishing, occurs. The proposed gate system includes widening of the deck on the structure, installation of new railing and installation of fencing to secure the gate operational area. This will enable continued recreational use, at the discretion of the Board, while securing the gate operational areas. The concept drawing in Appendix D shows the extended deck which would allow for fishing access.

It is recommended that the gate improvements be constructed at the same time as the repairs to the damaged pier. It will be cost effective to complete the pier repairs and gate improvements simultaneously.

### *C. Gages*

Obtaining accurate and reliable lake level data will facilitate more precise control of lake levels. Spicer Group recommends the installation of a new staff gage near the Houghton Lake LCS. Furthermore, digital gages with transmitting capabilities should be installed both upstream and downstream of the structure to allow discharge and lake level to be monitored remotely. To accurately determine the flow rate through the LCS, a detailed survey of the downstream channel cross section will be needed near the downstream sensor. These gages will allow the lake level to be monitored more closely and adjustments to be made more precisely based on accurate discharge rates. Additionally, lake level and discharge data will be stored digitally. These features can be used with the structure control guidelines outlined in the following section to more aggressively control lake level. It is recommended that these features be installed immediately.

*D. Operation Guidelines*

Lake level control guidelines should be implemented to standardize operation of the Houghton Lake LCS. The following guidelines are based on existing conditions of the LCS and based upon typical or average years. During extremely wet or dry years or due to significant runoff events, lake level operation may occur outside of the recommended range of these guidelines, beyond the control or intent of the County, due weather patterns and the constraints of the capacity of the existing system. Also, as the new upstream and downstream level and flow gages are installed and operational logs are kept, the data collected should be reviewed annually and used to update these guidelines. Note that these guidelines will depend largely on the capacity of the Muskegon River downstream of the LCS. Once the recommended level sensors are in place and a survey has been completed, discharge data for the Muskegon River may be collected. A more detailed set of operating procedures should be developed based on data collected from these sensors. Establishment of a detailed set of operating procedures will also depend on accurate records being kept of gate and stop log operation. Data from level sensors and gate operation should be reviewed annually and used to update these guidelines.

*1. Summer Level (NGVD 1138.10)*

Analysis of historical data has indicated that the level of Houghton Lake has averaged between 0.7 and 0.8 feet above the legal level in April, May, and June. This level typically falls to about 0.15 feet above the legal level in October which constitutes a seasonal loss of about 0.6 feet. Despite this seasonal water loss, the lake level typically does not fall below the legal level in summer. It is recommended that lake levels be more aggressively lowered during the summer to make average levels near the legal level.



Due to the observed seasonal loss of water from Houghton Lake, it is recommended that the lake level average be 0.3 feet above the legal level for the months of April, May and June. This will allow water to be conserved for the late summer months when water levels have typically dropped, however, will more closely adhere to the established legal lake level rather than the historical level of 0.7-0.8 feet above the legal level during the early summer months.

During the months of April, May, and June, the LCS should typically be operated with three (3) gates open when water levels are between 0.3 and 0.6 feet above legal level. In excess of 0.6 feet above, four (4) gates should be open and when the lake is in excess of 1.0 foot above, five (5) gates should be open. As water level drops below 0.3 feet above legal level, zero (0) to two (2) gates should be open. The water level should be monitored and gates operated in an attempt to maintain this level. The stop log bay should be set at legal lake level.

For the months of July through October, Houghton Lake typically loses around 0.6 feet of water. Therefore, water should be conserved during these months. Five (5) gates should be closed and stop logs set to an elevation matching that of the legal level. If lake levels drop below the legal level, one stop log should be removed to provide flow to the downstream river. If rainfall or high water conditions occur to cause the lake to rise more than 0.3 feet above the legal level, gates should still be operated as described above for early summer conditions until the lake is within 0.3 feet of the legal level.

In summary, currently the level of Houghton Lake is maintained above the legal level throughout the summer and a seasonal loss of roughly 0.6 feet is typically observed. To

more closely adhere to the legally established lake level, it is recommended that the lake be operated to release more discharge in the early summer months. This will result in the lake level falling under the legal level more frequently however the long term average should more closely match the legal level. The target range for the lake is between 0.3 feet above to 0.3 feet below the legal level.

2. *Winter Level (NGVD 1137.60)*

Historical winter levels on Houghton Lake have averaged roughly 0.6 feet above the legal level with a slight decrease of about 0.1 feet in the month of February. Therefore, as with summer levels, the winter lake level should be more aggressively lowered.

In transitioning from summer to winter, stop logs should be removed until they are at the elevation of the winter legal level. Draining of the lake may be facilitated by opening up to three (3) gates until the level is within 0.1 feet of the legal level. If the level rises to more than 0.3 feet above the legal level, one gate should be opened until the level returns to within 0.1 feet of the legal level. If the level reaches 0.5 feet above the legal level, an additional two (2) gates should be open so that flow is allowed through three (3) open bays.

On April 15 or ice-out, five (5) gates should be closed and stop logs in the remaining bay should be added incrementally added to match the legal summer level. Downstream flow should be maintained at all time. Once a store of 0.3 feet above the legal summer level has been achieved, stop logs should set at the legal level and zero (0) to two (2) gates should be open in attempt to average level at 0.3 feet above. Lake level should then be maintained in accordance with the summer guidelines.

### 3. *Adjusting Lake Level*

Because flow from Houghton Lake is partially controlled by the elevation of the Muskegon River, it is recommended to open gates in anticipation of large runoff events. This will allow flow to pass through prior to the peak of the storm, thus providing storage capacity in the lake and minimizing the peak water elevations and peak flow rates.

Based on the maximum discharge rate of 233 cfs for the Muskegon River calculated by the 1969 report by Ayres, Lewis, Norris and May, the maximum rate of drawdown for Houghton Lake is approximately 0.28 inches per day, assuming no inflow. Therefore, if gates are operated until no head loss is present across the LCS, the lake level will decrease at a rate of slightly less than one (1) inch every three (3) days.

## VII. PLANNING LEVEL COST ESTIMATE

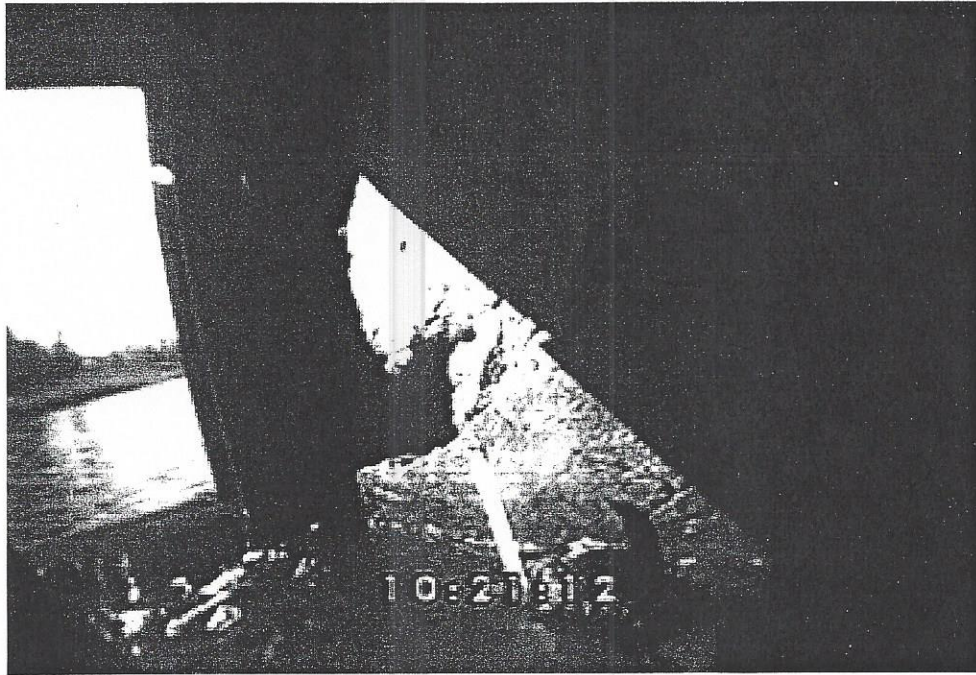
For planning purposes, a cost estimate has been compiled which includes the repairs and modifications outlined in the Recommendations section. An itemized list of all repairs and modifications to the existing structure along with associated costs can be found in Appendix E.

It is recommended that motorized gates be installed, a new stop log system be installed, the damaged pier be repaired, targeted scour protection be added and the monitoring system be improved. The planning level cost estimate for these items is \$670,000. This estimate includes five (5) new motorized slide gates, one (1) new stop log system, new metal decking and rails, new lake level control sensors, new electrical and internet service, concrete repairs and scour protection. It also budgets for engineering, permitting and administration of construction costs.

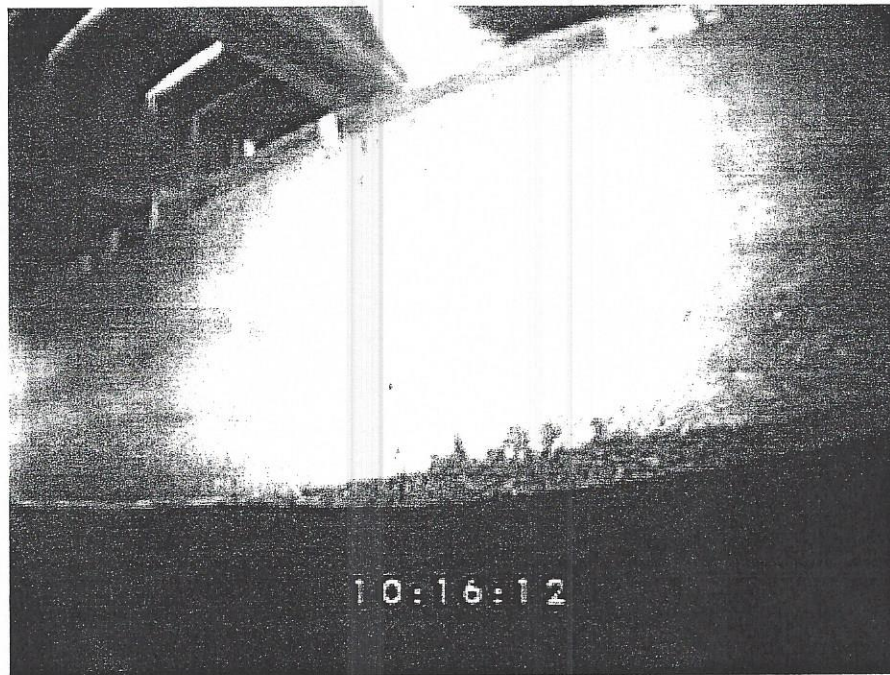
# **APPENDIX A**

## **Plan and Profile of Existing Structure**

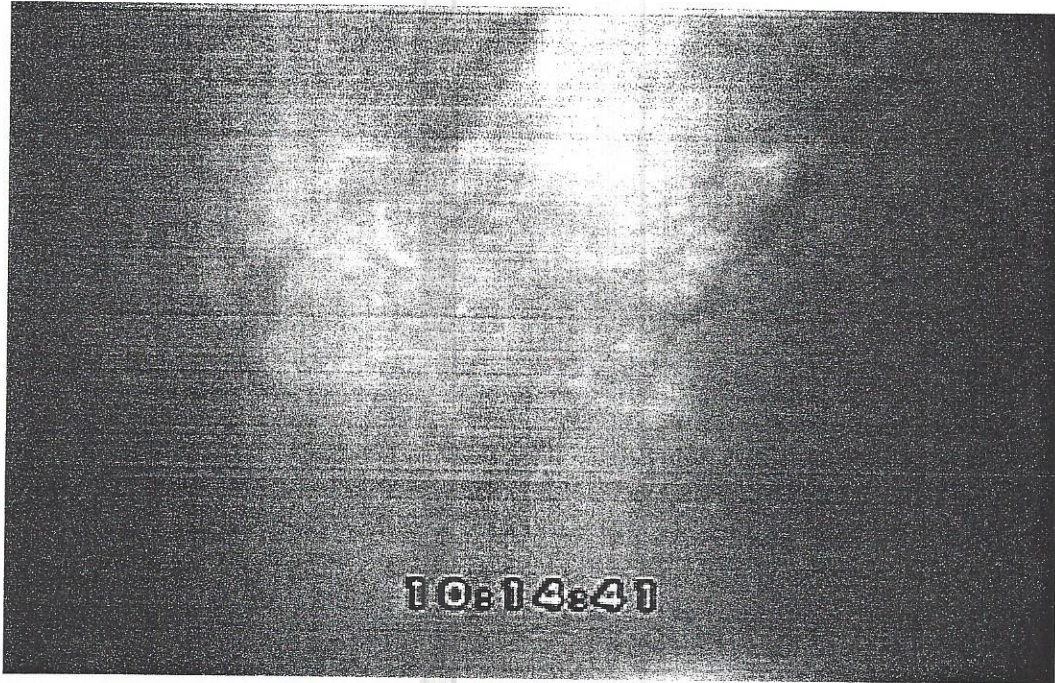
HOUGHTON LAKE LEVEL CONTROL STRUCTURE



**Photo #1**  
Dwg Bullet #27  
Looking at upstream west face of divider wall in Bay #5.



**Photo #2**  
Dwg Bullet #24  
Looking at east face of divider wall in Bay #4

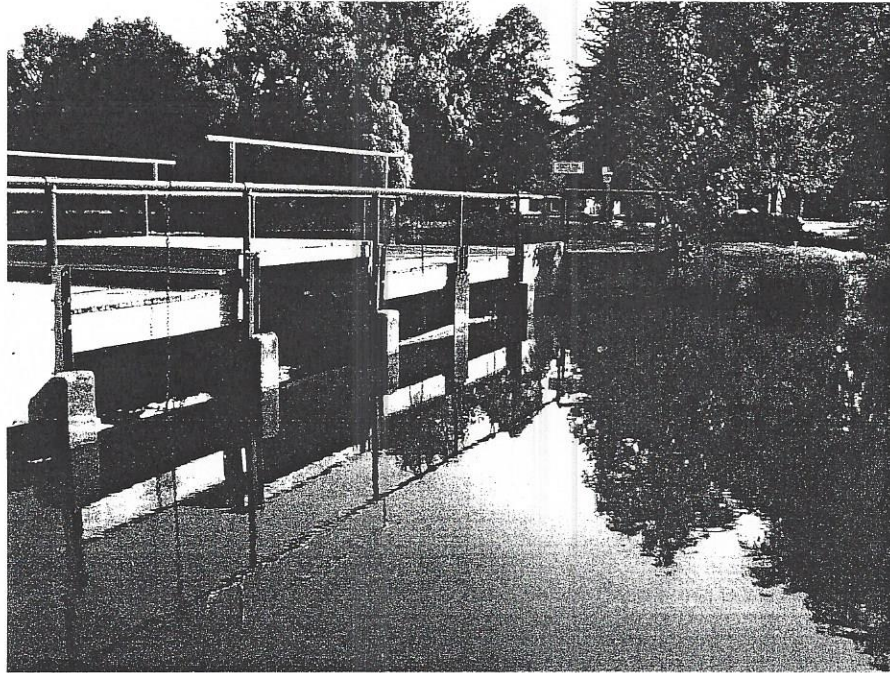


**Photo #3**  
Dwg Bullet #23  
Looking at cracks in east face of wall in Bay #4

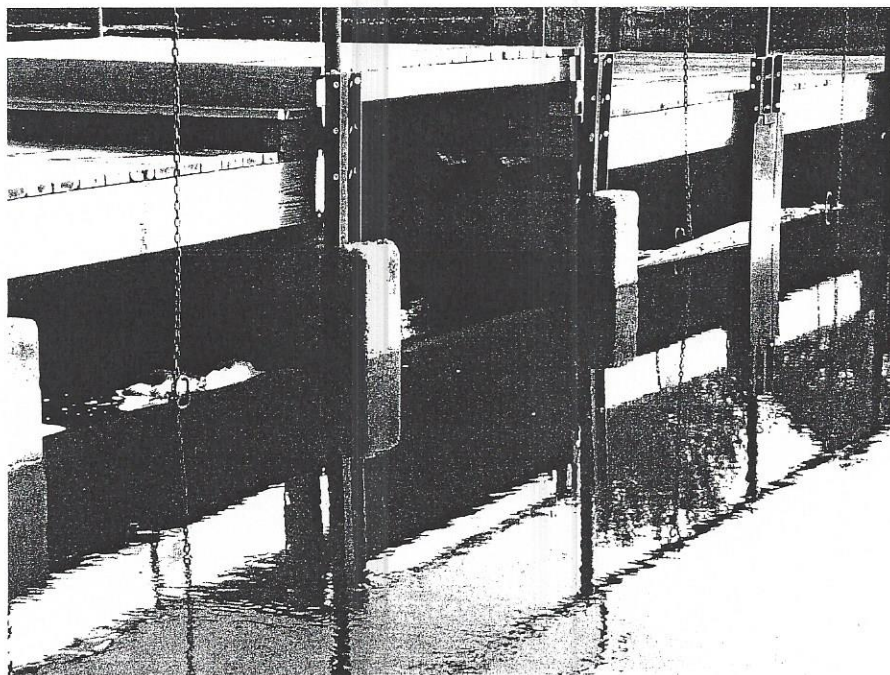


**Photo #4**  
Dwg Bullet #7  
Looking at stop log gap in Bay #3

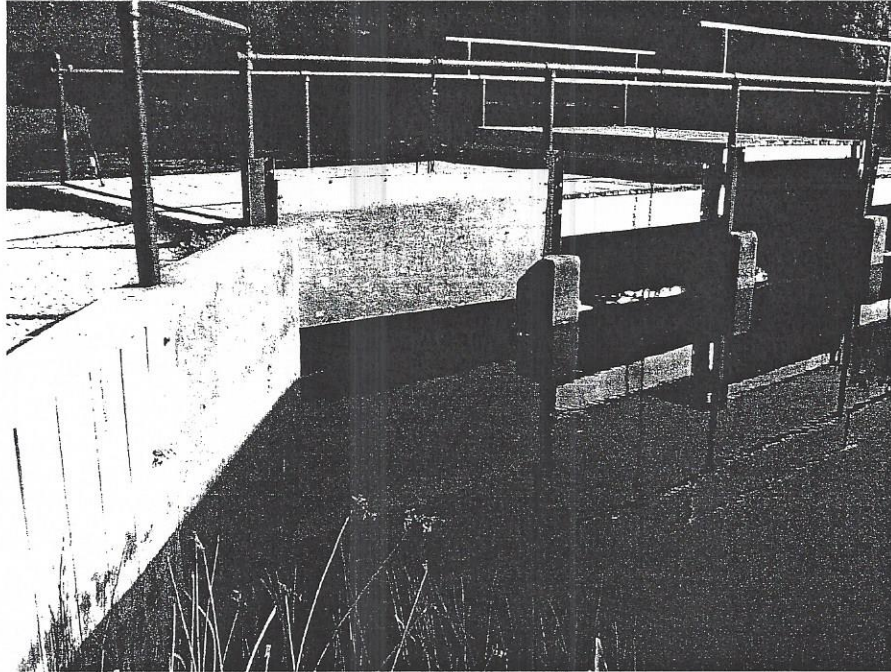
## ADDITIONAL PHOTOGRAPHS



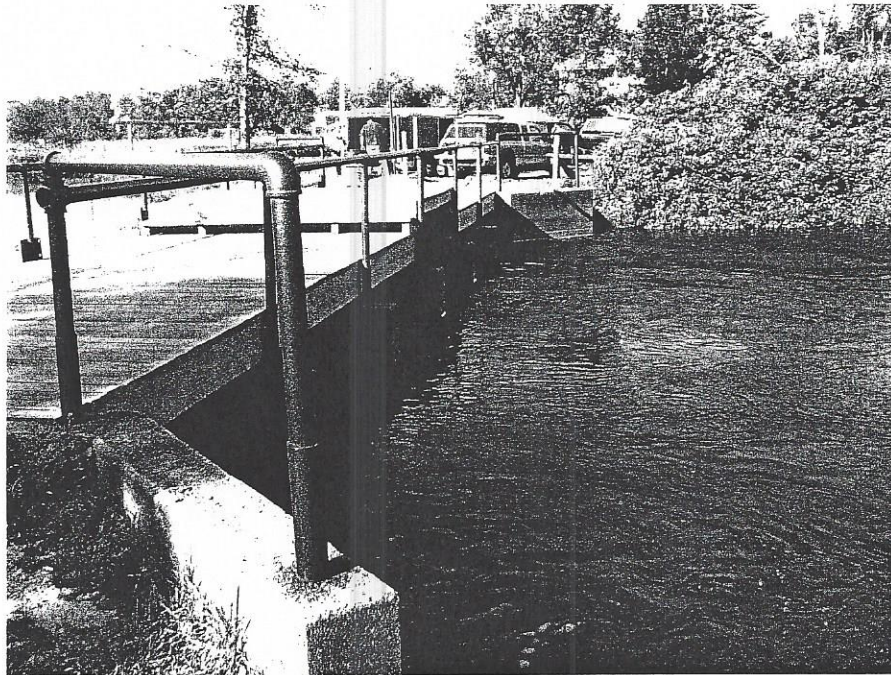
View from upstream face of Houghton Lake LCS.



Center stop log bay from upstream face of LCS.



Typical plywood gate on Houghton Lake LCS.

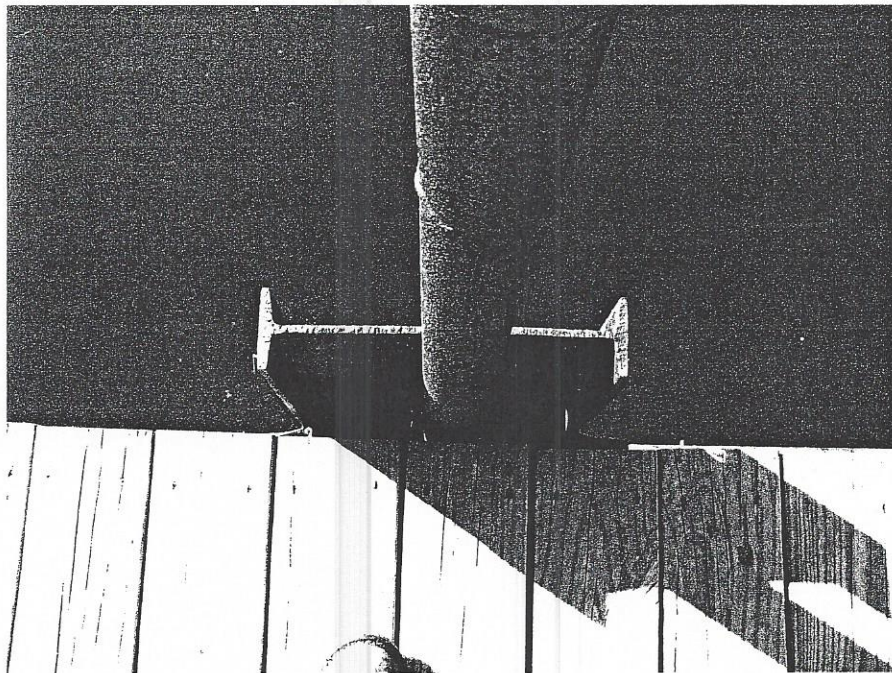


View from downstream face of Houghton Lake LCS.

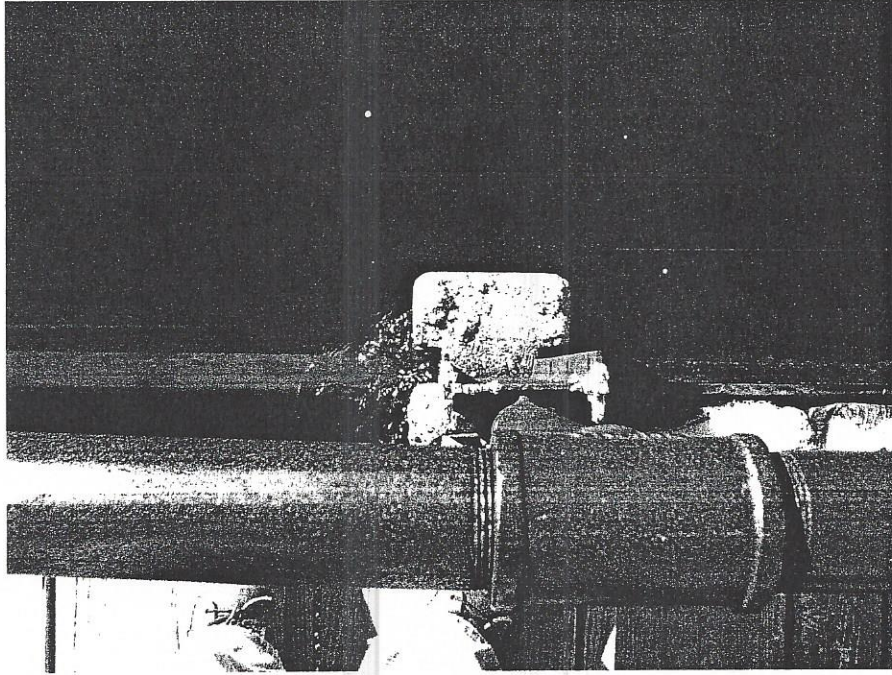




Wooden decking of Houghton Lake LCS.



Typical post of hand railing on Houghton Lake LCS.



Typical pier nose and stop logs on upstream face of LCS.

# **APPENDIX C**

## **Calculation of Hydraulic Capacity**

# Culvert Calculator Report

## Houghton Lake LCS

ve For: Headwater Elevation

### Culvert Summary

Allowable HW Elevation	1,140.53 ft	Headwater Depth/ Height	0.84
Computed Headwater Elevation	1,140.05 ft	Discharge	950.00 cfs
Inlet Control HW Elev	1,139.78 ft	Tailwater Elevation	1,139.00 ft
Outlet Control HW Elev	1,140.05 ft	Control Type	Outlet Control

### Grades

Upstream Invert	1.135.03 ft	Downstream Invert	1.135.03 ft
Length	20.00 ft	Constructed Slope	0.000000 ft/ft

### Hydraulic Profile

Profile	H2	Depth, Downstream	3.97 ft
Slope Type	Horizontal	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	2.79 ft
Velocity Downstream	6.65 ft/s	Critical Slope	0.004202 ft/ft

### Section

Section Shape	Box	Mannings Coefficient	0.013
Section Material	Concrete	Span	6.00 ft
Section Size	6 x 6 ft	Rise	6.00 ft
Number Sections	6		

### Outlet Control Properties

Outlet Control HW Elev	1,140.05 ft	Upstream Velocity Head	0.67 ft
Ke	0.50	Entrance Loss	0.33 ft

### Inlet Control Properties

Inlet Control HW Elev	1,139.78 ft	Flow Control	Unsubmerged
Inlet Type	90 and 15 ° wingwall flares	Area Full	216.0 ft <sup>2</sup>
K	0.06100	HDS 5 Chart	8
M	0.75000	HDS 5 Scale	2
C	0.04000	Equation Form	1
Y	0.80000		

## **APPENDIX D**

### **Concept Drawings of Proposed Improvements**

# **APPENDIX E**

## **Planning Level Cost Estimate**

**PRELIMINARY ESTIMATE OF COST**

**ROSCOMMON COUNTY  
HOUGHTON LAKE  
LEVEL CONTROL STRUCTURE IMPROVEMENTS**

Item No.	Estimated Quantity	Unit	Description	Unit Price	Amount
1.	2	Cubic Yd.	Concrete Repair	\$4,000.00	\$8,000.00
2.	5	Each	7'x5' S.S. Channel Gate	\$13,000.00	\$65,000.00
3.	1	Each	7'x5' S.S. Stop Log System	\$14,000.00	\$14,000.00
4.	300	Lin. Ft.	Fabricated Steel Handrail	\$125.00	\$37,500.00
5.	1	Lump Sum	Hoist Structure	\$10,500.00	\$10,500.00
6.	1	Lump Sum	Manual Lifting Hoist	\$1,500.00	\$1,500.00
7.	16	Each	Timber Maintenance Stop Logs	\$400.00	\$6,400.00
8.	100	Lin. Ft.	Fence	\$30.00	\$3,000.00
9.	50	Sq. Yd.	Heavy Riprap	\$75.00	\$3,750.00
10.	975	Sq. Ft.	Steel Floor Grating (Galv.)	\$40.00	\$39,000.00
11.	1	Lump Sum	Temp. Cofferdam(s)	\$70,000.00	\$70,000.00
12.	1	Lump Sum	Water Control	\$5,000.00	\$5,000.00
13.	1	Lump Sum	Main Floor Beams	\$12,000.00	\$12,000.00
14.	1	Lump Sum	Final Site Grading and Clean Up	\$5,000.00	\$5,000.00
15.	1	Lump Sum	Soil Erosion and Sedimentation Control	\$2,500.00	\$2,500.00
16.	2	Lump Sum	Automatic Controls and Level Sensor	\$75,000.00	\$150,000.00
17.	1	Lump Sum	Utility Allowance	\$5,000.00	\$5,000.00
18.	1	Lump Sum	Misc. Structural Floor Supports	\$15,000.00	\$15,000.00
19.	1	Lump Sum	Elevated Cat Walk System	\$10,000.00	\$10,000.00
20.	1	Lump Sum	Misc. S.S. Anchor Bolts and S.S. Hardware	\$4,000.00	\$4,000.00
21.	1	Lump Sum	Demo. Existing Timber Deck System	\$5,000.00	\$5,000.00
22.	12	Ea.	Modify Existing Stop Log Guides	\$500.00	\$6,000.00
23.	50	Sq. Yd.	Scour Protection at Toe of Structure (US/DS)	\$75.00	\$3,750.00
Sub-Total - Construction Cost					\$481,900.00
Engineering, Permitting, Easements, Construction Administration, Staking, Inspection, Study Phase, and Contingencies (35%)					\$188,100.00
<b>TOTAL PRELIMINARY ESTIMATE OF COST</b>					<b>\$670,000.00</b>

