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Lake Level Study for Twin Lakes

Houghton County Drain Commissioner

Elm River Township, Houghton County, Michigan

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I. SUMMARY & RECOMMENDATIONS

Purpose

The purpose of this study is to determine the feasibility of establishing and maintaining a legal lake level on Twin Lakes (Lake Roland & Lake Gerald). This includes collecting and evaluating data concerning the history and impacts of various lake levels of Twin Lakes located in Elm River Township, Houghton County, Michigan. If deemed feasible, recommendations to establish a legal lake level that will allow the greatest benefit to the users will be provided. Setting a legal lake level will:

- Protect property values
- Protect the public health, welfare, and safety
- Protect the lake environment and natural resources
- Maintain recreational benefit
- Designate authority to the Houghton County Drain Commissioner
- Provide a means to remove beaver dams located near the outlet structure

This study has been prepared in accordance with the Michigan Department of Environmental Quality procedures for Stabilizing Inland Lake Levels under Part 307, Inland Lake Levels, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, the Natural Resources and Environmental Protection Act (Act 451). All elevations in this study are referenced in NAVD88 datum. This study was conducted in accordance with a proposal that was submitted to and authorized by the Houghton County Drain Commissioner.

Summary of Findings

Based on the tasks completed as part of our study, a summary of our findings are below: A more detailed description of our findings is located in Section IV of the report.

1. The lakes appear to have increased in size from 547 aces (1937) to 658 acres. This may have been partially due to the "weir" and "rail" being placed at the Emily Lake Road Bridge in 1996/1997.
2. The existing top of the weir is at elevation 1187.60 and when the rail is installed, the top of the rail is at elevation 1188.04.
3. Based on the questionnaire results, some residents feel property will be impacted by low lake levels (25.6%) while others feel property will be impacted by high lake levels (13.2%). Also, respondents indicated that 39 structures may be impacted by water levels.
4. No wells appear to be impacted by the current lake level operations.
5. The lowest finished floor elevation adjacent to the lake was identified at a walkout basement on Lot 187.5 and was surveyed at elevation 1191.09. Scenario 5 of the backwater analysis shows the finished floor of the structure within 0.65' of the water surface elevation under the existing conditions (weir and rail in place) at the 100-year recurrence interval.
6. Based on our assumptions for the location of the septic fields, lots 46 and 139 will have their septic fields inundated during events greater than the 2-year recurrence interval for the existing condition. For the proposed condition (recommended Option 3 – with all rails out), the fields for these lots appear to be above the calculated lake level for the 2-year and 50-

year recurrence interval. For the 100-year recurrence interval, it appears that the lake level will be at or slightly above the estimated bottom of drain field for these lots.

7. According to the MDNR, the fish assemblage has changed dramatically over the last 40 years. A 2007 MDNR Fisheries survey found a "very attractive assemblage of panfish."
8. The watershed area is 10.5 square miles with approximately 0.3 square miles of depression storage (low areas in the land form that hold surface water runoff and/or allow infiltration) resulting in a contributing drainage area of 10.2 square miles.
9. Twin Lakes has a large storage area adjacent to the water's edge resulting in much lower peak flows exiting the lake to the Misery River.
10. The M-26 Bridge opening, located just downstream of the lake level control structure, restricts flows for a variety of flow events.
11. Even though the Wyandotte Dam and M-26 Bridge cause backwater upstream of each of their respective structures, the backwater does not appear to impact the lake water surface elevations for the events analyzed.
12. The M-26 Bridge is undersized for the 100-year recurrence interval event. M-26 causes nearly 2 feet of backwater in the Misery River under this event.
13. If there is more than one foot of debris on top of the Wyandotte Dam, lake water surface elevations start to be impacted.
14. Removing the rails during flood events reduces lake water surface elevations by 0.7 feet minimum for all events analyzed.

Recommendations

Based on our analysis and findings, a summary of our recommendations are below. A more detailed description of our recommendations is located in Section V of the report.

1. Remove the current weir (concrete pad) and rail system and replace with a system that provides a top of rail elevation of 1188.04 and a low lake level elevation of 1186.46 (weir elevation).
2. Obtain permanent easements between the dam lake level control structure and the Wyandotte Hills Country Club Dam so that the HCDC will have authority to remove beaver dams and other obstructions when appropriate.
3. Replace the M-26 Bridge and Emily Lake Road Bridges with larger structures as funding allows. The M-26 bridge is under MDOT jurisdiction and Emily Lake Road Bridge is under the Road Commission's jurisdiction.
4. Set up an assessment district and apportionment for financing of improvements and determine the costs to individual property owners.

I. INTRODUCTION

Background

Lakes Roland and Gerald were named for the sons of Charles Wright, one of the founders of the Copper Range Railroad which built a line through the area in 1900. Twin Lakes was a railroad stop along the railroad line which, even in 1900, was lined with summer cottages and camps. Some cabins dating from 1920's and 1930's still exist on the lakes today.

Twin Lakes is comprised of Lake Roland and Lake Gerald totaling 547 surface acres. The lakes range in depths up to forty feet (based on 1937 data). Land use surrounding Twin Lakes includes primarily undeveloped forest lands, residential property, wetlands, and a state campground (see Figures 1 and 2).

An existing concrete outlet structure (weir) controls the water surface level of Twin Lakes, which is located at the south end of Lake Roland, north of Emily Lake Road and at the headwaters of the Misery River. The weir appears to have been built in 1996/1997 when the Emily Lake Road Bridge was replaced. The Misery River flows westerly, eventually reaching Lake Superior.

On September 9, 1969 the Houghton County Board of Commissioners initiated legal action to determine a legal lake level for Twin Lakes. Since an engineering study was never performed, the petition was denied on March 24, 1972. Sometime between 1998 and 2008 a six inch steel "rail" was placed on top of the concrete weir outlet structure. The rail historically has been removed in the fall to prepare for the spring water levels and then placed back over the structure to maintain the lake level at a higher elevation at the beginning of the summer recreation season. During the summer, historically the lake surface elevation slowly drops below the top of rail elevation, due to hydrologic losses (evaporation, transpiration, etc.) being greater than summer rainfall amounts. Since there is no 'legal' lake level, however, there is no authority set up to place or remove this rail each year. This creates a potential liability for anyone performing these operations.

In order to remove liability and create a mechanism to change the lake level, a resolution must be adopted and an engineering study completed. Prior to March of 2013 the Houghton County Drain Commissioner recommended that the County proceed under the Inland Lake Level Act, Part 307 of the Natural Resources and Environmental Protection Act, MCL 324.30701 *et seq.* to adopt a resolution to determine a normal lake level for Twin Lakes.

On March 12, 2013, the County Board adopted a resolution to initiate action to determine the normal lake level for Twin Lakes. The Board instructed the Drain Commissioner to conduct a preliminary study of Twin Lakes by a licensed professional engineer. The preliminary study is to include:

- The feasibility of a project to establish and maintain normal level of the lake.
- The expedience of the normal level project.
- Feasible and prudent alternative methods and designs for controlling the normal level.
- The estimated costs of construction and maintenance of the normal level project.

- A method of financing initial costs.
- The requirements of a special assessment district and the tentative boundaries, if a district is deemed necessary.
- Other information that the county board resolves is necessary.

On June 20, 2013 the Houghton County Drain Commissioner approved and accepted the proposal of OHM Advisors to complete the preliminary engineering study of Twin Lakes.

Description of Problems

There are several issues that appear to be a concern for the property owners and users of the lakes. These are as follows:

Beaver Dams

Periodically, beaver have constructed dams in the Misery River reach from Lake Roland to the Wyandotte Hills Golf Club dam. In 2013, a total of 4 beaver dams existed within this river section with an additional dam constructed on top of the Wyandotte Hills Golf Club dam (by the beavers). The Golf Club dam is an earthen structure assumed to have been constructed in the 1960's for irrigation of the greens and fairways and is still currently utilized for this purpose. Historically, the Houghton County Drain Commissioner has removed the beaver dams in order to protect the public health, welfare and safety. Currently, the Drain Commissioner does not have any authority to enter on private property to remove any of the dams.

As of March 27, 2013 the Drain Commissioner does not intend to remove beaver dams from the Misery River until granted legal authority to do so. The Drain Commissioner was informed by the Michigan Department of Natural Resources (MDNR) that the responsibility for beaver dam removal lies with riparian landowner(s).

Spring Runoff and Low Lying Properties

Drain fields on several low lying properties can become flooded, mainly during spring runoff events (see Figure 3 in the Appendix). Large storms during the summer may also be a threat to these low lying properties if the legal limit is set too high.

Areas of Shallow Lake Bottom

Although most of the lake areas are navigable by small watercraft, there are a few areas where low summer water levels appear to be causing navigation problems. One such area is the connection between Lake Gerald and Little Lake Gerald. This channel becomes difficult to navigate during low water conditions due to the shallow water depth as well as weed growth.

Travel between the main lakes is through a narrow channel under the County Bridge on Twin Lakes Road. This channel is very shallow during the late summer/early fall, making boating through here difficult. To add further problems, the existing bridge span is narrow and the grouted riprap protecting the bridge abutments is failing and sliding into the channel. Barricades have been placed on both sides of the channel to contain the rock but as the riprap separates into smaller pieces it is finding its way into the channel. Dredging and/or widening this channel may not be feasible due to cost effectiveness. It has also been observed in old court reports that a large boulder may be located within the limits of the channel that would hinder dredging and further increase costs.

Existing Structures

Existing dock and boat house elevations vary by the year they were installed. The older docks and boat houses were constructed when the lake level was typically at a lower elevation throughout the summer. These docks and boat houses become nearly submerged during spring runoff high lake level events. As the years went on different outlet structures were installed altering the surface water level of Twin Lakes. The docks that have been installed in recent years were typically constructed at a higher elevation, so they end up being unusable if the water is too low in late summer.

III. STUDY METHODOLOGY

Information Gathering & Review

Recent and historic information, water surface elevation data and other physical and natural feature information was compiled and reviewed. Information reviewed included U.S. Geological Survey (USGS) topographic survey information collected in 1970, 1996, 1997, 2012, and 2013, photographs dated from 1937 to 2013, the location and condition of natural features surrounding the lakes, court documents, communications with area residents and correspondence, reports from the Michigan Department of Natural Resources (MDNR) and Environmental Quality (MDEQ) and records for drinking water wells and septic tanks were obtained through the Houghton County Health Department (HCHD).

Riparian Owner Questionnaire

Additional information was gathered through a questionnaire mailed to Twin Lakes riparian property owners in August of 2013. Questions pertaining to existing lake levels, the typical changes in the lake level throughout the year, wetland, wildlife and fishery information, erosion and vegetation information, recreational uses, well, septic and permanent structure locations were included on the questionnaire. The information requested in the mailer supports the lake level analysis and determination of a legal lake level, as set forth in Part 307 guidance. The riparian questionnaire was used to obtain key information about lake levels, wildlife, and areas affected by flooding. The responses were used as an aid in determining problem areas and current issues with the lake levels. The questionnaire and responses are included in Figure 4.1 and 4.2 in the appendix. Interviews with three riparian property owners were also conducted during the field reconnaissance portion of the project.

Survey

The Houghton County Drain Commissioner completed a level loop from the existing outlet structure to the Wyandotte Hills Golf Club dam June 10, 2012. Elevation data from the HCDC's survey was used as a basis for the stream cross section in this location. On September 23, 2013, personnel from OHM Advisors conducted a topographic survey which included:

- Three stream cross sections west of the MDNR ORV trail bridge extending 250 feet west of the bridge.
- A topographic survey of the MDNR trail bridge including road surface elevations and abutment locations.
- Three stream cross sections between the MDNR ORV trail bridge and the Highway M-26 Bridge.
- A topographic survey of the Highway M-26 Bridge including road surface elevations and abutment locations.
- Three stream cross sections east of the Highway M-26 Bridge extending 200 feet east of the bridge.
- Three stream cross sections southwest of the Emily Lake Road Bridge extending 300 feet southwest of the bridge.
- A topographic survey of the Emily Lake Road Bridge including road surface elevations.
- Abutment locations and the control structure weir with the rail installed.

- Two cross sections northeast of the Emily Lake Road Bridge extending 30 feet into Lake Roland.
- A total of 14 cross sections of the Misery River reach downstream of the control structure were obtained.

On November 4, 2014, personnel from OHM Advisors conducted additional survey of "low lying" areas identified during the September 26th field reconnaissance. Eight sites were visited during the November 4th survey which included; Lots 7, 45, 46, 138, 139, 162, 187.5, and 237 (see Figure 3 for Lot locations). The purpose of the survey was to obtain structure finished floor elevations and locate septic tanks and drain fields with potential inundation issues due to high water levels on Twin Lakes.

Field Reconnaissance

On September 26, 2013, personnel from OHM Advisors conducted a field reconnaissance of Twin Lakes, wherein staff walked portions of the perimeter of the lake and traversed the lake perimeter via boat. During the reconnaissance, personnel observed low lying structures, areas where ice damage and lake edge erosion has occurred and noted vegetation, wetlands and other observed physical features.

Environmental Assessment

In order to address wildlife, habitat and vegetation issues, a review of the national inventory of endangered species was completed. The local MDNR office was also contacted regarding their knowledge of any endangered or threatened species in the area.

A wetland survey of the lake was not included as part of this project, however, observations of wetlands from the site inspection, a review of soils and contour maps and a review of the US Fish and Wildlife Services National Wetlands Inventory was completed.

Watershed Hydrology

Twin Lakes is located in the west central portion of Houghton County, and is within the Ontonagon Lake Watershed. A location map is included as Figure 1 in the Appendix of this report. Lake Roland and Lake Gerald have a combined surface area of approximately 547 acres according to the MDNR maps. These maps were created prior to the installation of the outlet structure and represent the surface acreage of Twin Lakes around the year 1937.

The watershed and contributing drainage area were determined by the Michigan Department of Environmental Quality (MDEQ) for this study. Peak flow/recurrence interval information was also computed by the MDEQ.

The watershed soils were investigated by reviewing USGS soil survey reports and obtaining well logs from properties surrounding the lakes.

Misery River Channel Hydraulics

In order to determine the capacity of the downstream outlet channel (Misery River), a backwater analysis was performed. The analysis was performed on the stream reach from the Wyandotte Hills Golf Club dam to just upstream of the outlet structure at the south end of Lake Roland (near Emily Lake Road). This hydraulic analysis was also completed to determine the location of structures or cross sections that may be causing impacts to the Twin Lakes water surface elevations. The analysis was completed for the 2, 10 and 100-year recurrence interval events.

Water surface profiles were computed using the U.S. Army Corps of Engineers HEC-RAS computer program, Version 4.1.0. This software has the capability to perform one-dimensional steady flow calculations, and is intended to calculate water surface profiles for gradually varied flow for a full network of natural or constructed channels. The steady flow component is capable of modeling subcritical, supercritical, and mixed regime water surface profiles. The effects of various obstructions, such as bridges and culverts may be included in the computations, and capabilities for assessing the change in water surface profiles due to channel improvements.

Survey cross sections were obtained in the field for input in the program. Sections were limited to channel areas with overbank geometry supplemented through use of the County GIS information. The remaining surface elevations were obtained from interpolation of the USGS quadrangle maps.

Manning's roughness coefficients for the channel and overbank areas were selected on the basis of field inspection notes, photographs, professional judgment, and previously established values for similar conditions. The selected values for each cross section are available for viewing in the attached HEC-RAS report; see Figure 5 in the Appendix.

Based on the stream geometry, contraction and expansion coefficients of 0.1 and 0.3, respectively, were used for the majority of the cross-sections. These values represent previously established values for areas with gradual or natural transitions. For the cross sections just upstream and downstream of the bridges, contraction and expansion coefficients of 0.3 and 0.5, respectively, were applied.

IV. FINDINGS

Information Gathering & Review

From our review of the previous historical documents, pertinent findings are as follows:

- The original size of the Lakes is 547 surface acres based on a 1937 DNR study. It is unknown if any other structures were located on the Misery River at this time with the exception of the Railroad Bridge (now MDNR ORV trail).
- The age of the M-26 Bridge on the Misery River is unknown, however, based on its construction style and condition; it appears to be at least 50 years old.
- An earthen dam was installed at the Wyandotte Golf Course sometime during the 1960's to provide a pond where water could be removed to irrigate the course.
- The current outlet control structure (concrete weir) located on the Misery River at the south end of Lake Roland was constructed in 1996/1997 when the original culverts were replaced by a bridge on Emily Lake Road. See Figure 6 for a sketch of the existing outlet structure.
- A six inch rail was added above the weir sometime between 1998 and 2008 in order to provide a summer and winter water level for the lakes. Currently the top of the concrete dam pad is at elevation 1187.60 and when the rail is installed the top of rail is at elevation 1188.04.
- From a review of historical aerial photography and reports, it appears that the total area of the lakes has changed after the installation of the weir in 1996/1997. From the 1937 report, the total area of the lakes is 547 acres (although this could not be verified due to a lack of aerial photography). Utilizing the USGS maps and present water elevation at the outlet structure, the total surface area of Twin Lakes is approximately 658 acres. These measurements were taken from the USGS Quadrangle Map included as Figure 7 in the appendix. A review of aerial photographs of the lake in 1998, 2005, 2006, 2010 and 2011 also show very similar lake boundaries.
- Well records were obtained through the Houghton County Health Department (HCHD). 118 records were obtained from the HCHD (note: not all parcels contain a well). From review of the residential questionnaire and the files received from the HCHD it is noted that the nearest well is 20 feet from water's edge of Twin Lakes (7159 Twin Lakes Road).
- Most well records provided soil boring logs at the well location. Soils varied around the lake, but were primarily a mixture of sand, clayey sand and clay. Typical borings had various layers of sand intermixed with either clay or clayey sand. Very few borings were one or two uniform layers through the length of the bore. A majority of wells are 100 feet deep or greater, although a significant number of wells were in the 30 feet to 40 feet range.
- Since no municipal sewer system exists in the area, all of the homes with a sanitary sewer system have septic tanks and drain fields (except a few parcels may still have outhouse type structures). Drain field records were obtained through the Houghton County Health Department (HCHD). Records from sixty four parcel owners were received from the HCHD (note: not all parcels contain a septic tank or drain field). Figure 3 in the Appendix graphically show low lying parcels. From the information provided by the HCHD as well as the resident questionnaires, the closest septic field is approximately 30 feet from the lake's edge (33098 Maple Lane).

Riparian Owner Questionnaire

From the questionnaire that was sent to land owners in August of 2013, a total of 229 questionnaires were sent out and 121 responses were received (52.8% response rate). Most respondents found no change in wetlands, wildlife, fishing or invasive species around the lake. Although most respondents did not see any change to the lake shoreline erosion, several did mention that there was increased erosion or problems with their seawalls or structures (although some of this is more than likely due to the age of the structure and not necessarily erosion).

Of the 121 respondents, 51 felt that the lakes had more weed or vegetation growth recently, which is 42.1%.

For question 11, property owners were asked if there were more water level issues in the summer or winter. Of the 121 respondents, 85 felt that spring was the worst season for water level issues which is **70.2%.**

Two questions were directly related to water levels. Question 1 asked the property owners opinion of the Lake level and 58.7% felt that the water levels were higher this year while 6.6% felt that water levels were lower. Question 12 asked if property use was affected by water level and 25.6% of respondents felt that they or others were negatively affected by low water levels while 13.2% of respondents felt that high water levels were a problem.

Finally, several respondents have listed structures that are affected by changes in the lake levels (although not all are having issues). In total, respondents listed 39 structures which would be affected, including the following:

- 18 docks
- 5 septic tanks
- 8 seawall/stairs
- 1 beach
- 7 boat houses
- 5 saunas
- 1 home

Survey

During the low lying properties survey, OHM Advisors was able to identify structures that have the potential to be impacted by Twin Lake's high water levels. The lowest finished floor elevation was identified as Lot 187.5 (see figure 3) which had a walkout basement finished floor of 1191.09' (NAVD88). Since this is a newer residence it is assumed that the septic tank and drain field is placed at an upland elevation.

Lots 139 and 46 were identified as possible locations where septic systems could become flooded during high lake levels. The lowest ground elevations obtained for these Lots was 1992.12. These homes were also identified as older structures with no known septic system records on file. The

resident of Lot 46 previously identified inundation issues during the annual spring runoff making the septic system unusable during this time.

Field Reconnaissance

During the August 26, 2013 field inspection, the lake elevation was below the top of the rail and the elevation in the Misery River was actually higher than the lake. On the date of the field survey 10/23/2013 the water surface elevation at the control structure was 1187.75 feet which is 0.29 feet below the top of the rail. The water surface elevation downstream of the control structure was 1187.85 or 0.19 feet below the top of the rail.

From the inspection of the lake, the following items were observed:

- No significant areas of erosion were noted during the field inspection of the lakes with the exception of the areas around the Twin Lakes Road Bridge. Grouted rip rap slope protection around the bridge is starting to deteriorate and is sliding into the channel. Wood posts and plank have been placed in an attempt to mitigate this erosion.
- The channel between Lake Gerald and Lake Roland is somewhat shallow. There are areas of weed growth present in this area.
- The channel between Lake Gerald and Little Lake Gerald is very shallow. It appears that boats with a deeper keel would not be able to pass through this area during summer low water depths. Significant weed growth exists in this area as well.
- The lake appeared to be very weedy in coves where feeder streams empty into the lakes. These areas also appear to have low water issues as well.
- Although most of the shoreline around the lake is developed, there are several large areas along the north, east and west portions of Lake Gerald and along the east side of Lake Roland that are undeveloped and may contain wetland areas. Some of these areas contain wetland vegetation due to feeder springs from the surrounding drainage basin. There are two prominent feeder springs located on Lake Gerald that more than likely contain wetland vegetation. Significantly raising or lowering the lake elevations would have a detrimental effect to wetlands directly along the shore line and within these feeder spring areas.
- Most of the development along the lakes is to the south and west and much of it occurs in upland areas above the floodplain. The exception to this is a few of the older cabins near the north end of the lake and the various docks and boathouses near the water line. Some of these shoreline structures appear to be high enough while others appear to be too low.
- There are a handful of septic fields at older cabins located primarily on the north end of the lake. These fields are at elevations slightly above the normal high water mark and would be influenced by the high water during spring runoff events.

Environmental Assessment

Fish require access to a variety of habitat types for different activities (feeding, spawning, nursery areas, resting, etc.) and life-cycle stages. In lakes these different habitat types are generally determined by varying depths (from zero to the maximum depth of a lake), availability of aquatic

plant cover, and may change seasonally due to access of periodically flooded areas or according to different temperatures and dissolved oxygen gradients.

According to George Madison at the MDNR, the fish assemblage of Twin Lakes has changed dramatically over the past 40 years, possibly due to increased nutrient loading from aged septic tanks and lawn fertilizers. In essence, the lake has changed from an oligotrophic lake (a lake characterized by a low accumulation of dissolved nutrients) to a mesotrophic lake (having a moderate amount of dissolved nutrients).

Research shows, however, that nutrients are associated with algal growth, not macrophyte (weed) growth. Weed growth typically occurs in areas of shallow water where the plants can easily take root. It is difficult for most weeds to take root in deeper waters.

Both lakes have a fairly pronounced 'shelf', or area of shallow water thus providing an area where weed growth could occur. This shelf appears to be the result of the change in lake area as can be seen by comparing 1937 data to current information (a change from 547 acres to 658 acres – see the Watershed Hydrology Section below).

Furthermore, a brief lake aquatic vegetation survey was conducted on Little Lake Gerald in 2011 by the MDNR. This study had the following conclusions:

- Previous surveys/files for Twin Lakes show little to no submergent vegetation in 1937, 1970 and 1982.
- In 2007, a MDNR fisheries survey found a 'very attractive assemblage of panfish'.
- In 2007, a water analysis of Lake Gerald found low amounts of Nitrogen and virtually no Phosphorus.

Watershed Hydrology

Twin Lakes are glacial formed. The surface topography in this watershed is typically gently sloping forested land which covers a majority of the land mass. Development is comprised of waterfront cottages on small lots. The watershed's soils are mainly sand or a loamy sand composition. Kalkaska sand is the dominate soil type surrounding the lakes. Some small areas of muck soils are present in low lying areas. See Figure 8 in the Appendix for Soil Resource Report Map and supporting documentation.

The total watershed area for Twin Lakes consists of 10.5 square miles including depression storage areas (areas that will percolate into the surrounding soil) without contributing direct runoff to the lakes. The contributing drainage area, the total watershed area minus depression storage areas, is calculated to be 10.2 square miles.

Realizing that Twin Lakes has a vast storage area, it was requested that the MDEQ utilize storage routing in the hydrologic computations to determine the extent of attenuation and the reduction in peak flows to the Misery River. It was required to provide the MDEQ with a stage-storage-discharge rating curve for the lake/outlet. The stage-storage information was obtained through interpolation of the County GIS data and the stage-discharge information was developed through computing the

control structure hydraulics by the weir formula. A summary of the stage-storage-discharge data provided to the MDEQ is as follows:

MDEQ Stage-Storage Discharge Data

Elevation (NAVD 88)	Storage (Acres)	Discharge (cfs)
1187.5	658	0
1190.7	697	220
1193.4	721	370
1194.9	737	500
1195.7	758	1300

Twin Lakes' inflows and routed outflows at the Lake Roland outlet structure to the Misery River were calculated by the MDEQ as follows:

MDEQ Attenuated Flow Summary

Recurrence Interval (years)	Inflow Peak Flow Rate (cfs)	Outflow Peak Flow Rate (cfs)
2	220	25
5	370	not determined
10	500	60
25	750	not determined
50	1000	not determined
100	1300	120
200	1500	not determined
500	1900	not determined

As can been seen in the above table, appreciable attenuation (storage) occurs in Twin Lakes resulting in a large reduction in peak flow rates from the lakes to the Misery River. See Figure 9 in the Appendix for a copy of the original information provided by the MDEQ.

Misery River Channel Hydraulics

Field data was input into HEC-RAS program to determine backwater impacts from the Misery River on the lake level control structure. From this model, field observations and survey data, several observations were evident as follows:

1. The top of the weir outlet control structure is at elevation 1187.54; 1.08 feet above the Emily Lake Road wood box culvert invert elevation (1186.46). The culvert at Emily Lake Road is also narrower than the channel downstream.
2. The channel between Emily Road and M-26 appeared to be fairly uniform in shape.
3. The bridge at M-26 reduces the cross section of the channel both in width and depth. The stream bottom elevations actually increase at the cross section upstream of the bridge. Obstructions of this nature typically cause an increase in backwater under higher flow conditions.
4. The channel downstream of the M-26 Bridge is wider than the channel upstream.

5. The rail road bridge is significantly wider and higher than the M-26 Bridge. This would indicate that it more than likely does not cause additional backwater.
6. The channel is wider and the slope significantly increases between the railroad bridge and the golf course dam. This would also be an indicator that this channel reach does not cause additional backwater.

Based on these observations, five scenarios were evaluated to determine what impacts the Misery River, bridges, and dam have on the lake water surface elevations. Flow data was input into HEC-RAS to determine if individual structures/obstructions were causing backwater and, if so, the amount of backwater that would occur from different flow events. A summary of the scenarios analyzed is as follows:

SCENARIO 1

Summary

Wyandotte Dam in place (at elevation 1186.52 and assumed to be 50 feet wide); railroad, M-26 and Emily Lake Road bridges all in place as they currently exist; Twin Lakes weir in place at elevation 1187.54 as it currently exists, no rail in place.

Purpose

To determine backwater impacts for the system as it currently exists.

SCENARIO 2

Summary

Wyandotte Dam removed, Railroad Bridge in place, M-26 Bridge removed and Emily Lake Bridge in place. Twin Lakes weir at elevation at elevation 1187.54 as it currently exists, no rail in place.

Purpose

To determine impacts the removal of Wyandotte dam and M-26 Bridge have on Twin Lakes water surface elevations.

SCENARIO 3

Summary

Wyandotte Dam in place at elevation 1187.52 (1.0 feet above existing dam elevation and assumed to be 50 feet wide); Railroad, M-26 and Emily Lake Road Bridges all in place as they currently exist; Twin Lakes weir at elevation 1187.54, as it currently exists, no rail in place.

Purpose

To determine impacts that 1.0 feet of debris (ice, beaver material, etc.) will have on the Twin Lakes water surface elevations.

SCENARIO 4

Summary

Wyandotte Dam in place (at elevation 1186.52 and assumed to be 50 feet wide); railroad, M-26 and Emily Lake Road bridges all in place as they currently exist; Twin Lakes weir at elevation 1186.46 (1.08 foot lower), no rail in place.

Purpose

To determine impacts that removing the weir will have on Twin Lakes water surface elevations.

SCENARIO 5

Summary

Wyandotte Dam in place (at elevation 1186.52 and assumed to be 50 feet wide); railroad, M-26 and Emily Lake Road bridges all in place as they currently exist; Twin Lakes weir and rail in at elevation 1188.04 (as it exists today and as in the recommended option).

Purpose

To determine impacts of leaving the rail in place will have on Twin Lakes water surface elevations.

Recurrence Interval - Lake Water Surface Elevation Summary

Recurrence Interval	Scenario 1 (exiting with rail removed)	Scenario 2 (Wyandotte & M-26 bridge out)	Scenario 3 (existing plus 1 foot debris)	Scenario 4 (proposed condition with rails removed)	Scenario 5 (existing and proposed condition with rail in place)
2-Year	1187.94	1187.93	1187.99	1187.47	1188.88
10-year	1188.60	1188.60	1188.62	1188.21	1189.55
100-year	1189.47	1189.49	1189.51	1189.17	1190.44

Based on these scenarios, we have the following findings:

1. Even though the Wyandotte Dam and M-26 cause backwater upstream of each of their respective structures (almost 3.5 feet and over 1 foot for the 100-year event, respectively), the backwater does not impact the lake water surface elevation for the events analyzed (Scenario 2 compared to Scenario 1).
2. If there is more than one foot of debris on top of the Wyandotte Dam, lake water surface elevations start to be impacted (Scenario 3 compared to Scenario 1).
3. Lowering the weir 1.08 feet reduces lake water surface elevations by 0.3 feet to almost 0.5 feet for all events analyzed (Scenario 4 compared to Scenario 1).
4. During the events analyzed, if the rail remains in place then lake water surface elevations will be nearly 1 foot greater than if the rail is removed (Existing Condition - Scenario 5 compared to Scenario 1) and nearly 1.5 feet greater than if the rail is removed (Proposed Condition – Scenario 5 compared to Scenario 4).

V. CONCLUSIONS & RECOMMENDATIONS

Both Lake Roland and Lake Gerald are classified as all-sport recreational lakes. Some of the recreational uses of the lake are: fishing, canoeing, kayaking, skiing, boating, sailing, and swimming. Raising or lowering the lake significantly could have a negative effect on property owners, recreational activities and its ecosystem. Raising the lake level would reduce beach areas and increase wave action damage to seawalls but provide easier access between the lakes. Lowering the lake level would increase beach areas and aquatic weed growth but would hinder navigation between the lakes.

Results from Riparian Owner Questionnaire

Many residents use the lakes for boating and other sporting activities, and say the level drops in late summer leave docks unusable as well as making the shallow channels connecting the lakes impassable. 51% of questionnaire respondents also feel that there are more weeds, algae or other vegetation in the lake, which may be an indirect correlation with summer lake levels being too low.

Other residents, however, feel that lake levels are too high, particularly in the spring when runoff from snowmelt is a problem. Some residents have low lying septic tanks, docks or boathouses at lower elevations or small beach areas which would be influenced by these levels. This was observed from the results of question 11 in which 70.2% of respondents felt that there are more issues during the spring months due to higher water levels.

Looking at the results of the questionnaire, it appears that property owners have issues with water levels being both too high and too low at different times of the year. Several land owners directly stated this in their responses. The Responses from question 12 support this with 25.6% of respondents having property issues because of low water and 13.2% of respondents having issues from high water.

Survey

Based on the results of the low lying property survey completed on November 4, 2014 along with the hydrology data, it appears that several structures could be negatively impacted during high water events.

Lots 139 and 46 appear to be impacted during high lake levels as well. The ground surface elevation for the above mentioned parcels at the approximate drain field location were found to be approximately 1192.12. Assuming a minimum of 2 feet of cover over the drain field, the approximate bottom elevation of the drain field would be approximately 1189.12. Therefore, these drain fields would be inundated under all scenarios for a 100-year event.

Field Reconnaissance

Our inspection of properties along the lakes mirrors the results of the riparian owner questionnaire and survey. Septic tanks on low lying properties, low seawalls/docks, parcels with very small areas of beach, and boat houses and structures close to the water were all observed. These property owners would all be impacted by higher water levels.

Areas that would be impacted by lower water levels were also observed, including, areas of weed growth along the shores, low water levels between the lakes and docks and boat houses that were at higher elevations.

Finally areas of low water depth between the lakes could easily be seen, indicating that boating between the lakes is impacted when water levels are too low.

Environmental/Watershed Hydrology

As was discussed above, the lake area, weed growth and fish species have changed at some point between the early 1980's to the present time. Based on our review of the change in the lake area, it appears that the installation of the weir in 1996/1997 has caused this increase. Prior to 1997, areas along the shore were more than likely underwater during spring runoff events, but were exposed above the water during the summer, fall and winter months. This would explain the shallower shelf areas and increased weed growth, particularly in Lake Gerald and Little Lake Gerald.

In order to address the issues of weed growth and shallow areas of the lake, there are several options that could be implemented. These options are listed below with the associated pros and cons.

Option 1 – Remove the rail (lower the summer water elevation)

Pros: Would virtually eliminate weed growth as most of the shallow shelf areas would now be above water.

Would reduce the damage to lower docks/retaining walls/boat houses.

Cons: Would provide less lake area.

Would significantly reduce pan fish in the lakes.

Would render higher docks/retaining walls/boat houses unusable.

Option 2 – Place a new higher rail (Raise the summer water elevation)

Pros: Would make access between the lakes available to larger boats.

Cons: Would not significantly change weed growth.

Could possibly cause additional damage to low lying structures.

Option 3 – Dredge shallow areas of the lakes

Pros: The amount of dredging is fairly small and the cost, once distributed out to all property owners should be fairly minimal.

Would make access between the lakes available to larger boats.

Cons: Would not significantly change weed growth.

Dredging of the channel at Twin Lakes Road Bridge would be expensive as the grouted rip-rap would need to be removed and replaced.

MDNR and/or MDEQ representatives may have objections to dredging specific areas of the lakes.

Based on this information, it is recommended to obtain both public input and comments from the MDNR and MDEQ on Option 3 to see if there is support for the dredging and associated costs.

Misery River Channel Hydraulics

While the impacts of water level changes are felt by the land owners and observed in the field, the possibility of influencing these levels is limited by the channel hydraulics in the Misery River. The

various HEC-RAS scenarios that were run show multiple obstructions in the section of the river upstream of the Wyandotte Golf Club Dam. The M-26 Highway Bridge and Wyandotte Golf Club Dam can both influence water levels in the river, but do not ultimately influence the water in the lake. The existing lake level weir and Emily Lake Road Bridge are the controlling obstruction that causes increased lake levels during storm events (and particularly spring runoff events). Furthermore, any beaver dams in this section built above elevation 1187.75 feet has the potential to cause backwater in the lake.

Since the weir is the controlling factor, any change to the structure would influence the lake levels. Based on data collected, there is ample evidence that higher water elevations from spring runoff events are a concern. Lowering the top of weir elevation would provide greater control and would lessen the probability of high water issues, particularly during spring runoff events.

It appears that the existing weir structure can be fairly easily replaced, and although there would be cost involved, the dollar amount to each land owner would be reasonable once distributed out across the assessment district. It is for these reasons that we are recommending removing and replacing the concrete weir approximately one foot lower than its current elevation. It is also recommended to include with the court order, language that allows the Houghton County Drain Commissioner the authority to control beaver dams along the Misery River. See 'Recommended Lake Level' below for additional information.

Recommended Lake Level Options

There are a number of factors that must be considered when establishing a legal lake level. These factors include historic levels, impact on septic systems, public opinion, recreational uses, shore erosion and ice damage, fisheries and wildlife habitat, and aquatic weed growth, all of which have been previously discussed in this report. Public opinion is split as to whether the lake level should be raised, lowered, or left the same. Fisheries, wildlife habitat, and aquatic weed growth will not be affected by a minor change in water elevation (±6 inches), up or down. Recreational use would not be affected with a 6 inch rise in water elevation but would be affected if the lake level was lowered 6 inches. Passage between lakes would be hindered if the lake was dropped without assistance from dredging out the channel between Lake Roland and Lake Gerald but also the channel between "Little Lake Gerald" and Lake Gerald. Ice and erosion damage would be reduced if greater control over the water levels was provided.

There are several options available as follows:

Option 1 - Do nothing

Pros: No cost.

Cons: No reduction in threat of high lake levels.

Houghton County Drain Commissioner (HCDC) will cease making adjustments to the lake level which will increase the risk of flooding and/or low lake levels.

Option 2 - Control beaver dam issues.

Pros: Minimal cost.

Would reduce the probability of high lake levels during storm events.

Cons: No significant change from the current conditions.

Option 3 - Control beaver dam issues and replace the control structure north of Emily Lake Road with a stop log type structure (bottom of structure 1.08 foot lower than existing structure).

Pros: Would significantly reduce the probability of high lake levels during storm events.

Would allow for greater control of lake levels to be more accommodating to a greater range of riparian property owners.

Low cost.

Cons: Boating between the lakes may still be an issue during low lake level periods.

Option 4 - Control beaver dam issues and replace the control structure north of Emily Lake Road with a stop log type structure and investigate dredging the channels (bottom of structure 1.08 foot lower than existing structure).

Pros: Would significantly reduce the probability of high lake levels during storm events.

Would allow for greater control of lake levels to be more accommodating to a greater range of riparian property owners.

Boating between the lakes would no longer be an issue.

Cons: High cost.

MDNR and MDEQ approvals may not be gained.

Recommended Lake Level

Considering all of the factors listed above, OHM Advisors recommends pursuing Option 3. It is also recommended that the historic high water level of Twin Lakes be maintained with a seasonal drawdown during the late fall through spring months to accommodate a new low lake level (lower than recent historical levels) to accommodate the typically higher spring flow rates. It should be noted that the Option 3 weir/rail system can be designed with multiple rails to allow greater flexibility in raising and lower the lake level. Therefore, the recommended seasonal legal lake level for Twin Lakes to be established under Part 307, Inland Lake Levels, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, are as follows:

- High Lake Level Elevation: 1188.04 feet NAVD88
- Low Lake Level Elevation: 1186.46 feet NAVD88

Finally, the bridge at M-26 is undersized to properly convey a 100-year flow without causing significant backwater. It is recommended to seek funds to replace this structure once it nears the end of its useful life. Any future structure should be sized to adequately convey the 100-year flow event (reduce backwater impacts from the existing conditions).

Assessment District Boundaries

Assessment Districts are often created as a funding mechanism for public projects, including projects as set forth in Part 307 (Inland Lake Levels) of Act 451. The assessment district is determined by the entity that has authority over the project and is generally made up of landowners who would receive benefit from the project. The alternative option would be to pay for any improvements and

maintenance from the County's general fund. As such, the Assessment District provided in this report is a tentative district boundary (see Figure 15). A final determination of the district would be made by the Houghton County Drain Commissioner (HCDC) upon further research.

Apportionment

The assessment of project costs to property owners in the recommended district can be handled one of several ways. These include the analysis of assessment by lakefront footage, by parcel acreage, and by individual parcel or a combination of the above. Each method has advantages and disadvantages that should be considered. Since the County has not determined whether an assessment district will be used for financing, apportionment will need to be determined at a later time if the County proceeds with financing in this manner.

Approximate Costs

Estimated construction and maintenance costs for Option #3 are as follows. Note that these are rough estimates at this time as design of the replacement structure for this option has not been started.

1. Construction of the proposed concrete weir and three 6" rails: $25,000
2. Estimated costs for triennial inspections: $750/inspection
3. Estimated costs for beaver dam removal: $1,000/year average

Individual Property Owner Cost

As was discussed under Apportionment, if it is determined by the County to use an assessment district to finance the project, an apportionment will be developed and individual property owner costs will be determined based on the apportionment and total anticipated project costs.