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PROFESSIONAL ENGINEERS

Memorandum

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To:	Rick Goldt, C.E.T	**Date:**	July 28, 2015
From:	David Arseneau, P.Eng.	**ERI Project No.:**	1505
Re:	Embro Dam Hazard Potential Classification Update		

Background

The Embro Dam was constructed at an unknown date however the dam and property were purchased by the UTRCA in 1958. At the time of the purchase, the dam was in a state of disrepair and therefore the structure was replaced. The dam and pond were rebuilt for recreational and water supply purposes. The dam is an earth embankment dam with a grassed emergency spillway. The dam was overtopped in the summer of 2000, however only minor damage was reported. The dam is approximately 4.5m in height and 100m in length with a reservoir area of 0.05 km^2. The upstream pond slopes are inclined between 3 and 4:1 whereas the downstream slopes of the dam are inclined between 2 and 3:1.

Current Hazard Classification

A dam safety assessment report for Embro Dam was completed in 2007 (Acres), which included a dam hazard potential classification. The report references the Ministry of Natural Resource's 1999 Dam Safety Guidelines. The dam hazard potential classifications are summarized in the Dam Safety Guidelines and is reproduced below in **Table 1-1**. The Embro Dam was assessed for hydrotechnical issues and scored a rating of very low for flood and earthquake hazards referencing economic loss or loss of life. The environmental hazard potential was expected not to exceed a rating of very low. Based on the 1999 Dam Safety Guidelines, the minimum inflow design floods for dams are determined based on the height and storage characteristics of the dam and the hazard potential rating. The Embro Dam is classified as a small dam in both height and storage and with a rating of very low, the minimum inflow design floods are required to be the 25-year to 50-year flood. A hydraulic and hydrologic assessment was completed in order to confirm the very low rating for loss of life and determine the appropriate minimum IDF. The rating of very low for flood flows was confirmed and an IDF of 50-year, 8-day spring snowmelt event was utilized. The IDF was utilized to determine if Embro Dam had appropriate freeboard to safely pass the flood flows. It was determined that the dam will be overtopped and the spillway is not adequate to pass the IDF.

Updates to DHC Methodology

The Hazard Potential Classifications and Inflow Design Flood criteria have been modified since the completion of the 2007 Dam Safety Assessment for Embro Dam. The revised hazard potential ratings are summarized in **Table 1-2**. The hazard potential ratings have been revised as low, moderate, high and very high. The hazard categories have been revised to life safety, property loss, environmental losses and cultural – built heritage losses. The hazard categories for each hazard potential rating have been modified and improved to be more descriptive. The assessment of life safety is conducted with the application of the 2 x 2 rule which is described in the notes that correspond to the summary of the updated classifications in **Table 1-2**. Property damage is assessed based on third party losses, does not include costs associated with the failure of the dam, and losses must include present and anticipated development. The selection of the minimum inflow design floods can be determined based on the hazard potential ratings of each hazard categories. It is recommended that the hazard potential classification be reviewed and updated if major works are being completed for the study site.

Table 1-1. Hazard Potential Classifications for Dams: SELECTION CRITERIA (MNR, 1999)

Hazard Potential	Loss of Life	Economic and Social Losses	Environmental Losses
Very Low	Potential for loss of life: None	Damage to dam only. Little damage to other property. Estimated losses do not exceed $100,000	Environmental Consequences: Short-term: Minimal Long-term: None
Low	Potential for loss of life: None. The inundation area (the area that could be flooded if the dam fails) is typically undeveloped.	Minimal damage to agriculture, other dams or structures not for human habitation. No damage to residential, commercial, industrial or land to be developed within 20 years. Estimated losses do not exceed $1 million.	No significant loss or deterioration of fish and/or wildlife habitat. Loss of marginal habitat only. Feasibility and/or practicality of restoration or compensating in kind is high, and/or good capability of channel to maintain or restore itself.
Significant	Potential for loss of life: None expected Development within inundation area is predominantly rural or agricultural, or is managed so that the land usage is for transient activities such as with day use facilities. There must be a reliable element of warning if larger development exists.	Appreciable damage to agricultural operations, other dams or residential, commercial, industrial development, or lands to be developed within 20 years. Estimated losses do not exceed $10 million.	Loss or significant deterioration of important fish and/or wildlife habitat. Feasibility and/or practicality of restoration and/or compensating in kind is high, and/or good capability of channel to maintain or restore itself.
High	Potential for loss of life: One or more. Development within inundation area typically includes communities, extensive commercial and industrial areas, main highways, public utilities and other infrastructure.	Extensive damage to communities, agricultural operations, other dams and infrastructure. Typically includes destruction of or extensive damage to large residential areas, concentrated commercial and industrial land uses, highways, railways, power lines, pipelines and other utilities. Estimated losses exceed $10 million.	Loss or significant deterioration of critical fish and/or wildlife habitat. Feasibility and/or practicality of restoration and/or compensating in kind is low, and/or poor capability of channel to maintain or restore itself.

* Supporting References: MNR Guidelines for Approval Under the Lakes and River Improvement Act, 1977
MNR Fisheries Section, 1999
US Army Corps of Engineers, Dam Safety Assurance Program, 1995
Dam Structure Assessment Program, Ontario Hydro, 1990

Notes:

1. Consideration should be given to the cascade effect of dam failures in situations where several dams are situated along the same watercourse. If failure of an upstream dam could contribute to failure of a downstream dam(s), the minimum hazard potential classification of the upstream dam should be the same as or greater than the highest downstream hazard potential classification of the downstream(s).

2. Economic losses refer to all direct and indirect losses to third parties; they do not include losses to owner, Such as loss of the dam, associated facilities and appurtenances, loss of revenue, etc.

3. Estimated losses refer to incremental losses resulting from failure of the dam or misoperation of the dam And appurtenant facilities

4. For Hazard Potential Classification and Safety Criteria for tailings dams, refers to “Guidelines for Proponents, Rehabilitation of Mines”, issued by Ontario Ministry of Northern Development and Mines, 1995

Table 1-2. Hazard Potential Classification (MNR, 2011)

	Hazard Categories – Incremental Losses[1]			
Hazard Potential	**Life Safety[2]**	**Property Losses[3]**	**Environmental Losses**	**Cultural – Built Heritage Losses**
Low	No potential loss of life.	Minimal damage to property with estimated losses not to exceed $300,000.	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 sites 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 designated 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 Infrastructure and services includes regional roads, railway lines, or municipal water and wastewater treatment facilities and publicly-owned utilities.	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 sites 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 buildings, 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 includes 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.	

Notes
1. Incremental losses are those losses resulting from dam failure above those which would occur under the same conditions (flood, earthquake or other event) with the dam in place but without failure of the dam.
2. Life safety. Refer to Technical Guide – River and Streams Systems: Flooding Hazard Limits, Ontario Ministry of Natural Resources, 2002, for definition of 2 x 2 rule. The 2 x 2 rule defines that people would be at risk if the product of the velocity and the depth exceeded 0.37 square metres per second or if velocity exceeds 1.7 metres per second or if depth of water exceeds 0.8 metres. For dam failures under normal (sunny day) conditions the potential for loss of life is assessed based on both permanent dwellings (including habitable dwellings, trailer parks and seasonal campgrounds) and transient persons.
3. Property losses refer to all direct losses to third parties; they do not include losses to the owner, such as loss of the dam, or revenue. The dollar losses, where identified, are indexed of Statistics Canada values Year 2000.
4. An HPC must be developed under both flood and normal (sunny day) conditions.
5. Evaluation of the hazard potential is based on both present land use and on anticipated development as outlined in the pertinent official planning documents (e.g. Official Plan). In the absence of an approved Official Plan the HPC should be based on expected

development within the foreseeable future. Under the Provincial Policy Statement, '*designated growth areas*' means lands within *settlement areas* designated in an official plan for growth over the long-term planning horizon (specifies normal time horizon of up to 20 years), but which have not yet been fully developed. *Designated growth areas* include lands which are *designated and available* for residential growth in accordance with the policy, as well as lands required for employment and other uses (Italicized terms as defined in the PPS, 2005).

6. Where several dams are situated along the same watercourse, consideration must be given to the cascade effect of failures when classifying the structures, such that if failure of an upstream dam could contribute of failure of a downstream dam, then the HPC of the upstream dam must be the same as or greater than that of the downstream structure.
7. The HPC is determined by the highest potential consequences, whether life safety, property losses, environmental losses, or cultural-built heritage losses.

Revised DHC

The dam hazard potential classification requires update based on the 2011 Guidelines and due to the Class EA being completed for Embro Dam. Aerial photographs of Embro Dam were examined and it was determined that no significant land use changes occurred from 2006 to 2013 and it is presumed that no significant land use changes are expected to occur in the foreseeable future (**Figure 1**). Therefore, the hazard potential classifications of the study site should remain similar to that of the 2007 Dam Safety Assessment. Life safety hazard was rated as very low and given that no new permanent dwellings have been constructed in the study area, it is reasonable to assign a HPC of low for the current conditions of Embro Dam. Similarly, it is expected that the incremental hazard potential for property loss, environmental losses and heritage losses will remain low. Therefore, the overall incremental hazard potential for Embro Dam would be low based on these hazard potential ratings.

Summary of Revised Hazard Potential Ratings:

- Life Safety: LOW
- Property Losses: LOW
- Environmental Losses: LOW
- Cultural-Built Heritage Losses: LOW

Canadian Dam Safety Guidelines

In addition to the MNR Dam Safety Guidelines, the Canadian Dam Association (CDA) specifies safety guidelines for dams. The CDA dam classifications are summarized in **Table 1-3**. The dam classification system breaks down hazard potentials into population at risk and incremental losses. PAR assigns a rating to how many people will be affected in the event of a flood and is determined based on the presence of temporary or permanent residents. The incremental losses hazard potentials are similar to the MNR guidelines with loss of life, environmental, cultural and economic losses. The population at risk at Embro Dam would be none given that there are no permanent or temporary residences within the inundation zone and a dam classification of low is applicable. Similarly, the incremental losses for loss of life would be a rating of low due people not being expected within the inundation zone. Given that the inundation zone is primarily agricultural, it is expected that environmental, cultural and economic losses are expected to be low. Therefore, the overall hazard potential for Embro Dam according to the CDA guidelines would be low.

Summary of CDA Hazard Potential Ratings:

- Population at Risk: LOW
- Loss of Life: LOW
- Environmental Losses: LOW
- Cultural Losses: LOW
- Economic Losses: LOW

Figure 1: Aerial Photo Comparison of Study Area (Google Inc., 2015)

Table 1-3. Dam Classification (CDA, 2007)

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of Life [note 2]	Environmental and cultural values	Infrastructure and economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind possible but impractical	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implications for loss of life:

Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season

References

Acres International. July, 2007. Dam Safety Assessment Report for Embro Dam. Prepared for Upper Thames River Conservation Authority.

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