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File No. 22234

VIA EMAIL ONLY

November 17, 2022

Township of Southgate
185667 Grey Cty. Rd. 9, R. R. 1,
Dundalk, ON N0C 1B0

TOWNSHIP OF SOUTHGATE
HOLSTEIN DAM SAFETY REVIEW

INTRODUCTION AND BACKGROUND

At the direction of the Township of Southgate, BMROSS has undertaken a safety review of the Holstein Dam, located across Norman Reeves Creek in the village of Holstein.

It is understood that the dam belongs to the Township and was originally developed to provide water power to a mill located at the site. A feed mill still exists west of the dam but has not used the water power for many decades. At one time the earthen dam supported a railway line, and a concrete bridge bearing the year stamp of 1944 still spans the spillway.

Background historical research suggests that the dam was washed out in 1929, causing serious damage to buildings and infrastructure downstream. Another flood in 1948 caused damage but was reported as being not as severe. It has been reported that the dam has overtopped on a number of occasions, but not since 1975 unless; there is new information since 1999. *(ref. BMROSS report of July 4, 2000, based on a search of local newspapers and discussion with local residents and municipal staff in 1999).*

HAZARD POTENTIAL CLASSIFICATION

The Ontario Dam Safety Guidelines provide a table for the hazard classification of dams.

The classification is based on the assumption that the dam fails and consideration is given to the consequences of the failure. The consequences are dependent on the situation at the time of failure. Consideration should be given to a storm-related failure and a sunny-day failure. That is, a failure when there are high flows, or a failure when there are low flows. The worst of each case needs to be considered. Overall, the hazard classification for the Holstein dam is **high**, based on the four criteria discussed below.

Table 6.1
Hazard Classification per Ontario Ministry of Natural Resources (OMNR, 2011a)

Hazard Potential	Life Safety	Property Losses	Environmental Losses	Cultural – Build Heritage Losses
Low	No potential loss of life	Minimal damage to property with estimated losses not to exceed.	Minimal loss of fish and/or wildlife habitat with high capability of natural restoration resulting in a very low likelihood of negatively affecting the status of the population.	Reversible damage to municipally designated cultural heritage sited under the Ontario Heritage Act.
Moderate	No potential loss of life	Moderate damage with estimated losses not to exceed $3 million to agricultural, forestry, mineral aggregate and mining, and petroleum resource operations, other dams or structures not for human habitation, infrastructure and services including local roads and railway lines. The inundation zone is typically undeveloped or predominantly rural or agricultural, or it is managed so that the land usage is for transient activities such as with day-use facilities. Minimal damage to residential, commercial, and industrial areas, or land identified as designated growth areas as shown in official plans.	Moderate loss or deterioration of fish and/or wildlife habitat with moderate capability of natural restoration resulting in a low likelihood of negatively affecting the status of the population.	Irreversible damage to municipally designated cultural heritage sites under the Ontario Heritage Act. Reversible damage to provincially designate cultural heritage sites under the Ontario Heritage Act or nationally recognized heritage sites.
High	Potential loss of life of 1-10 persons	Appreciable damage with estimated losses not to exceed $30 million, to agricultural, forestry, mineral aggregate and mining, and petroleum resource operations, other dams or residential, commercial, industrial areas, infrastructure and services, or land identified as designated growth areas as shown in official plans.	Appreciable loss of fish and/or wildlife habitat, or significant deterioration of critical fish and/or wildlife habitat with reasonable likelihood of being able to apply natural or assisted recovery activities to promote species recovery to viable population levels. Loss of a portion of the population of a species classified under the Ontario Endangered Species Act as Extirpated, Threatened or Endangered, or reversible damage to the habitat of that species.	Irreversible damage to provincially designated cultural heritage site under the Ontario Heritage Act or damage to nationally recognized heritage sites.
Very High	Potential loss of life of 11 or more persons	Extensive damage, estimated losses in excess of $30 million to building, agricultural, forestry, mineral aggregate and mining, and petroleum resource operations, infrastructure and services. Typically includes destruction of, or extensive damage to large residential, institutional, concentrated commercial and industrial areas and major infrastructure and services, or land identified as designated growth areas as shown in official plans. Infrastructure and services include highways, railway lines, or municipal water and wastewater treatment facilities and publicly-owned utilities	Extensive loss of fish and/or wildlife habitat, or significant deterioration of critical fish and/or wildlife habitat with very little or no feasibility of being able to apply natural or assisted recovery activities to promote species recovery to viable population levels. Loss of a viable portion of the population of a species classified under the Ontario Endangered Species Act as Extirpated, Threatened or Endangered or irreversible damage to the habitat of that species.	

* People are assumed to be at risk if the product of the velocity and the depth exceeded 0 37 m2/s, or velocity exceeds 1 7 m/second, of if depth of water exceeds 0 8 m

Any failure of the dam is unlikely to involve the entire structure. Typically, a weakened section would break away. This would be in the order of 20 m width out of the 150 m wide embankment and spillway.

The bridge for Grey Road 109 is located only 140 m downstream of the dam. The bridge is a concrete single span structure. It effectively acts as a conduit with a significant barrier face. This would act as an effective buffer to any flow. If the bridge opening is insufficient to carry the flow during a dam break event, then the road is likely to be overtopped south of the bridge and may result in a road washout adjacent to the bridge.

The Holstein Dam is a moderate-height structure. At a face height of 5.3 m, it holds a significant volume of water up Norman Reeves Creek. On the upstream side of the spillway crest, the pond bottom is less than one metre below the crest, suggesting a significant depth of sediment or fill retained by the embankment and spillway.

Loss of Life

The table of selection criteria uses development in the area of inundation to determine the hazard potential for loss of life.

Downstream of the dam, along the Grey Road 109 corridor, there exist a number of buildings of commercial and residential use. Approximately 5 buildings are in the potential area for inundation. Considering the head of the dam and the volume of water to be discharged from the head pond, there is potential for soil scour and structural damage to these buildings, possibly with a loss of life.

Based on this, the hazard potential for loss-of-life should be considered to be **high**.

Property Losses

The area downstream is semi-urban with a number of commercial and residential properties and includes the feed mill. The bridge carrying Grey Road 109 would be at risk of scour failure during a dam-break flow event. The cost of dam repair or replacement would also need to be considered.

It is estimated that the property losses would be in the range of 3 million to 30 million dollars. Based on this, the hazard potential for property losses should be considered to be **high**.

Environmental Losses

There is potential for a significant release of sediment to accompany the flows from a dam break. This sediment could affect much of the stream bed from the Holstein Dam to the Orchardville dam at highway 6. There may be species-at-risk and their spawning beds in this reach of the stream. A breach of the dam would also change the head pond bottom profile and will greatly affect the types of aquatic wildlife that use the upstream reach of Norman Reeves creek.

There is reasonable likelihood that habitat recovery can be affected within a few years of a breach, whether the dam is restored or removed. Much of this would be through natural stabilization of the stream bed materials, possibly with some assisted dredging of material from deeply drifted deposits.

Based on this, the hazard classification for environmental losses should be considered to be **high**.

Cultural – Built Heritage Losses

This report does not include a study of built heritage assets in the floodplain. We are not aware of any sites that are designated under the Ontario Heritage Act in the area, so it is concluded that the hazard potential for cultural – build heritage losses are **low**.

SITE INSPECTION

A site inspection was made on August 15, 2022 by Steve Jackson, P.Eng. and Andrew Ross, P.Eng. The weather was sunny and warm. The upstream water level was lower than normal summer level, probably because of repair work on a bypass pipe north of the spillway. The spillway was carrying minimal flow over the crest and much of the spillway was accessible or visible.

The inspection was made with the use of sounding hammer to detect concrete delaminations on the spillway and a range pole to probe for undercuts and scour pockets. Chest waders were used to help with observations on the upstream side, where safe to do so.

On June 21, 2022, both of the inspecting engineers had an opportunity to observe the site and take photos while the head pond was drawn down by a gate failure at an unused bypass pipe. The pond level was at least 1 metre below the crest of the concrete spillway structure.

From the two inspections, the following observations were made.

Upstream embankment

- Review started with the upstream embankment, primarily looking for rodent holes, erosion and tree uprooting.
- Inspectors waded along the toe of the slope where possible and accessed the embankment from the top of the slope.
- The embankment was determined to be the area between Lane St and Petrie St.
- The water in the head pond was at the height of the sill of the concrete weir during the August 15 review.
- There is armour stone above the water line.
- Some localized erosion due to foot traffic and under-cuts were found, but no major erosion identified.
- The embankment is vegetated with trees and shrubs except for the location of informal paths to the water.
- There are multiple trees growing out of the embankment that exceeded a diameter of 4 to 6 inches.
- The bank was approximately 1.5:1 in most locations.

Crest

- The crest was a granular path that is used as a community trail.
- No erosion or settlement was observed.
- The crest is void of trees.
- No evidence of rills or overtopping.

- There are concrete blocks adjacent to the concrete dam structure that appear to be acting as a retaining wall to hold the trail in place. Failure (shifting towards the head pond) of the blocks may compromise the crest in these locations.

Downstream Embankment
- The inspectors walked the embankment in an ‘X” pattern.
- Some small rodent holes were observed.
- No major erosion issues were observed, but some small areas (< $1m^2$) of sloughing were observed.
- No seepage was observed.
- There was water at the toe of the bank that was very slowly flowing towards the stream. The water appears to start in the area of the headrace into the mill. During the site visit, the cofferdam and the related construction work resulted in no water pressure at the sluiceway. A subsequent site visit to look for signs of obvious piping along the headrace should be conducted when there is water above the sluiceway gate.
- The embankment was heavily vegetated with trees and some shrubs. The largest tree was estimated to by 350 mm to 400 mm in diameter. The ground was bare in some locations due to the tree canopy.

South Wingwall, abutment and apron
- The wingwall was undercut with concrete missing from the interface.
- Some delamination at the cold joint.
- The apron was undercut by more than 1.5 m.

Apron
- The apron was undercut in one area (towards south) by 0.5 m.
- One decayed timber exposed, running E-W.

Concrete Spillway
- Localized delamination north of low flow pipe.
- Area of spalled concrete north of low flow pipe.
- Some decayed timber planks and misplaced steel angle gains around low-flow pipe. These are likely part of a previous control and concrete formwork. They are of no consequence now.
- One area of sill, (location with flow over dam) had aggregate visible due to spalling.

North abutment, wingwall, apron
- Concrete about 90% fair and about 10% poor (delamination).
- Video taken during tap testing.
- The top of the apron/footing has been spalled or eroded and lateral lengths of steel rails are visible. Concrete missing from interface between wingwall bottom and top of apron.

Ballast Walls
- No issues identified on south wall.
- Localized delamination on north wall.

DESIGN AND CONSTRUCTION

No details were provided on the construction type or history of the dam. It is understood that the dam was developed for hydraulic power for a mill. There is still a feed mill located just west of the dam but it does not use any water flow for power. At some point, the dam was developed to support a railway. The existing concrete bridge over the spillway is date stamped 1944, but this does not appear to be the original bridge at this span.

There are reports of a washout of the dam in 1929 and a minor washout in 1948. The photographs below are assumed to be from the 1929 event since the 1944 bridge is not shown.

The photographs show what appears to be timber cribbing and the remains of a broken concrete wall. It can be assumed that the existing concrete abutments of the spillway were constructed after the 1929 washout.

Typically, dams of this era and this area were first constructed of rock filled timber cribs with wood planking on the upstream side. As the wood decayed, concrete walls and aprons were added to add strength and reduce water permeability. Instead of the concrete facings, or in addition to it, earth embankments have been used. Certainly the earth embankments would have been required to provide a structural base for the railway.

Assuming that this may have been the construction sequence, it is probable that the Holstein dam may be classified as an earth embankment dam with a concrete spillway. No design drawings are known to be available, and it is likely that the dam was constructed, modified, and repaired with the materials and methods common to mill operators of the day. Below the surface materials, it is likely that there are remains of different components of timber, rock, and concrete.

The site review on August 15, 2022 observed no seeps on the downstream slope of the dam, except close to the old millrace pipe. This is an indication that the core materials of the earthen embankment dam are effective at containing the water.

RECOMMENDATIONS

The following work is recommended to restore the strength and integrity of the dam by addressing the deficiencies observed. The recommended tasks are listed in priority. The budget values shown are approximate only and include allowances for mobilization, engineering design and contract administration, and a contingency allowance. There may be some economy realized by combining these repair items into a single contract. This may reduce the total costs of mobilization and environmental controls.

Before proceeding with any work plan, a more detailed budget should be prepared with specific dimensions and using the most recent unit prices from similar projects.

1. Repair Spillway Footings $82,000

The footings of the two wingwalls and the spillway apron show signs of some scour and undermining. Although not severe at this time, the condition is likely to accelerate with each significant flow. It is recommended that a lean concrete grout be cast to fill the voids that exist under these foundations.

The gaps at the bottom of each wingwall face are also a concern for discontinuity between the concrete of the foundations and concrete of the walls. If the hidden reinforcing steel is insufficient or corrodes over time, there may be a risk of the walls kicking out or sliding over the top of the foundation. It is recommended that a reinforced concrete overlay be cast on the top of the wing foundations to fill the undercuts and provide an effective shear key to prevent displacement of the walls over their foundations.

2. Repairs to Upstream Face of Berm **$25,000**

The upstream face of the earthen dam has a number of trees that pose a risk to the integrity of the dam. Trees can be uprooted during storms and the displaced root ball can compromise the effectiveness of the clay seal that prevents water penetration. As well, roots of larger trees can die, decay, and leave a conduit for water to pipe through the seal of the dam. It is recommended that trees be removed where their trunk diameter at 1 m above ground is more than 100 mm. The stumps or roots of the trees do not need to be removed.

There are some isolated undercuts and over-steep slopes, especially near the precast concrete blocks beside the concrete spillway. Quarry stone riprap could be placed and graded to restore slope stability in these areas.

3. Repairs to Spillway Faces **$65,000**

The exposed concrete faces of the spillway, abutments and wingwalls have spalls and delaminations that should be repaired to maintain the integrity of these structures in the long term. The work would involve providing access scaffolds or booms to reach all the affected areas. Unsound concrete would be chipped out and patches would be squared off, prepared, and cleaned. New concrete would be cast and cured in the voids. Mechanical anchorages would be used to fasten the new concrete to the existing base structure.

Respectfully submitted by:

Yours very truly

B. M. ROSS AND ASSOCIATES LIMITED

Per [redacted]

S.D. Jackson, P. Eng.

Per [redacted]

A.I. Ross, P.Eng.

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APPENDIX A

PHOTOGRAPHS

Head pond, looking east from dam

Upstream face of spillway

View of spillway and south abutment

Looking upstream at spillway

Low flow pipe in spillway

Typical vegetation on upstream embankment

Typical vegetation on upstream embankment

Trees and shrubs on the downstream embankment

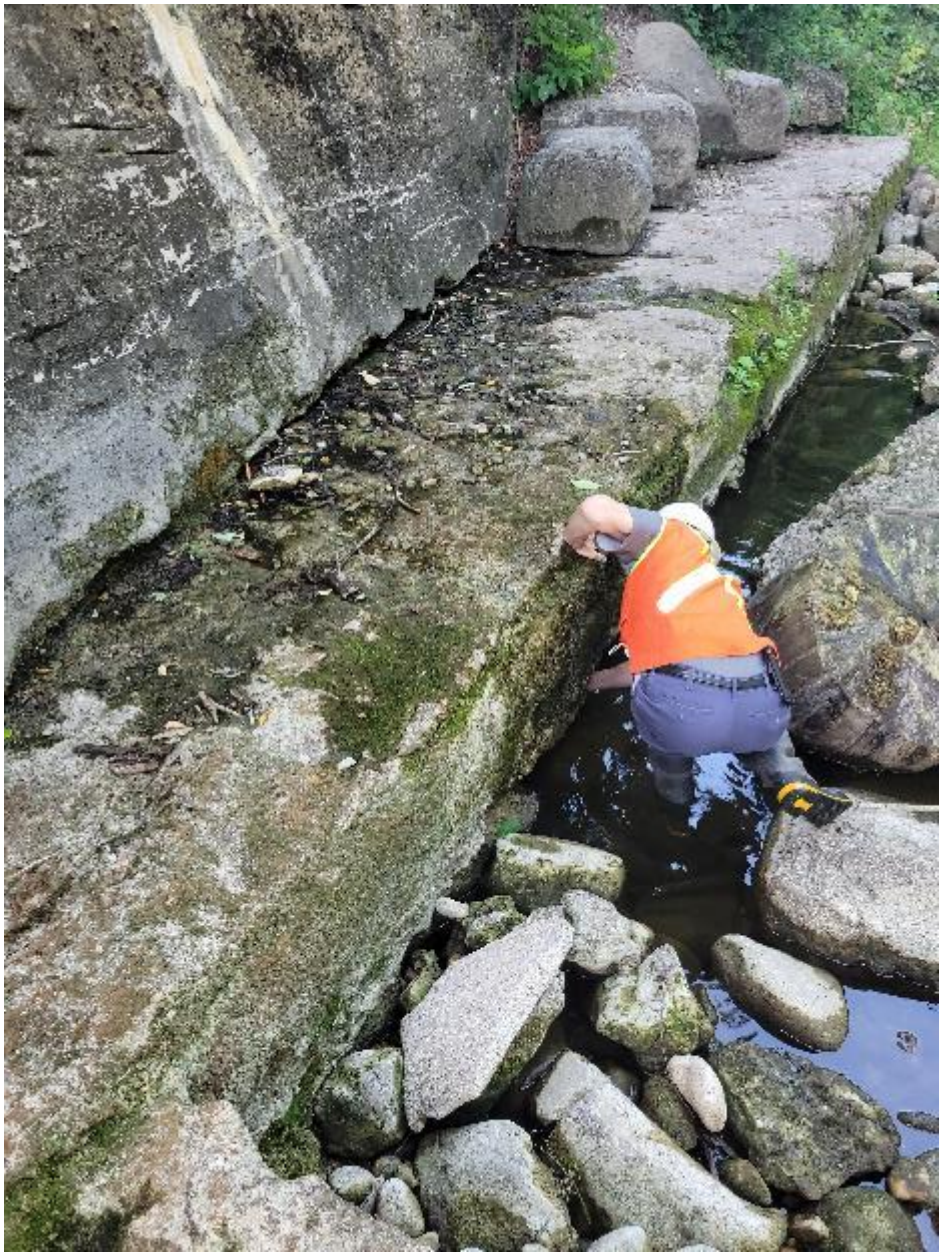
Larger diameter tree on downstream embankment (near spillway)

Downstream embankment with bare ground

Crest, looking north. Vegetation on both upstream and downstream embankments.

Undercut of spillway apron

North wingwall apron/footing with lateral lengths of steel rails visible



South wingwall apron/footing undercut

Abutment and south wingwall; Delamination at cold joint.

North wingwall concrete missing from interface between wingwall bottom and top of apron