



DAM SAFETY REVIEW BURGESS 1 DAM

for

Township of Muskoka Lakes



September 6, 2019

TULLOCH Project No.: 19-1493

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LIST OF ACCRONYMS

CDA	Canadian Dam Association
DSD	Dam Safety Deficiency
DSI	Dam Safety Inspection
D/S	Downstream Side of Dam
EPRP	Emergency Preparedness and Response Plan
EWL	Existing Water Level
FOS	Factor of Safety
HPC	Hazard Potential Classification
HWL	Headwater Level
ICC	Incremental Consequence Category
IDF	Inflow Design Flood
IEL&D	Incremental Economic Loss and Damage
ILOL	Incremental Loss of Life
NOL	Normal Operating Water Level
MDE	Maximum Design Earthquake
MNRF	Ontario Ministry of Natural Resources and Forestry
PAR	Population at Risk
PGA	Peak Ground Acceleration
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RFP	Request for Proposal
SFI	Scope for Improvement
U/S	Upstream Side of Dam

EXECUTIVE SUMMARY

ES-1 OVERVIEW

This report presents the results of a Dam Safety Review (DSR), performed by TULLOCH Engineering (TULLOCH) for the Burgess 1 Dam structure associated with the powerhouse at Bala, Muskoka, Ontario. The DSR was triggered by an overtopping event in the spring of 2019.

The DSR included a site visit On July 4th, 2019 by Frank Palmay, P. Eng. and Erik Giles, P. Eng., where existing conditions of the structure were observed and recorded along with site measurements. This report summarizes the results of the DSR and has been prepared according to CDA (2007, 2014) and MNRF (2011) guidelines.

Based on this DSR, the Burgess 1 Dam is in “poor to fair safe condition”. However, some deficiencies and non-conformances were identified as summarized in Tables ES-1 and ES-2, respectively. The following summarizes the DSR findings.

E-2 HYDROTECHNICAL ASSESSMENT

The following is a summary of the hydrotechnical assessment of the Burgess 1 Dam based on the available information provided in MRWMP.

- The Inflow Design Flood at the MNRF Bala Dams was established as the 100 years event with a maximum lake of El. 226.5m. The identical IDF (1/100yrs) with a water level of El. 226.5 m applies to Burgess 1 Dam;
- The Normal Operating Level (NOL) is also defined by Bala North and South dam. The NOL is in the range of El. 224.6 m to El. 225.75 m (Acres, 2006).
- Based on document review, the existing dam crest elevation is at El. 226 m (to be confirmed by survey). TULLOCH recommended that the reservoir level upstream of the Burgess 1 Dam should be kept within the operating levels as per the MRWMP of El. 225.75 m (upper bound) in order to ensure a minimum freeboard of 0.25 m during operation.
- The current dam does not have enough freeboard to store the IDF at present. Design measures for proper management of overflows should be developed for IDF event.
- The reservoir water level was at about El. 225.3 m at the time of TULLOCH’s dam safety inspection (DSI) conducted July 4th, 2019. This level is inferred to be the normal operating water level (NOL) of the facility.

- Based on the incremental consequences of dam failure during the IDF and sunny day breach (i.e. non-flood) conditions, the Burgess 1 Dam is classified as having a LOW HPC according to both MNRF and CDA guidelines.

E-3 GEOTECHNICAL STABILITY

The following table summarizes the results of the calculated factor of safety for the existing Burgess 1 Dam section under various loading conditions compared to the MNRF required minimum FOS.

Table ES-1: Calculated FOS for Stability of Burgess Dam Structures

Dam	Case ¹	Water Level (m)	FOS-Sliding	FOS - Overturning	Required FOS – Sliding/Overturning
Non-overflow Dam Section	Static Loading with NOL	El. 225.75	2.7	1.4	1.5 / 2.0
	Pseudo-static $\alpha=0.01g$ and NOL	El. 225.75	2.7	1.4	1.1 / 1.1
	Static Loading with IDF	El. 226.49	2.3	1.1	1.3 / 1.3
Powerhouse Dam Section	Static Loading with NOL	El. 225.75	1.2	1.0	1.5 / 2.0
	Pseudo-static $\alpha=0.01g$ and NOL	El. 225.75	1.2	1.0	1.1 / 1.1
	Static Loading with IDF	El. 226.49	1.1	1.0	1.3 / 1.3

Note: ¹ NOL is the Normal Operating Level

Based on the geotechnical stability assessment, Repair or mitigation measures have to be developed for both the non-overflow dam section and powerhouse dam section to improve the FOSs to meet the criteria.

E-4 DAM MANAGEMENT AND PUBLIC SAFETY CONCLUSIONS

Based on the site inspection it was determined that there are a number of concerns towards public safety that need to be addressed such as upgrading and adding signage on the site, repairing and extending broken fencing, burying exposed ground wires and the creation of a Public Safety Plan. Further details can be found in table ES.2.

E-5 SUMMARY TABLES

Tables ES-2 and ES-3 summarize the recommended remedial actions to address the observed deficiencies and non-conformances at the Burgess 1 Dam site.

Table ES.1: Dam Safety Recommendations

Dam Structure	Issue	Category	Recommended Action	Recommended Schedule
Non-overflow dam section	Moderate to significant washouts along the dam toe area caused from 2019 flooding The FOS of the concrete dam section depends on the remaining fill material on the d/s toe area for the post-overflow event in 2019 flooding. Significant washout /scouring was observed along the downstream toe area with a scoring depth in excess of 1.0 - 1.5 m. The observed lake level in 2019 spring was about El. 226.45 m, is comparable to an IDF event for the Bala Falls Dams. Under the current site condition, the calculated FOSs against sliding and overturning are inadequate and do not meet required minimums.	Deficiency	Replace/reinstate the d/s fill material with rockfill/rip rap erosion protection to improve the FOS to meet the criteria	Spring/Summer 2020 High Priority
	No emergency spillway	Deficiency	A spillway option or the alternative overflow control options should be designed and constructed to pass the IDF conditions during a flood event.	Within 5 years
	Inadequate water level monitoring program	Deficiency	Install permanent water level gauges and / or other reliable monitoring measures tied to the Bala North and South Dams and monitor the water level regularly.	Spring/Summer 2020

Dam Structure	Issue	Category	Recommended Action	Recommended Schedule
Powerhouse Dam Section	The powerhouse structure is in poor condition. The dam and powerhouse are integrated into one structure. Large diagonal cracks observed in the concrete foundation slab likely caused by undermining from long-term scouring during powerhouse operation have compromised the load path of the structure and have limited the slabs ability to uphold the structure. In its current state the FOS of the powerhouse does not meet required minimums. The current site condition, the calculated FOSs against sliding and over-turning for the powerhouse dam section are inadequate to meet the required minimum FOSs.	Deficiency	Repair or mitigation measures must be developed for the powerhouse dam section (including the foundation treatment) to improve the FOS to meet required minimums.	Fall 2020 High Priority
	Powerhouse operation Under current condition, the powerhouse needs to cease operation to prevent further scouring and undermining of the foundation which are causing stability issue of the powerhouse.	Deficiency	Stop the units running or extend the tailrace pipeline to a safe distance d/s.	Spring/Summer 2020

Table ES.2: Maintenance and Surveillance Recommendations

Dam Structure	Deficiency or Non-Conformance	Category	Recommended Action	Recommended Schedule
Non-Overflow and Powerhouse dam Section	Lack of record drawings	Non-conformance	Compile the following records and keep them on file for Dam Safety Purposes: - Existing dam as-built drawings and design reports - As-built records for dam modifications/repairs.	Within 2 years after completion of the dam upgrade.
	OMS document	Non-conformance	Develop an OMS Manual for the facility. The normal operating water level and maximum operating water level should be defined in the OMS.	Within 1 year after completion of the detail design of the dam upgrade.
	Emergency Preparedness and Response Plan (EPRP)	Non-conformance	Develop an EPRP	Within 1 year after completion of the detail design of the dam upgrade.
	A survey of the dam structures and associate facilities	Non-conformance	A survey of the existing dam structures should be conducted for the design of dam structure upgrade to meet the CDA and MNRF guidelines	Complete by end of 2019
	Dense vegetation present at the dam site	Non-conformance	The vegetation should be removed within 3-5 m footprint of the selected option for the dam upgrade	Prior to the construction of the dam upgrade.
	Grouting or concrete patching the cracks in the existing dam sections	Non-conformance	Grouting or concrete patching is recommended to repair the existing cracks in the dam.	Complete by Spring/Summer 2020

Dam Structure	Deficiency or Non-Conformance	Category	Recommended Action	Recommended Schedule
Non-Overflow and Powerhouse dam Section (con't)	There is no signage at the dam sites, upstream from or downstream from the dams, or at the access points	Non-conformance	Safety and warning signage should be posted at both entrances to the site. Signage should be installed on the dams indicating hazards, including presence of deep water in the lake approaching to the dam, required PPE, hazards of working at or around dam and signage at the discharge facilities indicating unexpected release of flows or fast-moving water. Signage should be posted upstream and downstream of facility to warn the public of fast-moving water and the presence of the dam	Complete by Spring/ summer 2020
	Public Safety Plan (PSP)	Non-conformance	A Public Safety Plan (PSP) should be drafted to address the safety issues and ensure they are properly managed, and controls are properly maintained.	Complete by Spring 2020
	The existing boom line is in a poor condition	Non-conformance	Upgrade the boom line and adjust the safety distance to the powerhouse inlet; Regular maintenance is recommended.	Complete by Spring / Summer 2020
	Exposed grounding wire along site	Non-conformance	Backfill all exposed wires	Complete ASAP High Priority
	The existing fence / gate to constrain the public access to the dam site	Non-conformance	Upgrade the fence / gate to constrain the public access to the dam site without permits. Regular maintenance is recommended.	Complete by Spring / Summer 2020

Dam Structure	Deficiency or Non-Conformance	Category	Recommended Action	Recommended Schedule
River Street Concrete Retaining Wall and Embankment	River Street Concrete Retaining Wall is in a fair safe condition	Non-conformance	Retaining wall drainage efficiency upgrade design and construction are recommended; survey and geotechnical investigation and assessment are required.	Prior to the construction of the dam upgrade.
	River Street Embankment with Gabion Wall is in poor condition The embankment to the west of the retaining wall was in poor to fair safe condition during 2019 DSI. There exists a potential slope failure risk for River Street adjacent to the tailrace of the dam.	Non-conformance	A slope stability evaluation of the embankment along River Street is recommended. Detailed geotechnical investigation and assessment are strongly recommended.	Complete by Spring / Summer 2020

1. INTRODUCTION

1.1 Purpose and Objectives

TULLOCH Engineering Ltd. (TULLOCH) was retained by the Township of Muskoka Lakes (the Township) to carry out a Dam Safety Review (DSR) for the Burgess 1 Dam structures in Bala, Ontario within the District of Muskoka. Appendix A shows the site the location.

A DSR is an independent and systematic review and evaluation of the design, construction, maintenance, operation, and management systems affecting dam safety. For this DSR, the Burgess 1 Dam and associate structures were assessed in accordance with the Canadian Dam Association (CDA) Dam Safety Guidelines (2007, 2014) and Ontario Ministry of Natural Resources (MNR) Best Management Practices and Technical Bulletins (2011). Prior to this report, a formal DSR has not been carried out for the Burgess 1 Dam structures.

The overall objective of the DSR is to provide the Township with an independent and comprehensive assessment of the adequacy of the current Burgess 1 Dam facility to meet or exceed the applicable dam safety requirements. This review is intended to identify and categorize all dam safety issues that require remedial attention. Further, the issues identified are prioritized in Table ES-1 to ES-2 to assist the Township in setting priorities and developing an action plan to deal with the safety related deficiencies identified for the Burgess 1 Dam.

The scope of the work for the DSR was detailed in the TULLOCH Proposal dated May 31st, 2019 (Proposal #19-0001-179). The process commenced with The Township providing historical documents relating to the project to TULLOCH for review. Next, a DSI was performed by TULLOCH engineers accompanied by Mr. Steve Dursley a representative of KRIS Renewable Power the current lease and operator of the facility on July 4th, 2019. The DSI was limited to the civil/geotechnical, hydrotechnical and structural aspects of the facilities. Following the site inspections, a detailed DSR was completed including:

- Background data review
- Key/critical findings and preliminary recommendations
- Geotechnical, Structural and Hydrotechnical assessments
- Preliminary study for the mitigation/repair options
- Conclusion and recommendations
- DSR Report

Th following sections provide details of the DSR completed for the Burgess 1 Dam Structures. A Key Location Plan for the site can be found in Appendix A.

2. BACKGROUND INFORMATION

2.1 Document Review

The DSR process began with a review of available background information. The following documents were reviewed and formed the basis of this DSR.

- MRWMP Final Plan Report by Acres international, dated 2006
- Bala – Small Hydro Development Burgess Dam Site – Report on Proposals for Development by Totten Sims Hubicki Associates, not dated (circa 1987)
- Township of Muskoka Lakes Small Hydro Development Bala Tender Documents by Totten Sims Hubicki Associates, dated 1987
- Structural Report Bala Dam and Power Building Township of Muskoka Lakes by Totten Sims Hubicki Associates, dated 1986
- A Proposal for Historic Site Development of The Bala Power Generating Facility by Integrated Resource Group, dated 1984
- Feasibility Study for The Restoration of the Bala Power Generation Station by Integrated Resource Group, (not dated circa. 1984)

2.2 General Site Layout

The Burgess 1 Dam mainly consists of the following structures:

- Concrete dam structure (Water Retaining structure, Non-overflow dam section);
- Concrete dam with downstream (d/s) powerhouse structure;
- River Street Retaining Wall and Embankment;
- Other ancillary structures including the access road, fence, gates, tailrace and walkways.

A key location plan can be seen in Appendix A which shows the Burgess 1 Dam general site layout.

2.3 Organization and Responsibilities

Originally the dam was built by J.W. and A.M. Burgess between 1917 and 1922 and the dam/generating station was purchase by the Ontario Hydro Commission in 1929. Burgess 1 Dam was owned and operated by Ontario Hydro from 1929 to 1957 and was then sold to the Township in 1963 who currently owns the facility.

Based on Township records the facility was largely unused for a long period of time until it was partially refurbished and leased to Marsh Power in 1988 for the purpose of power generation until

1999. The facility was then leased to Algonquin Power (Fund) Canada Inc. and operated by Algonquin Power Systems Inc. until 2011. Upon expiry of the lease KRIS Renewable Power Ltd (KRIS). Began to lease and operate the generating station. The current Lease started in August of 2012 and expires in 2022. KRIS currently operates the facility employs a part time care and maintenance operator who works e at the facility to run the generating station, remove debris from the headwaters/spillway inlet and generally maintain the property. KRIS has also partially upgraded the facility by adding new metal sluiceways and a new turbine on the north inlet of the headwaters.

2.4 Burgess 1 Dam Facilities

The Burgess 1 Dam was built and began operation in 1917. The facility consists of a 59 ± meter long concrete dam founded on bedrock with a maximum height of approximately 3 meters. Fill has been placed on the downstream face of the dam to provide resistance against the overturning and sliding of the structure. The powerhouse is approximately 9 m x 14 m in dimension including the turbine, generator and associated electrical equipment. Finally, a 16 m long retaining wall connected to the north wall of the powerhouse supports River St immediately to the north of the facility. The tail race is armored with gabion baskets sitting atop a historic boulder rock wall on the north bank of the facility. The dam and powerhouse are integrated into one structure, which is situated in a constructed channel on the existing bedrock. Table 2-1 below summarizes the main features of the dam structures on site:

Table 2-1: Summary of the In-situ Features of the Burgess 1 Dam

No.	Dam	Main Features	Reference
1	Non-overflow Dam Section	Concrete Retaining Structure on Bedrock supported by d/s fill embankment.	TSHA Structural Report, 1986 Drawing P-1 and P-2
2	Powerhouse Dam Section	Concrete gravity dam and powerhouse are integrated into one structure and founded on the bedrock	TSHA Structural Report, 1986 Drawing P-1 and P-2
4	Dam Crest Elevation (m)	El. 226.0 m	TSHA Structural Report, 1986 Drawing P-1 and P-2
5	Maximum Dam Height (m)	- Max. 3 m (non-overflow section) - Max. 6 m (Powerhouse Section)	TSHA, Structural Report 1986 Drawing P-1 and P-2
6	Crest Width (m)	Approx. 0.6 m	TSHA, 1986 Drawing P-1 and P-2
7	Dam Length (m)	59 m (total length of dam) 14m (Powerhouse Section)	TSHA, 1986 Drawing P-1 and P-2

No.	Dam	Main Features	Reference
8	Spillway	No Spillway	MRWMP, 2006
9	Reservoir Levels	- NOL Range between 224.6 and 225.75 m - IDF El. 226.49m	MRWMP, 2006
10	Powerhouse	0.14MW, 2 Units - Max. flow rate 4m³/s	MRWMP, 2006

For further information/details of the features of the Burgess 1 Dam, relevant historic drawings/site plans can be viewed in Appendix F. The aforementioned plans along with field measurements formed the bases for the modelling and the figures presented in this report. It is strongly recommended that a detailed survey of the site be undertaken to verify dimensions and elevations.

3. SITE CONDITIONS

3.1 Site Surficial Geology

Based on review of Bedrock Geology and Surficial Geology of Southern Ontario mapping as published by the Ontario Geological Society (OGS), the site surficial geology is comprised of Canadian Shield with formations of Precambrian Bedrock typical within the Muskoka region. The bedrock on site was located close to ground surface and comprised of typical geologic formations for the Bala area including hard and smooth pink to grey migmatitic rocks as well as quartzofeldspathic gneisses (OGS 2019). The Burgess 1 Dam is located at the lower section of the Muskoka river watershed near the bottom of Lake Muskoka where regional topography is typically mapped as low local relief varying from plains to undulating hummocky conditions (Acres 2006). Overburden in the Bala area is typically sandy and shallow in depth with thick organic deposits found in low lying wetland areas. Overburden observed on site was typically shallow and sandy in nature.

3.2 Site Seismicity

The site seismicity is based on the 2015 National Building Code seismic peak ground acceleration (PGA). Based on the DSR, the Burgess 1 Dam has been classified as a dam structure with LOW flood and earthquake hazards, indicating the return period of the design earthquake to be 1/100 according to CDA Guidelines (2013 Edition). Accordingly, the PGA seismic coefficient for the dam sites has a 40% probability of exceedance in 50 years corresponding to a return period of 1 in 100 years, based on the 2015 National Building Code. Appendix B shows the PGA data obtained from the 2015 National Building Code Seismic Hazard Calculation Index which is specific to the site. This corresponds to a PGS value of 0.01.

3.3 Site Hydrology

Located on the lower tier of the Muskoka Watershed, the Burgess 1 Dam generating facility along with the North and South Bala Falls Dams hold back most of the water collected from the Muskoka River Watershed sharing a drainage area of 4683 km² and a lake surface area of 120 km² (Acres 2006) . Generally, flood events for the watershed occur in two basic types, a spring freshet from melted snow along with increased precipitation and major storm events.

The Burgess Dam is largely controlled by the larger North and South Bala Falls Dams located ~ 300m south of the facility which typically handles the flood flow through the watershed. Water from the Burgess Dam flows south west into the Moon and Musquash Rivers eventually into Georgian Bay. The majority of the watershed meets in Bala forming a bottle neck that must handle significant flows during flooding conditions from the majority of the watershed. Recorded river flow data at the Bala Reach of the Muskoka river indicate a long-term average stream flow of approximately 76.7 m³/s (Acres 2006).

The allocated maximum flow to the Burgess Generating Station is 4 m³/s and there is no spilling capacity. As a result, all flood flows passing from Lake Muskoka are routed through the North and South Bala Dams. The facility has two turbine units and is rated at 0.14 MW. Power is generated at the facility only when Lake Muskoka water levels are within an acceptable range.

4. DAM SAFETY GUIDELINES

This DSR was executed in accordance with the following guidelines from both the MNRF (2011) and Canadian Dam Association (2007, 2011, 2013):

- The Ontario MNRF Guidelines including Ontario Ministry of Natural Resources and Forestry Lakes and Rivers Improvement Act Administrative (LRIA) Guide (dated August 2011),
- Associated Technical Bulletins and Best Management Practices.
- Canadian Dam Association, 2007 Dam Safety Guidelines, including 2013 Revisions.
- Canadian Dam Association, Guidelines for Public Safety Around Dams, 2011.

Dam classification and design criteria for the DSR are based on the MNRF (2011) Hazard Potential Classification (HPC) system, the CDA (2007) dam classification category and associate Inflow Design Flood (IDF) and Earthquake Hazards. Appendix C includes the dam classification and criteria used in this study from the CDA and MNRF guidelines.

5. DSR PROCEDURES

5.1 DSI and Interviews

A DSI in support of the DSR were carried out on July 4th, 2019 by Mr. Frank Palmay, P.Eng. and Mr. Erik Giles, P.Eng. of TULLOCH Engineering. The DSI personnel were accompanied by Mr. Steve Dursley, who was a KRIS representative. The inspected areas included the Burgess 1 Dam structures, powerhouse and associate equipment, u/s reservoir, the downstream tailrace, River Street retaining wall structures and the surrounding areas.

The details of the DSI field report and findings are in Appendix D and the previously issued Key Findings Memorandum can be found in Appendix E.

5.2 DSR Assessments

The following technical assessments were carried out in support of this DSR:

- Hydrotechnical assessment to determine the Hazard Potential Classification (HPC) and Inflow Design Flood (IDF) for the structures
- Geotechnical assessment to evaluate the stability of the existing dam under various loading conditions
- Development of a preliminary options for Dam mitigation/repair including baseline cost estimation
- DSR report

6. DAM SAFETY INSPECTIONS

6.1 General

The site inspections at the Burgess 1 Dam were completed on July 4th, 2019, based on the following sequence:

- The site DSI was undertaken with an emphasis on the nature, extent and condition of the contained material(s), reservoir levels, upstream (U/S) and downstream (D/S) areas and abutment contacts, the geotechnical environment, and included the flow discharge facilities as well as the structural condition of the existing powerhouse structure and retaining wall attached to the dam;
- Walk-arounds and visual inspections at the dam site included observations of components such as dam crests, U/S and D/S slopes, abutments, toe areas, and a record of relevant details indicative of the stability and potential risk of instability of the structures. The recorded information includes facility name, height of structure, approximate slope gradients, activity status and physical condition (i.e. visible depressions, cracking,

deformation, surface erosion, freeboard, signs of past flooding, overtopping, internal erosion, piping, sand boils etc.);

- Inspections of the appurtenant structures were done to assess their condition, functionality and adequacy;
- Inspection forms were completed for each of the significant structures, including the gathering of other relevant information such as GPS data (georeferenced using UTM coordinates), digital photographs of all pertinent features, and area characterization (refer to Appendices D and E);
- Where background information was not available, the dimensions of the structures were estimated with a measuring tape or by pacing;
- No underwater inspections were proposed nor were any inspections of high steep slopes carried out when accessibility was limited.
- Assessment was based on exposed physical condition only and did not include destructive testing of any element of the structure. No samples were collected and therefore no laboratory analysis of the concrete or soils was conducted.

The objective of the inspections was to identify and address any deficiency findings and recommend associated mitigation measures. The key points of the findings for the facility are summarized below. As noted above, the field inspection checklist for the dam facility is included in Appendix D of this report. Recommendations with respect to the findings in the report are presented in Sections 9.0 through 11.0.

6.2 Access, Safety and Security

Access to the site was via Portage Street located south of the main downtown area of the Town of Bala. The dam was built adjacent to River Street and there are both full year and seasonal residents located on both Portage and River Streets. The main access to the dam is through a locked entrance gate from Portage Street, with a second locked man gate that exits onto River Street. A Chain-link fence runs across the south side of the property and connect to the south abutment of the dam. A small length of chain-link fence also ties into the guardrails west of the River Street retaining wall. However, the fencing located to the south of the dam has fallen into disrepair and needs to be replaced. Furthermore, the man gate and locking system to the River Street entrance along the north side of the powerhouse also should be upgraded. Fencing should be extended along the dam crest to prevent boaters from accessing the facility from the headwaters.

No significant signage is present along the facility either at the headwaters or tailrace locations. A small faded sign warning of moving water is located otop of the sluiceways however it is difficult to read and should be replaced. There is no signage posted on either gate. For the purpose of public safety warning signs should be posted in all aforementioned locations.

The sluice gate of the dam appeared to be outfitted with warning lights however they were not in use or tested during the DSI, visual and auditory warnings should be implemented if not already and tested frequently to ensure they are in good working order.

The boom-line for the dam is comprised of historic timbers which are half sunken and the setback distance is too close to the dam. The line is poorly visible from the headwaters of the dam and does not provide an ample barrier for the public. The boom line should be upgraded to modern standards and setback further from the dam.

6.3 Observations

Generally, the dam structure was found to be in fair condition considering the age of the structure. However, the powerhouse section of the dam is in poor overall condition from both a structural and dam safety perspective and will require remediation due to the presence of failed or failing structural members and a large transverse crack through the floor slab of the dam. Furthermore, significant washout of the downstream fill from another future flooding event has the potential to cause the structure to fail. As such there are dam safety issues associated with this site that will require remediation. Detailed observations for the DSI can be found in Table 1 of the Key Findings memo issued on July 24, 2019 which can be found in Appendix E. Preliminary recommendations were also made in this document but have since been refined and will be addressed below in Section 11.0.

7. HYDROTECHNICAL ASSESSMENT

7.1 Methodology

A hydrotechnical assessment was carried out mainly based on literature data review and desktop study. As described in the preceding sections, the Burgess 1 Dam facility is currently rated at 0.14 MW, operates when Lake Muskoka water levels are within an acceptable range. The facility has no spill capacity as upstream water level control is provided by the Bala North and Bala South dams. The hydrotechnical assessment mainly consist of the following steps:

- Compile the lake levels taken from Environment Canada hydrometric data measured from the nearest upstream station near the inflow of the Bala dams (Station ID:02EB015);
- Compile the operating lake levels of the Burgess dam as outlines in the MRWMP (2006);
- Determine the IDF for Burgess dam based on available data;
- Determine the Hazard Potential Classification (HPC) based on the MNRF and CDA criteria;
- Assess if the existing Burgess Dam has adequate freeboard for IDF event.

7.2 Water Levels

Figure 7-1 shown below illustrates the water levels at Burgess 1 Dam Site in 2019 and compares it to critical water levels associated with the structure according to the MRWMP. Table 7-1 summarizes the critical water levels. Summarizing:

- The maximum measured water level in 2019 during the flood event was at El. 226.1m at Gauge Station 02EB015, which occurred on May 1st, 2019;
- The IDF value provided by the MNRF and illustrated in the Muskoka River Dam Operation Manual for both the Bala Falls Dams is 226.49 masl and corresponds to the 100-year flooding event. The observed maximum water level at Burgess 1 Dam during overtopping in 2019 spring was at approximate El. 226.45m, which is very close the IDF (1/100yrs return) level of El. 226.49m;
- The facility has no spill capacity as upstream water level control is provided by the Bala North and South Falls Dams. Based on their proximity and virtually parallel positioning along the watershed it has been determined that the design IDF for the Bala South and North Dams is the most appropriate value for use at the Burgess 1 Dam location.
- The existing Burgess 1 Dam crest is at El. 226 m. During the determined IDF event water levels are above the dam crest by 0.39 m. Therefore, it can be determined that the Burgess dam does not have sufficient freeboard nor was the existing facility designed to handle IDF in its current state.

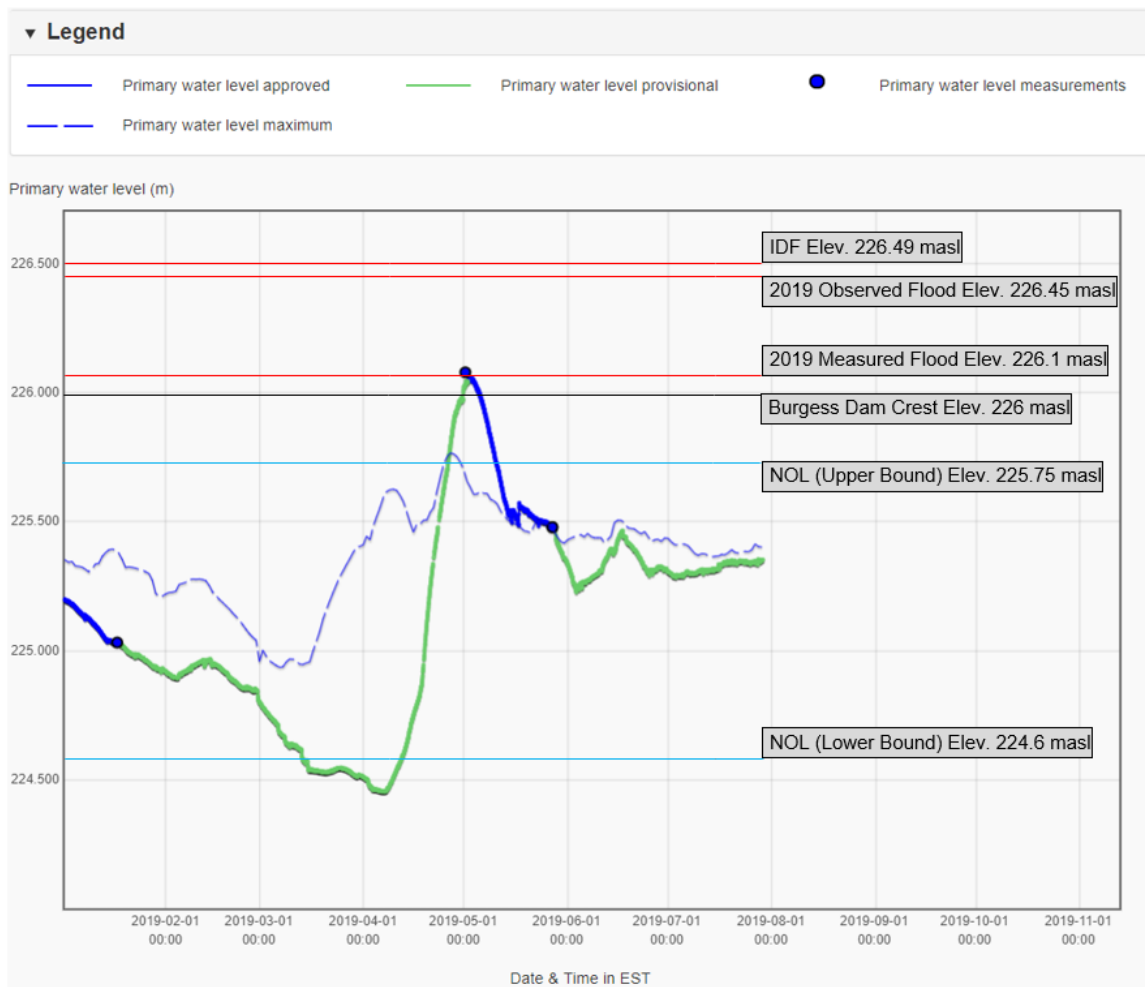


Figure 7-1: Burgess Dam 1 - 2019 Water Levels vs. NOL and IDF

Table 7-1: Water Levels Associated with Burgess 1 Dam

Parameter	Elevation (masl)
Burgess Dam Crest Elevation (to be confirmed by survey data)	226.00
2019 Flooding Measured Maximum Level at nearest Gauge Station 02EB015	226.10
2019 Observed Flooding level at the dam site	226.45
NOL Burgess Dam 1 (Upper Bound)	225.75
NOL Burgess Dam 1 (Lower Bound)	224.60
IDF – 100-year Lake Muskoka Flood Level	226.49

7.3 Hazard Potential Classification (HPC)

Table 7-2 summarizes the hazard potential classification (HPC) based on MNRF guideline (as provided in Appendix C). Given the above criteria, the HPC of the Burgess 1 Dam is LOW.

Table 7-2: Burgess 1 Dam Classification Summary

Category	Burgess 1 Dam	
	Flood	Non-Flood
Incremental Loss of Life (LOL)	0	0
	Low	Low
Economic Damages	<\$300,000	<\$300,000
	Low	Low
Environmental	Low	Low
Cultural / Heritage	Low	Low
Governing Criteria	Economic / LOL	Economic / LOL
Overall Classification (HPC)	LOW	LOW

8. GEOTECHNICAL ASSESSMENT

As part of the DSR, the stability analyses for the existing dam sections were carried out to assess the Factor of Safety (FOS) for both Non-overflow and powerhouse dam section under various loading conditions. The following sections summarize the geotechnical assessment.

8.1 Criteria

Table 8-1 summarizes the analyzed cases, u/s water levels and the applicable stability criteria based on CDA and MNRF Guidelines.

Table 8-1: Analyzed Cases and Applicable Stability Criteria

Case	Description	Water Level (m)	FOS-Sliding	FOS-Overturning
1	Static Loading NOL	El. 225.75	1.5	2.0
2	Seismic Loading with NOL	El. 225.75	1.1	1.1
3	Static Loading with IDF	El. 226.49	1.3	1.3

8.2 Methodology

The FOS calculation for stability analysis of the dam sections involved the following Equations:

FOS against sliding failure:

$$FOS = \frac{\sum \text{Resisting Force}}{\sum \text{Driving Force}} \quad [8-1]$$

FOS against overturning failure:

$$FOS = \frac{\sum \text{Resisting Moment}}{\sum \text{Driving Moment}} \quad [8-2]$$

FOS against bearing Failure

$$FOS = \frac{q_{\text{allowable}}}{q_{\text{maximum}}} \quad [8-3]$$

Bearing failure for the facility was calculated for both sections and found to have an FOS greater than 3.0 using a conservative allowable bedrock capacity of 1 MPa. Considering that the facility has a short dam height and is founded on bedrock it was determined that the focus of the analysis will be on failure against sliding and overturning.

Therefore, the FOS against foundation bearing failure is considered to be sufficient and no further calculation is included in the geotechnical assessment. Table 8-1 summarizes the geotechnical parameters used in the stability calculation.

Table 8-2: Summary of Geotechnical Parameters Stability Calculation¹

No.	Type of Material	Cohesion, c' (kPa)	Internal Friction Angle, ϕ' (Degree)	Unit Weight, γ' (kN/m ³)
1	Dam Unreinforced Concrete	0	50	24
2	D/S Fill Material	0	35	19
3	Concrete-to-Bedrock Interface ¹	0	45	20

Note: ¹-Geotechnical parameters are assumed for the DSR based on TULLOCH's engineering experience.

8.3 Stability - Seismic Event

Based on Section 7, the Burgess 1 Dam has been classified as a LOW HPC rating, indicating that the return period of the design earthquake is 1/100 according to CDA Guidelines (2013 Edition). The following site-specific PGA has been used to perform pseudo-static stability analysis of these dams:

- For 1/100-year return period, the PGA for the site is 0.01 g, corresponding to a Class 'C' site classification. Appendix C shows the PGA data obtained from the 2015 National Building Code Seismic Hazard Calculation.

- For pseudo-static analysis, the horizontal PGA value was multiplied by $\frac{2}{3}$ giving $0.7(0.01g) = 0.007g$. Considering the shallow bedrock present at dam site, two thirds of the horizontal PGA on bedrock is considered to replicate the sustained ground motion. Correspondingly, a ground acceleration of $0.005g$ was applied for the pseudo-static seismic assessment of the dam structures at this site.

8.4 Results

Table 8-3 summarizes the results of the stability analysis calculations. The results are discussed in the following sections of this report. Figures 8-1 and 8-2 show representative sections of the dam that were analyzed which are show below.

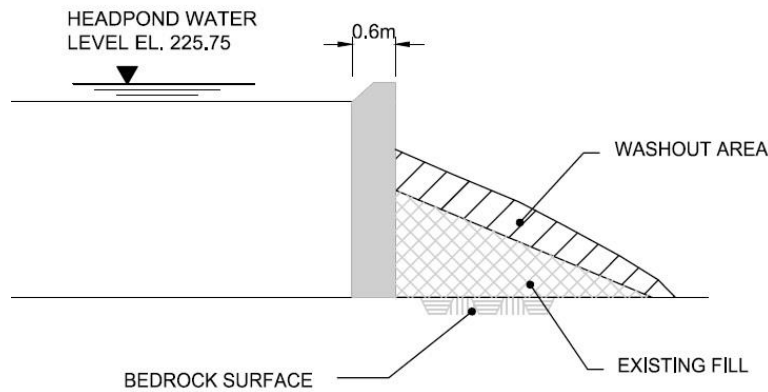


Figure 8-1: Typical Non-overflow Dam Section for Stability Analysis

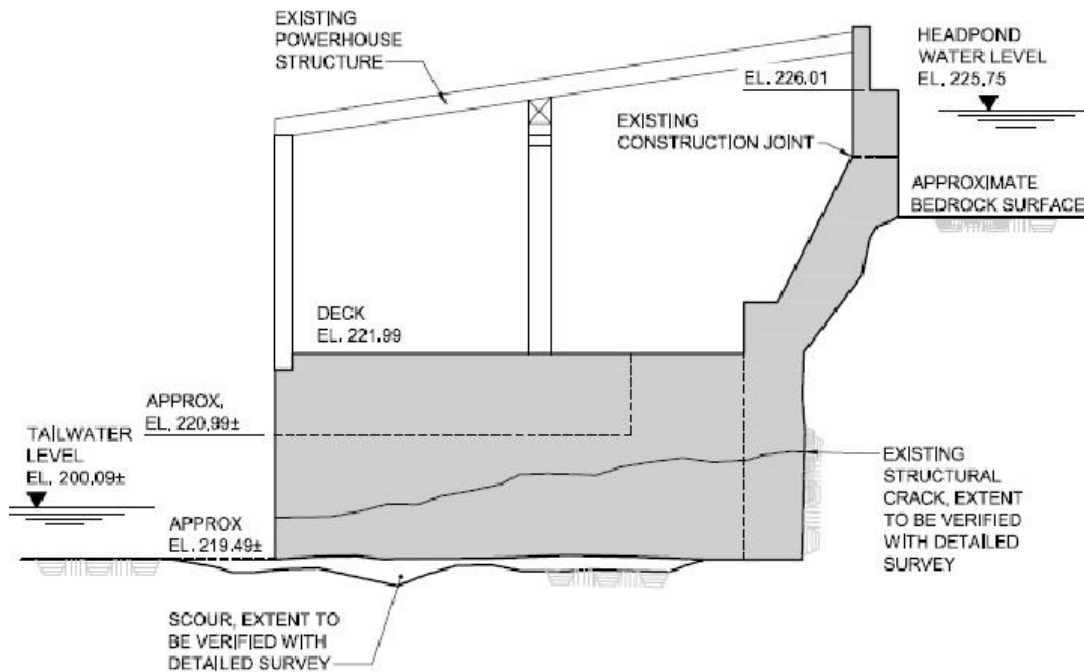


Figure 8-2: Typical Powerhouse Dam Section for Stability Analysis

Factor of Safety calculation results are summarized below for the various loading conditions under each section mentioned above:

Non-overflow Dam Section

- Under static loading condition with NOL at EL. 225.75 m, the calculated FOS against sliding is 2.7, which meets the required minimum FOS of 1.5; The calculated FOS against overturning is 1.4, which does not meet the required minimum FOS of 2.0.
- Under seismic loading condition with NOL at EL. 225.75 m, the calculated FOSs against sliding and overturning are 2.7 and 1.4, respectively. The calculated FOSs meet the required minimum FOSs of 1.1. Due to a short dam height and low PGA value at the site, the seismic loading has a negligible impact on the stability of Burgess dam.
- Under static loading condition incorporating the IDF water level, the calculated FOS against sliding is 2.3, which meets the required minimum FOS of 1.3; The calculated FOS against overturning is 1.1, which does not meet the required minimum FOS of 1.3.

Powerhouse Dam Section

- Under static loading condition with NOL at El. 225.75 m, the calculated FOS against sliding is 1.2, which does not meet the required minimum FOS of 1.5; The calculated FOS against overturning is 1.0, which does not meet the required minimum FOS of 2.0.
- Under seismic loading condition with NOL at El. 225.75 m, the calculated FOS against sliding is 1.2, which meet the required minimum FOS of 1.1; the calculated FOS against overturning is 1.0, which does not meet the required minimum FOS of 1.1. Due to a short dam height and low PGA value at the site, the seismic loading has a negligible impact on the stability of Burgess dam.
- Under static loading condition incorporating the IDF water level, the calculated FOS against sliding is 1.1, which meets the required minimum FOS of 1.3; The calculated FOS against overturning is 1.0, which does not meet the required minimum FOS of 1.3.

Based on the geotechnical stability assessment, Repair or mitigation measures must be developed for both the non-overflow dam section and powerhouse dam section to improve the FOS to meet the minimum acceptable criteria.

Table 8-3: Calculated FOS for Stability of Burgess Dam Structures

Dam	Case	Water Level (m)	FOS-Sliding	FOS - Overturning
Non-overflow Dam Section	Static Loading with NOL	El. 225.75	2.7	1.4
	Pseudo-static $\alpha=0.005g$ and NOL	El. 225.75	2.7	1.4
	Static Loading with IDF	El. 226.49	2.3	1.1
Powerhouse Dam Section	Static Loading with NOL	El. 225.75	1.2	1.0
	Pseudo-static $\alpha=0.005g$ and NOL	El. 225.75	1.2	1.0
	Static Loading with IDF	El. 226.49	1.1	1.0

8.5 River Street Concrete Wall and Embankment

Based on site inspection, the concrete retaining wall along River Street is in a Fair condition. The presence of the vertical cracks in the wall encountered during the DSI indicated drainage efficiency of the retaining wall may not be adequate. The inadequate drainage likely caused water pressures to build up behind the retaining wall. This could be alleviated by implementing better drainage and water management through and around the wall. Preliminary recommendations will be discussed further in Section 11.0.

The Embankment along River Street downstream of the site is very steep and appears to be eroding at the toe where there are newer gabion baskets placed on a historic boulder/stone wall.

There is a concern for the slope failure of the embankment due to the erosion/ scour caused by water flows during power generation activity. The slope stability evaluation of the embankment along the River Street is not included in the scope of this DSR, however, a detailed geotechnical investigation and assessment are strongly recommended.

9. DAM MANAGEMENT CRITERIA

9.1 Operation, Maintenance, and Surveillance

It is our understanding that there is currently no OMS Manual for the Burgess 1 Dam facility. However, Operating levels for all control dams in the Muskoka watershed can be found in the Muskoka River Dam Operation Manual. The manual does not provide the necessary detail for the site-specific operation, maintenance and surveillance for the Burgess 1 Dam site. Therefore, it is TULLOCH's recommendation that an OMS manual be drafted for the Burgess 1 Dam.

9.2 Emergency Preparedness and Response Plan

There is no formal Emergency Preparedness and Response Plan for the dam in the event of failure. The Muskoka River Dam Operating Manual describes typical operating levels but does not describe issues relating to a response of a failure/emergency event.

It is recommended that an Emergency Preparedness and Response Plan be prepared for the facilities now that a DSR has been completed for the site which should include the anticipated effects of a dam failure under the selected IDF.

10. PUBLIC SAFETY

10.1 Review

The Burgess 1 Dam main access gate is located off Portage Street and is typically locked when site personnel are not present. The man gate located on the south bank of River Street is poorly secured with a thin chain and padlock, although it is kept locked upgrades to the gate would improve security. Fencing around the property is damaged in some places and could allow for access to the general public. Although not generally accessible a cottager has also built a dock on the south abutment of the dam. The site is generally inaccessible by foot, but it is possible to access the site by boat or by walking up the tailrace due to poor signage and an inadequate boom line. There is no signage for the Burgess 1 Dam warning the public of the dangers associated with active hydro generation except for one badly faded poorly sized sign located on the top of the sluiceway. The boom line for the dam is poorly visible, dated, and does not have appropriate clearance from the dam.

10.2 Recommendations

- Signage should be added for the Headwaters and Tailrace of the facility indicating danger and the unexpected release of flows/fast moving water

- The faded sign should be replaced on the dam
- Fencing should be expanded along the dam crest and repaired where broken
- The dock on the south abutment should be removed
- The north access gate should be repaired, and the locking system upgraded

11. MITIGATION RECOMMENDATIONS

Recommended mitigation measures are outlined below for the Non-overflow, Powerhouse and River Street Retaining Wall sections of the Burgess 1 Dam site. TULLOCH has provided improvement options for each section of the structure with a brief discussion on each option. It should be noted that these recommendations are at a conceptual level and quantities/cost estimations need to be verified with a detailed survey of the property. Conceptual figures of the facility upgrades can be seen in Appendix G.

11.1 Non-Overflow Dam Section

11.1.1 Option N1 – Downstream Rip Rap Placement and Toe Berm

Option N1 is to reinstate the fill of the existing dam by replacing rockfill/ rip rap over a non-woven geotextile for erosion protection d/s of the existing dam site. Fill should be replaced in washout section and then covered with a geotextile. The addition of rip rap will provide added erosion protection in the event of overtopping to avoid excessive washout of fill similar to the 2019 event. In order to collect overflow water during flooding events a toe-berm could be constructed along the downstream property line to channel water down to the in-situ river channel. A similar berm would be constructed along the south wall of the powerhouse to keep flows away from the building foundation. Figures 19-1493-C-01 and 02 in Appendix G show the conceptual design for Option N1. Highlights of the N1 design include:

- Downstream; clear and strip organics as required;
- Reinstall washed-out sections of downstream fill
- Place Non-woven geotextile and rip rap (500mm thick); grade back toward the tailrace for erosion protection;
- build toe berms along the existing property line and the south wall of the powerhouse to manage and divert the overflow (if it occurs) toward the river;
- Extend the existing dam to the south end to accommodate toe berm and flow management (about 8m in length);
- Grouting or concrete patching the cracks in the existing dam to limit the leakage;

11.1.2 Option N2 – Partial Dam Raise and Emergency Spillway

Option N2 is to partially raise sections of the Non-overflow area of the dam and install and emergency spillway to control overflow during flooding events.

The spillway invert could be kept at the current dam crest elevation and the remainder of the dam would subsequently be raised 0.5m to meet the minimum freeboard criteria during the operation of the spillway during a flood event. The final spillway invert elevation and grade as well as the dam raise will need to be determined based on a detailed survey and hydrotechnical assessment. Figures 19-1493-C-04 and 05 in Appendix G show the conceptual design for Option N2. Highlights of the N2 design include:

- Downstream; clear and strip organics as required;
- Partially raise the dam 0.5 m for the dam section about 20 m in length south of the proposed spillway invert and 6 m in length north of the invert;
- Build an emergency spillway channel with rip rap placed a minimum of 500 mm thick over non-woven geotextile with a total approximate width of about 18m through the middle of Non-overflow section of the dam;
- The spillway should be angled such that water is directed into the existing tailrace and away from the River Street embankment;
- Re-instate the fill south of the spillway that has been washed away during the flooding event and tie into the spillway;
- Extend the existing dam abutment south to accommodate a higher elevation (about 8m in length);
- Grouting or concrete patching the cracks in the existing dam to limit the leakage;

11.2 Powerhouse Dam Section

11.2.1 Option P1 –Demolish Powerhouse and Replace with New Dam

Given the relatively poor condition of the existing powerhouse, Option P1 is to demolish the existing powerhouse dam section and build a new replacement concrete dam section upstream of the existing powerhouse. Figures 19-1493-C-08 and C-10 in Appendix G show the existing condition of the section and a conceptual design for Option P1. Highlights of the P1 design include:

- Installation of u/s and d/s cofferdams;
- Removal of the old dam section and associate powerhouse structures;

- Construction of a new concrete gravity dam (about 2.5m high) on excavated bedrock for water retention (i.e. to maintain the lake level); the new dam section will be tied into the existing non-overflow section.
- Removal of cofferdams after construction is complete.

11.2.2 Option P2 – Powerhouse Refurbishment and Reinforcement

It may be advantageous to keep the powerhouse section of the dam intact given its historic value and the potentially prohibitive cost of decommissioning and deconstruction. Furthermore, the possibility of continued power generation may be appealing to the Township. As such, given that the current FOS of the existing powerhouse dam section is marginally stable a refurbishment of the facility is possible to meet current standards. Option P2 entails the structural reinforcement of the existing building as well as to remediate and reinforce the dam section and foundation of the powerhouse. Figure 19-1493-C-09 in Appendix G shows the conceptual design for Option P2. The highlights of Option P2 include:

- Fill the scour areas (i.e. undermined holes) in the foundation the powerhouse with mass pour concrete;
- Grout the cracks developed in the existing concrete piers;
- Reinforce the powerhouse structures with 9 rock anchors ($\Phi 35\text{mm}$, 8m long) to be installed to a minimum depth of 6 m into the bedrock; Grout the existing crack through the foundation once bolts are installed;
- Repair/Replace the Roof;
- Add shear struts and additional structural bracing in the powerhouse building;
- Grouting or concrete patching the cracks in the existing dam to limit the leakage;
- Extend the existing tailrace pipes for the turbine units d/s to keep them a safer distance away from the powerhouse to avoid scour and undermining of the foundation.

11.3 River Street Concrete Retaining Wall

Based on review of site photos and field findings, the following mitigation actions should be considered to improve the performance of the existing concrete retaining wall structure:

- Install a drainage ditch u/s of the retaining wall to divert the surficial run-off water from River Street;
- Drill drainage holes and install drainage pipes along the base of the existing concrete retaining wall;

It should be noted that all options described above are conceptual in nature. Verification of design elements, dimensions and quantities and associated costs will require topographical survey, geotechnical investigation and further geotechnical/structural analysis to move towards detailed design.

11.4 Cost Estimation

Preliminary costs and material quantities were estimated based on historical design drawings (seen in Appendix F) provided by the Township and an assumed ground profile. Table 11-1 shows a summary of the cost estimation for the options discussed above. It should be noted that the costing and quantities are considered preliminary for the purpose to help select a preferred option for detailed design. Costs and quantities should be verified with a detailed ground survey and confirmed with further geotechnical and structural analysis. Tables H-1 through H-4 in Appendix F show the details of the preliminary cost estimation for each option discussed above.

Table 11-1 Summary of the Preliminary Cost Estimates (FEL1 Level)

Area	Option	Cost Estimation (\$)
Non-overflow Dam Section	N1	\$ 171,535.00
	N2	\$ 227,570.00
Powerhouse Dam Section and River Street Concrete Retaining Wall	P1	\$ 1,884,400.00
	P2	\$ 535,150.00

11.5 Preliminary Remediation Recommendations

Based on the assessment above, the following option combinations are feasible considering both technical and economic aspects, including:

- Option N1 and Option P2 (total cost: \$ 706,685.00)
- Option N2 and Option P2 (total cost: \$ 762,720.00)

TULLOCH recommends Option N2 and P2 for the proposed remediation of the facility the decision was made given the following considerations:

- Although the total cost for Option N2 / P2 is about 8% higher than Option N1/P2 combination, Option N2 will allow the dam to handle large flows more predictably and ensure that water flow is controlled and directed down the tailrace.
- By channeling the water down a dedicated spillway there is less likelihood of irregular erosion and scour and the risk of property damage is significantly reduced, as well it will reduce the likelihood of large flows against the River Street embankment.

- Based on the cost estimates and constructability for the powerhouse dam section, it may be more advantageous to leave the powerhouse in place. Option P1 (i.e. Removal of the powerhouse and replaced by a new dam) is the most expensive option and would present considerable difficulties in construction. In addition, due to the historic significance of the structure it may be advantageous to maintain a refurbished structure.

Ultimately the decision on the future of the Burgess 1 Dam facility will be up to the Township and TULLOCH would be pleased to offer any further services towards the rehabilitation of this structure.

12. CLOSURE

This DSR report has been prepared by TULLOCH for the exclusive use of the Township of Muskoka Lakes and their authorized agents for the evaluation of the performance and safety of the Burgess 1 Dam located in Bala, Ontario.

We trust that the information in this report will be sufficient to allow the Township of Muskoka Lakes to better understand the risks associated with the Burgess 1 Dam Facility and provide a clear path forward towards rehabilitation of the structure. Should further elaboration be required for any portion of this project, we would be pleased to assist.



George Liang, Ph.D., P.Eng.
Senior Geotechnical Engineer



Erik Giles., P.Eng.
Geotechnical Engineer



Frank Palmay P.Eng.
Structural Design Engineer, Project Manager

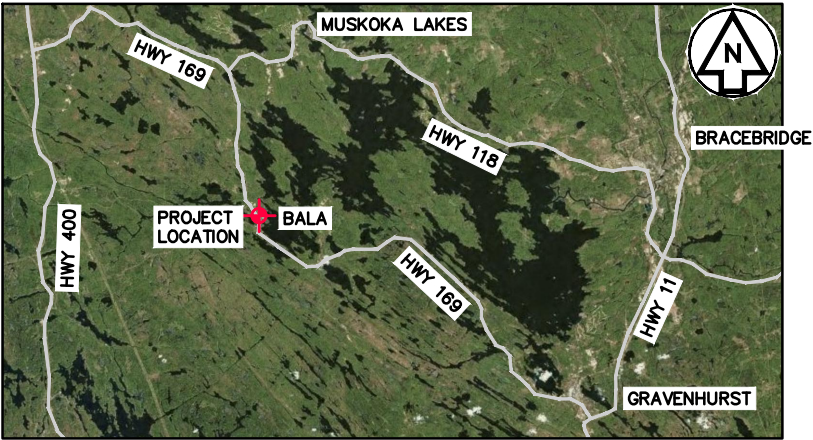
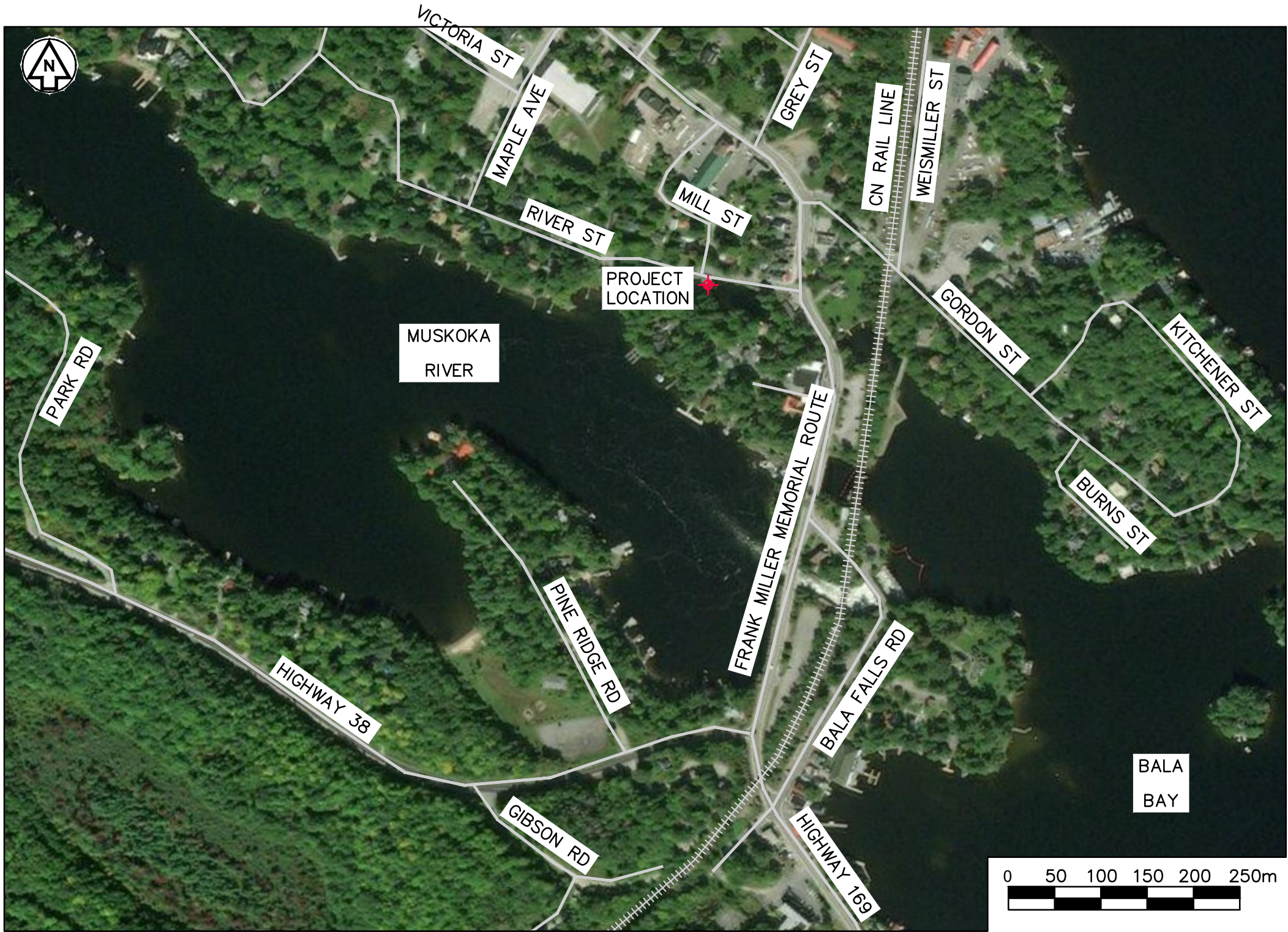


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APPENDIX A

KEY LOCATION PLAN



PROJECT LOCATION
N.T.S

PLAN - BALA, ONTARIO
N.T.S.



DRAWING:

PROJECT LOCATION
KEY PLAN

CLIENT:
TOWNSHIP OF
MUSKOKA LAKES

PROJECT:
BURGESS DAM 1
DAM SAFETY ASSESSMENT

DRAWN BY: K. KORTEKAAS	CHECKED BY: E. GILES	DESIGNED BY: G. LIANG
APPROVED BY: G. LIANG	SCALE: AS NOTED	DATE: 2019-08-07
DRAWING No. 19-1493-C-00		REVISION No. A

A	2019-08-13	KK	ISSUED DRAFT FOR CLIENT REVIEW
No.	DATE	BY	ISSUES / REVISIONS

APPENDIX B

NBCC SEISMIC HAZARD VALUES

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 45.015N 79.616W

2019-08-13 17:41 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.078	0.049	0.032	0.011
Sa (0.1)	0.109	0.071	0.048	0.018
Sa (0.2)	0.109	0.074	0.051	0.020
Sa (0.3)	0.095	0.065	0.045	0.018
Sa (0.5)	0.080	0.054	0.037	0.014
Sa (1.0)	0.049	0.033	0.022	0.007
Sa (2.0)	0.026	0.016	0.011	0.003
Sa (5.0)	0.006	0.004	0.002	0.001
Sa (10.0)	0.003	0.002	0.001	0.000
PGA (g)	0.064	0.041	0.028	0.010
PGV (m/s)	0.067	0.042	0.027	0.008

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada

APPENDIX C

CDA AND MNRF TECHNICAL RESOURCES

1. DAM CLASSIFICATION AND DESIGN CRITERIA

According to the Technical Bulletin of the MNRF Guidelines, dams are classified us the following classification system which is based on four classification categories that define incremental losses due to dam failure based on increasing level of magnitude. Similarly, the CDA has five classification categories. Tables 1.1 and 1.2 outline the 2011 MNRF and the 2013 CDA criteria for determining the classification for individual dams. Table 1.3 and Table 1.4 identify the range of based on MNRF and CDA criteria.

Table 1.1: Dam Classification based on CDA Guidelines (2013)

Dam Class	Population at Risk ¹	Incremental Losses		
		Loss of Life 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 highly possible	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.

Table 1.2: Hazard Potential Classification based on MNRF Guidelines (2011)

Hazard Potential	Hazard Categories – Incremental Losses ¹			
	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 <u>viable</u> portion of the population of a species classified under the Ontario Endangered Species Act as Extirpated, Threatened or Endangered or <u>irreversible</u> 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 meters per second or if velocity exceeds 1.7 meters per second or if depth of water exceeds 0.8 meters. For dam failures under flood conditions the potential for loss of life is assessed based on permanent dwellings (including habitable buildings and trailer parks) only. 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 to 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 to 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.

Table 1.1: Range of Minimum Inflow Design Floods

Hazard Potential Classification (HPC)	Range of Minimum Inflow Design Floods ¹			
	Life Safety ³		Property and Environment	Cultural – Built Heritage
LOW	25 year Flood to 100 year Flood			
MODERATE	100 year Flood to 1000 year Flood or Regulatory Flood whichever is greater			
HIGH	1-10	1/3 between the 1000 Year Flood and the PMF	1000 Year Flood or Regulatory Flood, whichever is greater, to 1/3 between the 1000 Year Flood and the PMF	1000 Year flood or Regulatory Flood, whichever is greater
VERY HIGH	11-100	2/3 between the 1000 Year Flood and the PMF	1/3 between the 1000 Year Flood and the PMF to the PMF	
	Greater than 100	PMF		

Notes

1. The selection of the IDF within the range of flows provided should be commensurate with the hazard potential losses within the HPC Table. The degree of study required to define the hazard potential losses of dam failure will vary with the extent of existing and potential downstream development and the type of dam (size and shape of breach and breach time formation).
2. As an alternative to using the table the IDF can also be determined by an incremental analysis. Incremental analysis is a series of scenarios for various increasing flows, both with and without dam failure that is used to determine where there is no longer any significant additional threat to loss of life, property, environment and cultural – built heritage to select the appropriate IDF.
3. Where there is a potential for loss of life the IDF may be reduced provided that a minimum of 12 hours advanced warning time is available from the time of dam failure until the arrival of the inundation wave, provided that property, environment, or cultural – built heritage losses do not prescribe a higher IDF.

Table 1.2: Floods and Earthquake Hazards, Standard-Based Assessments (CDA)

Dam Class	Annual Exceedance Probability – Floods¹	Annual Exceedance Probability – Earthquakes⁴
LOW	1/100 year	1/100
SIGNIFICANT	Between 1/100 and 1/1000 year ²	Between 1/100 and 1/1000
HIGH	1/3 between 1/1000 and PMF ³	1/2475 ⁵
VERY HIGH	2/3 between 1/1000 and PMF ³	½ between 1/2475 ⁵ and 1/10,000 or MCE ³
EXTREME	PMF ³	1/10,000 or MCE ³

Notes

1. Simple extrapolation of flood statistics beyond 10⁻³ AEP is not acceptable.
2. As an alternative to using the table the IDF can also be determined by an incremental analysis. Incremental analysis is a series of Selected on basis of incremental flood analysis, exposure, and consequences of failure.
3. PMF and MCE have no associated AEP.
4. Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake(s) with the AEP as defined in this table is then input as the contributory earthquake(s) to develop Earthquake Design ground Motion (EDGM) parameters as described in Section 6.5 of the CDA Guidelines.
5. This level has been selected for consistency with seismic design levels given in the National Building Code of Canada.

APPENDIX D

DSI FIELD INSPECTION REPORT



FIELD INSPECTION REPORT

Site Identification:	Burgess Dam
Structure Identification:	Burgess Dam
Location:	Bala, Ontario
Inspection Date:	04-07-2019
Inspection Time:	09:10
Inspected By:	E. Giles, F. Palmay
Accompanied By:	Steve Dursley
Inspection Type:	Dam Safety Assessment

Atmospheric Conditions

Inspection Day:	Clear
Temp:	27
Previous Week:	26 - 32
Temp Range:	26-32
Current Pond Level:	Unknown
Current Freeboard:	0.7 m

Dam Structure

1.1 Surface Cracking, Displacement, etc. Comments	Yes Cracks apparent on concrete upstream and downstream surface, ranging from hairline to narrow expected with age of dam, efflorescence observed on cracks. Some cracks evidence of historic repairs
1.2 Concrete Deterioration, Spalling, etc. Comments	No Minor to moderate Spalling on concrete on dam and along u/s face of Dam, small delaminated section ~ 1.0m long on dam crest
1.3 Evidence of Scouring Comments	Yes Scouring evident typical of age of structure, the worst section observed was along south side of powerhouse on the downstream face of the dam where significant deterioration was observed.



1.4 Evidence of Seepage

Comments

Yes

Seepage along d/s face at south edge of power station, as well as ~ 10m downstream of the dam near the joint between section DC/CB. Significant was observed at east wall of powerstation/downstream face of dam.

In discussion with operator, seepage had improved since applying cold patch repairs to upstream and

Yes

Powerhouse still in operation, original roof with bracing, joists failing, corrosion of bracing observed particularly on the floor

1.5 Unusual or Special conditions

Comments

1.6 Undesirable Vegetation, Debris, etc. at toes

Comments

Yes

Significant vegetation along downstream toe including trees/stumps, debris from flooding, and significant washouts were observed caused by the flooding.



View of downstream dam face, note concrete degradation on cold joint



View of upstream face, note broken fence and vegetation build up along downstream toe of dam



Seepage observed along downstream face of dam built into powerhouse

Abutments

2.1 Surface Cracking, sinkholes, etc.
Comments

No
Minor cracking and deterioration evident typical with age of structure, good contact at abutment observed

2.2 Evidence of Settlement, movement, etc.
Comments

No
No evidence of movement on the dam

2.3 Gap, Leakages, etc. at Contact.
Comments

No
South abutment contact observed to be good some cracks visible expected with age of structure

2.4 Evidence of Repairs
Comments

Yes
Evidence of repair on larger cracks of dam, cold patch concrete placed over large cracks plus cracks were also filled upstream near the generating station during low water levels. Cold patch placed throughout powerhouse on downstream face of dam to curtail seepage.

2.5 Unusual or Special Conditions.
Comments

Yes
There is a dock built into the south abutment and of



the dam by a local cottager. The north abutment is built into river street and terminates at the road shoulder guard rail.



South abutment of dam, note dock built into dam crest at tie-in, good contact



North abutment of dam, concrete ends at guard rail at embankment of Riiver Street, good contact observed



Historically repaired crack with cold patch concrete on downstream face of dam near south abutment

Pond Level and Perimeter

3.1 Concerns with pond level.
Comments

Yes
Minimal freeboard observed with approximately 0.7m,



measured at time of inspection. Based on discussion with operator the dam was close to overtopping during the flooding events of 2013 and overtopped for the first time 2019.

Yes

Risk of property damage from overtopping, the retaining wall on the north side of the powerhouse was observed to be cracked through the wall and moving, steep embankment observed on north side of tail race holding up River Street

Yes

River Street berm at north edge of the pond with low freeboard (<1.0 m) poor/insufficient erosion protection

3.2 Concerns with pond perimeter

Comments

3.3 Other concerns with pond area

Comments



View of pond and sluiceway, note road embankment on pond, insufficient erosion protection



Area of washout where water was spilling over the dam and down to tail race, site of temporary ditch excavated to channel water away from properties



Upstream pond note ~0.7m of free board at time of site visit

4. Other Unusual Conditions Comments

Yes

The embankment north of the dam and located west of the powerhouse is eroded and very steep, washout in 2019 observed at toe of concrete retaining wall. Rock fill was placed back in the area of the washout by the township



Steep embankment on north side of dam, photo taken downstream at tailrace note retaining wall



Large crack through retaining wall, note movement of wall



Large transverse crack running through powerhouse foundation, hole in wall at outlet of power house with significant seepage of ~ 2.0 L/s, possible outlet of historic box drain

5. Instrumentation Comments

No
Water level is monitored just inside of the sluice gate to detect debris build up at spillway entrance, remnants of staff gage observed.

Spillway, Discharge Structure, Etc.

6.1 Concern for Discharge Control Structure Comments

Yes
There is no emergency spillway for the dam and properties on both sides of the dam were effected during flooding of 2019.

6.2 Concern for Adequacy & Reliability of Emergency Comments

Yes
See comments 6.1 there is no emergency spillway for this facility

7. Environmental Concerns Comments

Yes
According to Steve Dursley downstream of the dam in the tail race fish can spawning is observed



8. Safety Concerns
Comments

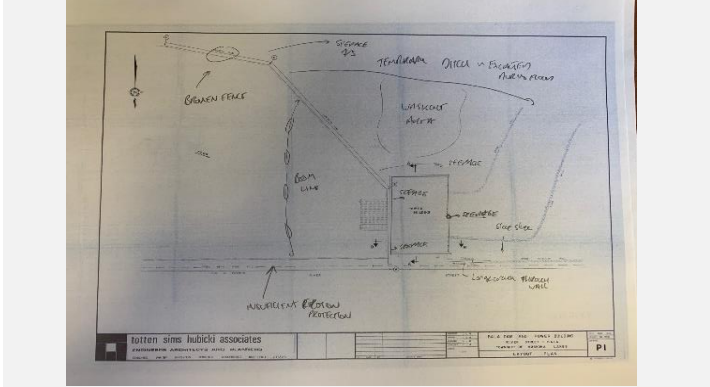
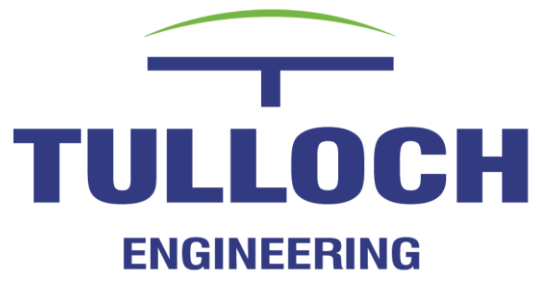
Yes

Poor guarding for turbine/ moving parts within the power house, broken fence on dam crest, expose grounding wire, washouts/debris and uneven ground caused from flooding

Signature:

General Dam Information

Structure Type:	Concrete hydro electric dam
Spillway:	Sluice gate leading to two turbines, no emergency spillway
Foundation:	Bedrock
Crest Elev. (Current):	226.93
Abutments:	Concrete on bedrock
Max Height (Current):	~6m
Crest Length:	~59.2 m
Decants & Outlets:	Sluicagate into two turbines, outlet in two openings at generating station
Catchment Area:	Unknown
Normal Pond Elev:	224.6 - 225.61 (Bala Falls Dam)
Fetch Length & Direction:	~140 m
Max/Min OWL:	225.75 (Bala Falls Dam)
Construction History:	Built in 1917, minor rehabilitations through the years, Large rocks added to tail race to prevent erosion of properties downstream, Upgrade to south turbine in late 80s by Marsh Power and upgrade of north turbine and sluicagate in 2010s by current leasor KRIS power. Property owned by Township of Muskoka Lakes, leased to Kris Power, currently actively generating power
Last DSIs:	Unknown
Additional Notes:	



Site sketch with notes

APPENDIX E

KEY FINDINGS MEMORANDUM

MEMORANDUM

Date: Wednesday, July 24, 2019

To: Ken Becking

CC: George Liang; Sean Hinchberger

From: Erik Giles; Frank Palmay

Re: KEY / CRITICAL FINDINGS FOR BURGESS 1 DAM IN BALA, ONTARIO

1. DATE

- July 4th, 2019

2. PERSONNEL AT SITE

- KRIS Power: Steve Dursley (Care and Maintenance Operator)
- TULLOCH: Frank Palmay (P.Eng.), Erik Giles (P. Eng.)

3. SUMMARY OF THE KEY/CRITICAL FINDINGS

The dam safety inspection (DSI) for the Burgess 1 Dam took place on the morning of July 4th, 2019. Steve Dursley (KRIS Power) met the TULLOCH team on site and permitted entrance to the facility. The inspected structures included the following:

- Concrete dam structure (Water Retaining structure, Non-overflow dam section);
- Concrete dam with downstream (d/s) powerhouse structure;
- River Road Retaining Wall and Embankment;
- Downstream erosion and scouring conditions during 2019 flooding;
- Upstream (u/s) reservoir (within 500m approaching to the Burgess 1 Dam);
- Other ancillary structures including the access road, fence, gates, tailrace and walkways etc. where accessible.

Table 1 summarizes the key/critical findings during the site inspection. The detailed field inspection checklist and comments including selected photographs are presented in Appendix A.

Section 4 presents the discussion based on the key findings and the preliminary engineering assessment; Section 5 summarizes the three preliminary recommendations for remediation with respect to the scope of work.

Table 1: Key/Critical Findings During the DSI

Site	Site Segment	Observation Criteria	Key/Critical Findings
Burgess 1 Dam	Concrete Dam (Water Retaining Structure, Non-overflow section)	Structural	- Cracking in dam – hairline to narrow, no to minimal movement based on observation; - Sections of delamination on dam crest; - Evidence of historic crack repairs with cold patch concrete; - Concrete degradation observed with moderate spalling – worst section south of powerhouse near tie-in with powerhouse walls; - Minor to moderate pitting and scour observed along structure and on visible sections of u/s face of dam, expected given age of structure.
		Geotechnical	<u>General</u> - Abutment contacts sound at each end of the dam; - South abutment has a dock built on top of it by a cottager - North abutment ties into River Street - Moderate to significant washouts along the dam toe area caused from flooding; - Freeboard at time of inspection was ~0.7m from dam crest; - Significant vegetation builds up on d/s toe of dam including large trees ~ 0.3m in diameter, evidence of historic vegetation clearing i.e. stumps; - Debris from flooding piled on and around dam section.
			<u>Seepage</u> - Minor seepage observed ~ 15m d/s of the dam near the access gate, ponded water visible; - No evidence of boils or piping beneath the dam section; - Cold patch concrete has been placed on the d/s and u/s sections of dam to reduce the seepage/leakage since KRIS power has taken up the operation of the dam facility, this has reduced the seepage/leakage according to Mr. Dursley.

Site	Site Segment	Observation Criteria	Key/Critical Findings
			<u>Geotechnical Stability</u> - Moderate to significant washouts were observed caused by flood waters at the d/s of the concrete dam, a ~ 1.0m depth of the d/s toe fill material along the concrete dam have been washed away; a ~ 2.0m depth of the d/s fill materials have been eroded/washed out at the south end of the powerhouse section. The erosion of the d/s toe fill materials may cause dam stability issue; - Upstream slope/River Road embankment has insufficient erosion protection/armouring; - Based on visual inspection, the concrete dam and the powerhouse section have not experienced obvious moving or shifting at the time of DSI.
			<u>Water Control/Spillway</u> - There is no emergency spillway for this facility, a temporary trench was excavated to channel flood waters during the 2019 flooding event and diverted the water to the south of the property near the access gate and down into the tailrace area; - A new sluiceway was installed by KRIS power.
			<u>Instrumentation</u> - There is no monitoring program or instrumentation installed for the lake levels at the dam site, remnants of a staff gauge were observed on the outlet of the powerhouse - KRIS power does monitor water levels at the sluiceway invert to determine if blockages are accumulating, this data was not available on site.

Site	Site Segment	Observation Criteria	Key/Critical Findings
	Powerhouse Section	Structural	• Roof of powerhouse is overstressed; joists are cracking at midspan; • Roof of powerhouse is not watertight and has polyethylene vapor barrier placed overtop, this is trapping moisture and not allowing the roof to dry out, likely causing accelerated deterioration of members; • Steel frame installed in powerhouse is corroding at the bottom as a result of continued exposure to standing water, significant section loss noted; • Carpenter ants or termites present (observed sawdust in powerhouse); • Diagonal cracks in powerhouse indicating foundation of structure may be compromised; • Water leaking through rear wall of powerhouse; • Efflorescence present on walls and floor slab of powerhouse indicating seepage is passing through concrete.
		Geotechnical	• Generally moderate seepage observed along the d/s of the powerhouse dam section, a significant seepage was observed at south and north ends of powerhouse. In conversation with Steve Dursley, the seepage is relatively unchanging throughout the course of the year in 2019. And remains in a steady state; • Large hole ~ 0.2m in diameter leaking a significant amount of water ~ 2.0 l/s, this has been a known issue, and has remained unchanged. This may be the outlet to a historic box drainage system installed in the dam, again indicating a steady state condition; • Moderate seepage observed along downstream toe concentrating outside of south end of powerhouse, likely through worn section of dam; • Transverse crack through powerhouse as noted above indicate potential foundation failure and reduced capacity of floor slab to act as ballast for the gravity dam section.

Site	Site Segment	Observation Criteria	Key/Critical Findings
Other Associated Infrastructure	River Road Retaining Wall and Embankment	Structural	- Undermining of stone retaining wall supporting River Street; - Crack in cast in place wall supporting River street and portion of wall now leaning away from the road indicating movement;
		Geotechnical	- Embankment along River Street upstream of the Burgess Dam is very steep and appears to be eroding at the toe where there are newer gabion baskets placed on a historic boulder/stone wall. There is a concern for the slope failure of the embankment due to the erosion/ scour caused by the water flows. The slope stability evaluation of the embankment along the River Street is not included in the scope of this DSR. Detailed geotechnical investigation and assessment are strongly recommended; - Evidence of slope movement based on guardrail; - Sediment build-up observed within tail race due to washout material.
Burgess 1 Dam Site	Dam Site	Public Safety	- Inadequate/ no signage for safety warning at the u/s dam for the potential hazards of the vortex/swirl caused by the running flow during operation of the powerhouse; - Inadequate boom line, poorly visible and half sunken logs; the boom line is in a poor condition and the distance to the inlet of the powerhouse is inadequate; - Broken fencing on dam crest allows for access from public, lack of physical barriers along dam crest to prevent access; - Inadequate gating/locking system, easily accessed.

4. DISCUSSION

The following sections discuss the key findings and preliminary structural / geotechnical assessment for the Burgess 1 Dam.

4.1 Structural

Based on the DSI, it is believed that the roof of the powerhouse has failed in several locations. Broken roof joists were noted in several locations with failure along the midspan of the beams. The joists had been reinforced in the past; however, the current bracing is providing inadequate support for snow loads as detailed in the Ontario Building Code. Furthermore, the roof membrane has failed and has been temporarily repaired with polyethylene vapor barrier weighted on the roof with various cobbles and debris. The vapor barrier is currently trapping condensation and moisture on the roof which is expediting deterioration.

It was also noted during the inspection that there had been previous attempts to rehabilitate the structure by evidence of a steel frame constructed on the interior of the powerhouse, however, moisture present along the base of the columns as a resultant of the seepage has left the bracing with severe corrosion, which significantly reduces the structural capacity of the steel frame.

Finally, a large/wide crack along the powerhouse foundation walls was observed running through the entire structure. The cause of this may have been a result of losing the foundation material over time below the walls during the powerhouse operation, which may have caused the foundation to drop, or excessive pressure brought on from the hydrostatic forces acting on the dam. This large crack also poses a risk to the stability of the dam which will be discussed in Section 4.2.

Based on the above evidence, major rehabilitation or replacement of the building would be required.

4.2 Geotechnical

4.2.1 General Dam Conditions

Inspection of the concrete dam indicated that the concrete wall of the dam area was generally in a fair condition. Seepage was noted at various areas under the dam sections, however, there was no indication of boiling or piping through the dam foundation and the observed seepage rate was relatively stable. Significant seepage was observed in the powerhouse, however, the amount of the seepage was reported to remain steady in recent years.

Generally, the condition of the concrete was found to be expected with the age of the structure, some hairline to narrow cracks were observed in the dam with a small section of delamination at the crest on the southern side. Areas of scour / erosion were observed particularly around the south side of the powerhouse where aggregate was observed. Evidence of historic repairs with

cold patch concrete were evident along some sections of the dam including the powerhouse dam section. The contacts at both abutments for the powerhouse dam sections were generally in a good condition with no evidence of seepage. However, a large crack observed under the powerhouse floor slab (discussed in Section 4.1) indicated that the d/s support for the concrete gravity dam (i.e. the powerhouse dam section) has been compromised.

4.2.2 Factor of Safety for Dam Stability

Based on the review of the available documents and drawings provided by the Client, it is understood that the as-built concrete dam (non-overflow section) was constructed on the in-situ bedrock and supported by the downstream fill placed against the dam; at the powerhouse section, the d/s powerhouse structure with a massive concrete floor slab are likely to work together with the concrete gravity dam structure to take the loads. The typical dam sections are included in Appendix B.

Preliminary stability calculations were carried out for both non-overflow concrete dam section and the powerhouse dam section (see Appendix B). Table 4-1 is a summary of the preliminary results of the calculated factor of safety for the dam under current condition.

Table 4-1: Summary of the Calculated FOS (Static)¹

Dam Section	Maximum Height (m)	Calculated FOS		Required Min FOS
Non-overflow Section	3	Against Sliding	2.2 to 2.4	1.5
		Against Overturning	1.2 to 1.4	2.0
Powerhouse Dam Section	6	Against Sliding	2.4-3.3	1.5
		Against Overturning	1.6-1.9	2.0

Note:¹ The water level is assumed to be 30cm below the dam crest.

Based on Table 4-1, it can be seen that:

- For non-overflow dam section, the calculated FOS is depending on the remaining fill material at d/s toe area for the post-overflow event in 2019 flooding. Significant washout /scouring was observed along the downstream toe area with a scoring depth in excess of 1.0 - 1.5 m. Under the current site condition, the calculated FOS against sliding is in the range of 2.2 to 2.4, which meet the required minimum required FOS of

1.5; The calculated FOS against overturning is in the range of 1.2 to 1.4, which does not meet the required FOS of 2.0. Repair or mitigation measures have to be developed for the non-overflow dam section to improve the FOS to meet the criteria;

- For the powerhouse dam section, a large longitudinal crack that was observed through the floor slab/foundation of the dam during DSI. The presence of the crack likely indicated that both the dam section and the powerhouse structure worked together carrying loading. Under the current site condition, the calculated FOS against sliding is in the range of 2.4 to 3.3, which meet the required minimum FOS of 1.5; The calculated FOS against overturning is in the range of 1.6 to 1.9, which does not meet the required FOS of 2.0. Repair or mitigation measures need to be developed for the powerhouse dam section to improve the FOS to meet the criteria.
- For the powerhouse dam section, caution should be taken if/when the powerhouse is considered to be removed. If the powerhouse is to stay intact it is recommended that the floor slab be repaired by anchoring the two pieces together and seating the anchors into bedrock to ensure that the slab can act as one unit. Furthermore, to achieve an acceptable safety factor the slab should be anchored into the bedrock to prevent overturning or sliding. Further geotechnical investigation and engineering assessment may be required.

4.2.3 Overflow Water Management

There is no emergency spillway installed at the dam site to manage the overflow. The overflow water was largely reported to the south side of the dam near the right abutment and was then channeled down to the tailrace through a temporary trench during 2019 overtopping event. Significant scour and washout for the downstream fill materials were caused by the random overflow. Furthermore, the current dam is at risk of failure due to the severe erosion/scouring at the downstream toe area. To improve the dam safety condition, replacement of the d/s fill material, the overflow water management facility and the d/s erosion protection measures should be developed.

4.2.4 Vegetation Control

Significant vegetation was observed on the downstream edge of the dam with large trees growing directly downstream of the dam. Vegetation should be removed within 3 – 5 m of the footprint of the selected repair/mitigation option.

5. PRELIMINARY RECOMMENDATIONS

The following sections briefly discuss the preliminary recommendations for the rehabilitation of the Burgess 1 Dam facilities. The preliminary recommendations are based on the consideration of the following factors:

- The key findings of 2019 DSI and dam safety;

- Preliminary structural / geotechnical assessment;
- Impact on the environmental and permitting for the construction at the dam site;
- Technical and economic feasibility and constructability;

Several preliminary options for the rehabilitation of the Burgess 1 Dam facilities are evaluated at an FEL 1 level (i.e. preliminary design). However, for the purpose of this Memoranda, three (3) primary feasible options will be briefly discussed. The further engineering assessment of the feasible rehabilitation options are in progress, the final recommended option will be presented in the DSR report.

5.1 Option #1 Re-instate downstream Fill and add Erosion Protection

The objective of the Option #1 is to reinstate the FOS of the existing dam by replacing d/s fill material and manage the overflow by re-grading the d/s slope associate with rockfill/ riprap for erosion protection. A small toe berm is required to divert the overflow (if it occurs). Option #1 mainly consists of the following (see Appendix B-Option #1):

- Downstream vegetation removal as required;
- Strip the top organic soil as required;
- Replace the d/s fill materials to reinstate the FOS of the dam;
- Regrade the d/s fill materials and build a toe berm to manage and divert the overflow (if it occurs) toward d/s main river; The finish grade should be generally higher grade at the North side and progressively lower to the south side approaching the d/s river channel;
- Add appropriate rockfill/riprap for erosion protection if overtopping occurs;
- Grouting or concrete patching the cracks in the existing dam to limit the leakage;
- At the powerhouse the slab should be repaired and anchored to the bedrock, or if the powerhouse is to be decommissioned then fill could be placed over-top of the slab to compensate for the compromised slab.

5.2 Option #2 Partially Dam Crest Raise without Spillway

The objective of the Option #2 is to partially raise the dam on both left and right abutment sides and direct the overflow (if occur) through the middle existing dam section toward the d/s river channel. Option #2 mainly consists of the following (See Appendix B-Option 2):

- Downstream vegetation removal as required;
- Strip the top organic soil as required;

- Partially raise the dam crest on the north and south dam sections; the middle section of the existing dam will be maintained to pass and divert the overflow to the d/s river channel;
- Replace the d/s fill materials to reinstate the FOS of the dam;
- For the area between the middle dam section and the d/s existing river channel, regrade the d/s fill and add appropriate rockfill/riprap for erosion protection to divert the overflow (if occur)
- Grouting or concrete patching the cracks in the existing dam to limit the leakage;
- At the powerhouse the slab should be repaired and anchored to the bedrock, or if the powerhouse is to be decommissioned then fill could be placed over-top of the slab to compensate for the compromised slab.

5.3 Option #3 Dam Crest Raise plus Spillway Construction

The objective of the Option #3 is to raise the entire dam and install an emergency spillway to manage and control any overflow for flood event.

The installation of a spillway to the Burgess Dam facility would be highly advantageous. In the flood event, the overflow would be safely controlled and channeled to d/s river channel that would not affect the u/s lake operation level and the existing d/s facilities/ properties. Given that the overtopping occurred along the south section of the dam, the proposed spillway location would be at the south side of the dam, which has the shortest distance to the existing river channel. Furthermore, based on the topography of the site the most direct route to connect back to the tailrace would be along the southern edge of the property south of the existing water course. This would avoid unnecessary flows running against the River Street embankment. The spillway invert could be kept at the current dam crest elevation and the remainder of the dam could be raised minimally to meet the minimum freeboard criteria during the operation of the spillway in the flood event. The final spillway invert elevation and dam raise will be determined based on the hydrotechnical assessment. Option # 3 mainly consists of the following (see Appendix B-Option 3):

- Downstream vegetation removal as required;
- Strip the top organic soil as required;
- Raise the dam crest as per design;
- Install the emergency spillway as per design (e.g. Geomembrane Lined Rockfill Channel);
- Replace the d/s fill materials to reinstate the FOS of the dam;
- Grouting or concrete patching the cracks in the existing dam to limit the leakage;

- At the powerhouse the slab should be repaired and anchored to the bedrock, or if the powerhouse is to be decommissioned then fill could be placed over-top of the slab to compensate for the compromised slab.

For all three options, appropriate topographical survey of the existing dam and surrounding area is required.

5.4 River Street Embankment and Retaining Wall

Visual inspection of the retaining wall and downstream embankment of River Street indicates that there is significant risk posed to the road.

River street currently sits on an embankment at an approximate 2H:1V on which the toe is supported by a more recent gabion basket retaining wall sitting on a historic boulder retaining wall. There is also a concrete retaining wall that abuts the south side of River Street and connects to the north wall of the powerhouse. A large crack through the retaining wall was observed and a large section of the wall has failed and has shown signs of movement.

There was also evidence of washout at the toe of the retaining wall. If a flood event were to occur again, and water were to make its way along the toe of the River Street embankment, there is a significant risk of a slope failure which could result in loss of the road and surrounding property damage. The existing concrete retaining wall is in a poor condition and should be replaced.

The embankment to the west of the wall should be better reinforced including the addition of erosion/scour protection to prevent future washout and slope instability. While this is not considered a direct risk to the dam, the observations on site deemed it necessary to be brought to the Township's attention as there exists a risk to River Street adjacent to the tailrace of the dam. The slope stability evaluation of the embankment along the River Street is not included in the scope of this DSR. Detailed geotechnical investigation and assessment are strongly recommended.

5.5 Public Safety and Access

The following summarize the recommendations regarding the public safety and access based on the DSI, including:

- A Public Safety Plan (PSP) should be drafted to address these issues and ensure they are properly managed.
- Install adequate safety signage at the dam site for warning of flow, deep water, the potential hazards of the vortex/swirl etc.
- Upgrade the boom line and adjust the safety distance to the powerhouse inlet;
- Upgrade the fence / gate to constrain the public access to the dam site without permits;

- The sluiceway of the dam appeared to have overhead flashing lights, however, they were not able to be tested during the site visit. Visual and audio warnings if not installed should be implemented and tested regularly to ensure that during startup/operation adequate warning can be given to members of the public.
- Grounding wire is currently exposed due to the washout. Exposed wire should be backfilled as soon as possible as this poses a significant hazard currently on the site. Furthermore, debris that has washed up on and over the dam crest should be removed.
- The south abutment currently has a dock from the neighboring resident built on the dam crest which should be removed.

6. CLOSURE

We hope that this draft memo helps frame the critical issues and proposed remediations for the Burgess 1 Dam facility. The detailed dam safety assessment is in progress and the final results will be presented in the final DSR report. If you have any questions, please feel free to reach out to the undersigned.

Sincerely,



Erik Giles, P.Eng
Geotechnical Engineer

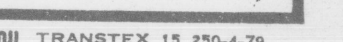


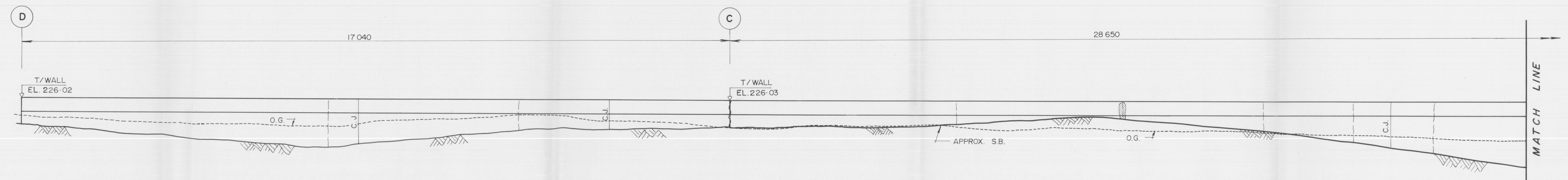
Frank Palmay P.Eng
Structural Design Engineer

Attachment(s)/Enclosure: Field Inspection Reports

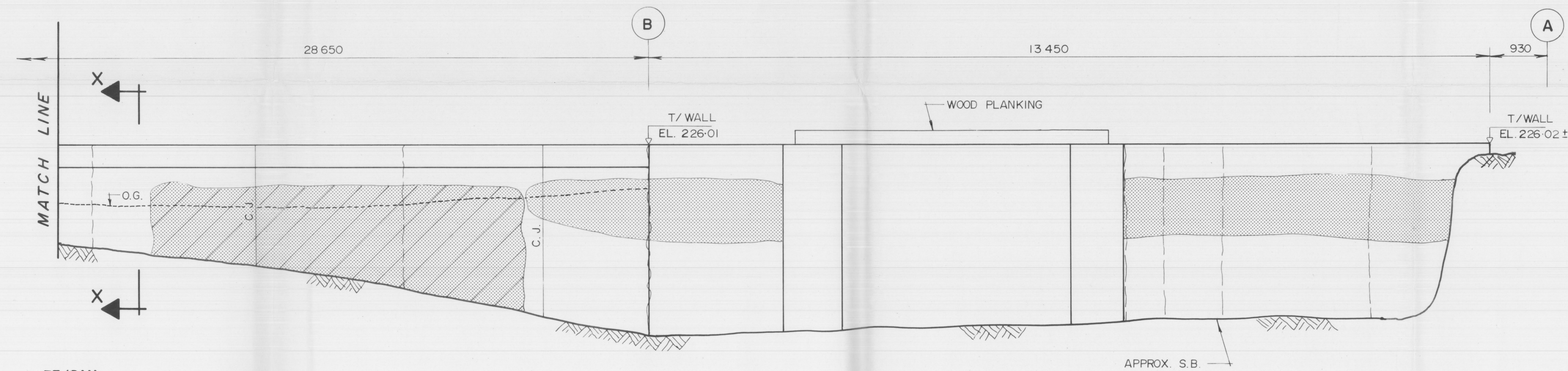
APPENDIX F

HISTORIC SITE PLANS

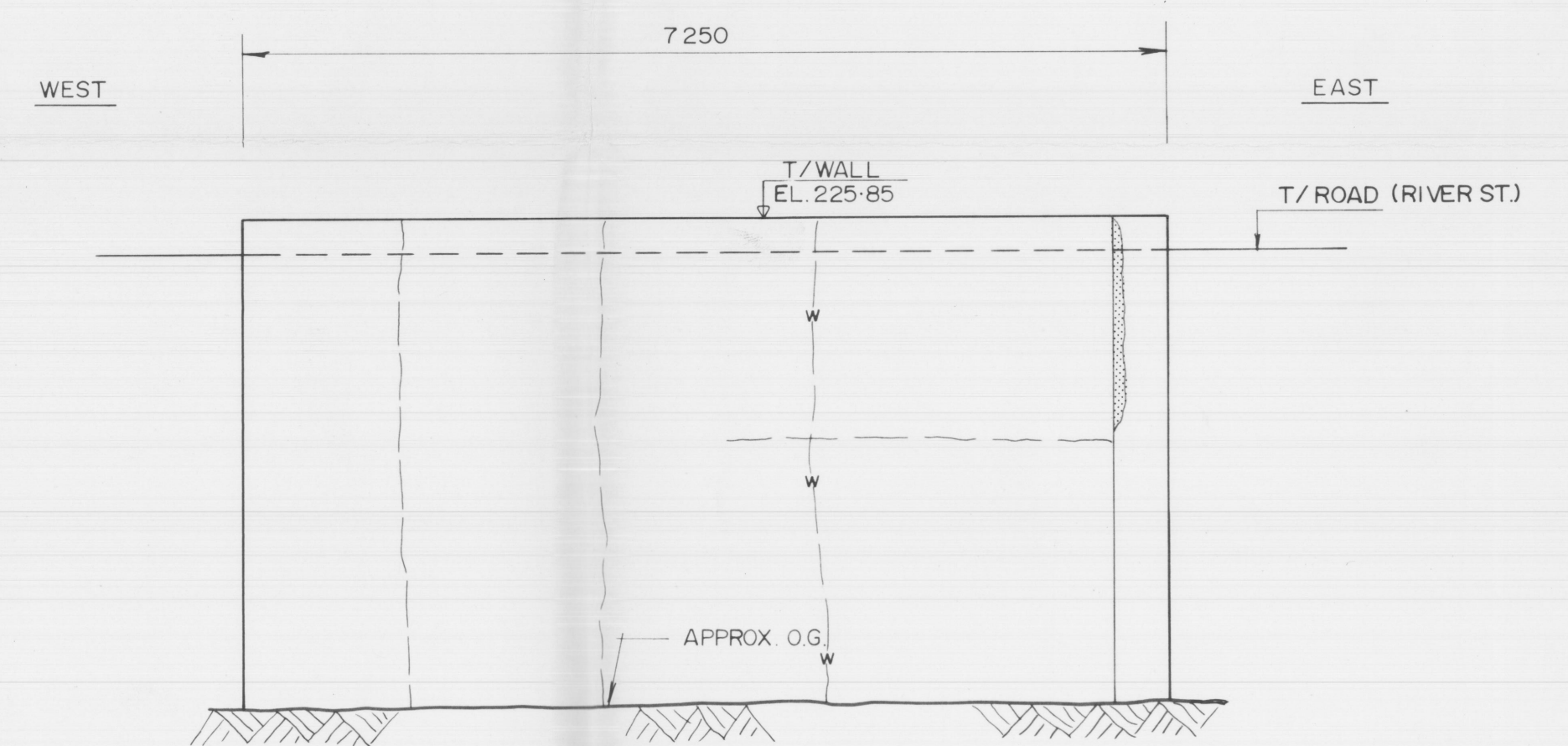




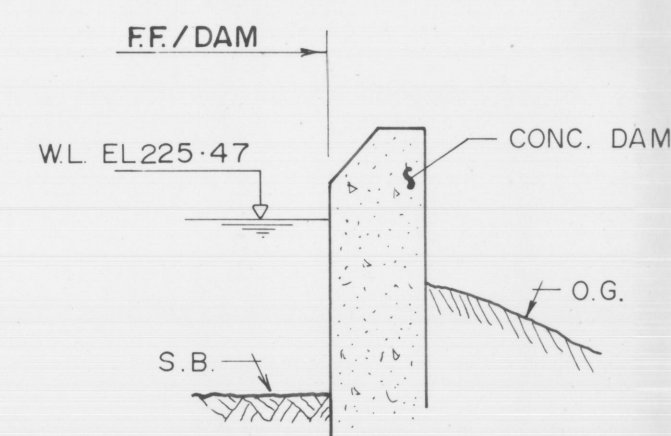
ELEVATION - CONCRETE DAM



ELEVATION - CONCRETE DAM



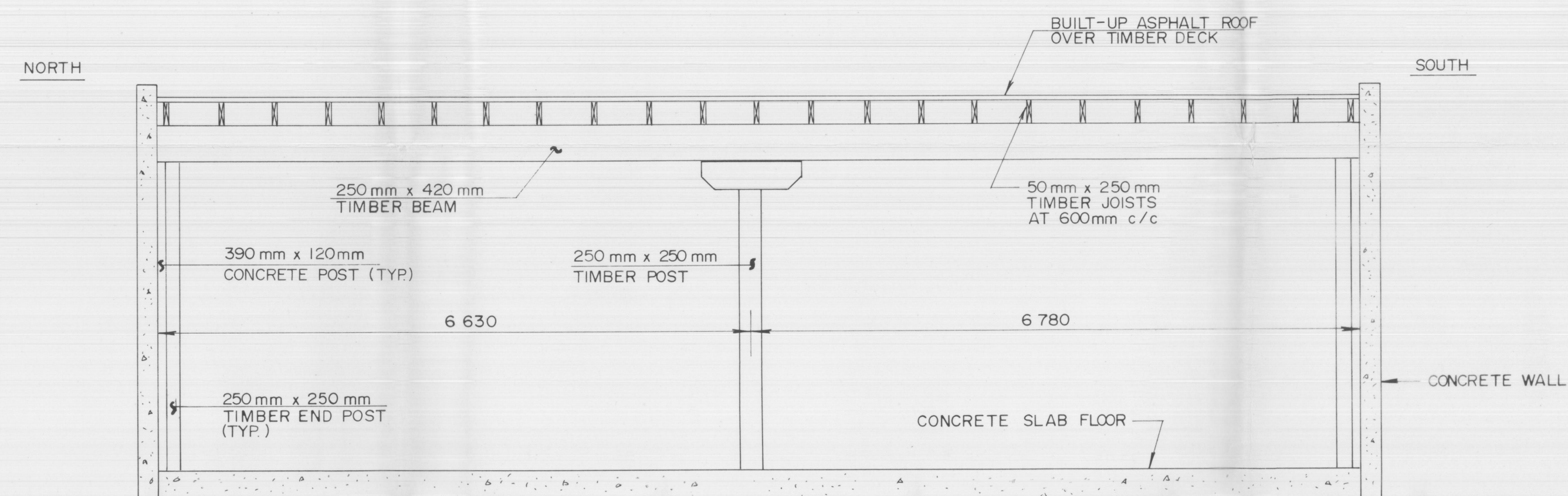
ELEVATION - CONCRETE RETAINING WALL



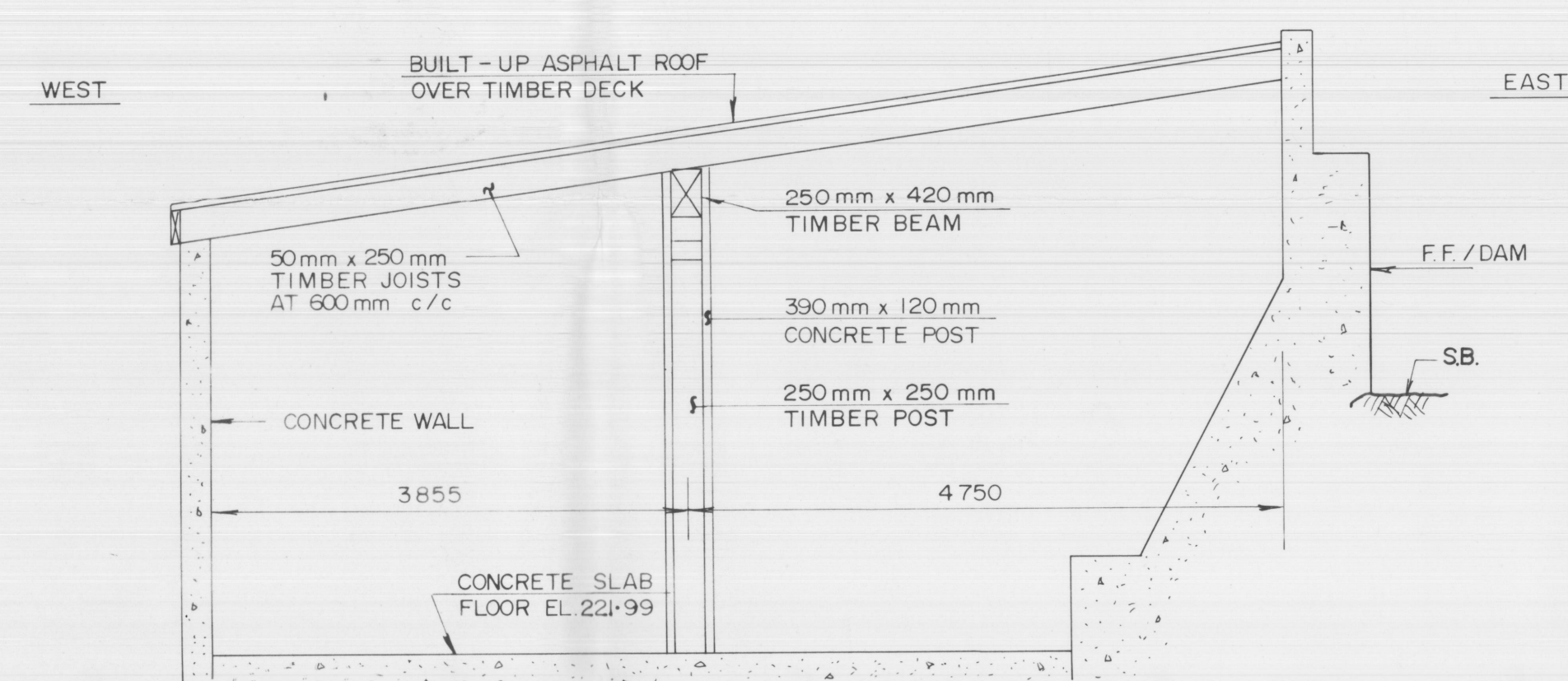
SECTION X-X

LEGEND

- DENOTES MINOR CRACK
- DENOTES WIDE CRACK
- DENOTES SPALLED AREA
- DENOTES MINOR SPALLED AREA
- DENOTES ORIGINAL GROUND (O.G.)



SECTION A-A



SECTION B-B

POWER BUILDING

totten sims hubicki associates

ENGINEERS ARCHITECTS AND PLANNERS

COBOURG WHITBY KINGSTON TORONTO BRACEBRIDGE BROCKVILLE OTTAWA

No.	DATE	BY	REVISIONS

DESIGNED: D. L. B.
DRAWN: R. G. W.
CHECKED: D. L. B.
APPROVED: G. L. A.
SCALE: 1:50 UNLESS NOTED

BALA DAM AND POWER BUILDING
RIVER STREET - BALA
TOWNSHIP OF MUSKOKA LAKES
SECTIONS & ELEVATIONS

DATE: AUG., 1986
PROJECT: 36-7058
DRAWING:

P2

DATE	AMBIENT NOISE LEVEL MEASUREMENT STATIONS (dB)					
	1	2	3	4	5	6
FEB. 3, 1988	46	39	52.5	41	46	56.5
MAR. 22, 1988	42	36	44	36	38	40
MAR. 24 1988	40	38	48	39	38	40
APR. 5, 1988	46	42	45	45	43	56
APR. 8, 1988	52	40	50	42	40	43
MAY 10, 1988	52	44	62	50	54	57
MAY 30, 1988	55	48	65	53	52	49
JUL. 11, 1988	52	50	60	50	52	48
JUL. 26, 1988	53	48	58	50	53	54
AUG. 3, 1988	50	40	72	48	54	55
SEP. 7, 1988	55	42	48	50	53	50

WINDY

WINDY

WINDY
REDUCED DIVERSION



EXISTING SITE PLAN

RESTORATION
BY
MARSH HYDROPOWER LTD.

REVISION	NO.	DESCRIPTION	DATE	APP'D	DRAWN BY	G.K.	DESIGNED BY	B.R.	CHECKED BY	F.N.	APPROVED BY	DATE	FEB. 1988	SCALE	1:250
A		PROPERTY LINES CHANGED	23SEPT88	F.M.N.											



Cumming Cockburn Limited
Consulting Engineers and Planners

TOWNSHIP OF
MUSKOKA LAKES

[Signature]
CLERK - ADMINISTRATOR

BALA

ONTARIO

LITTLE BURGESS
GENERATING STATION

BALA

ONTARIO

EXISTING SITE PLAN

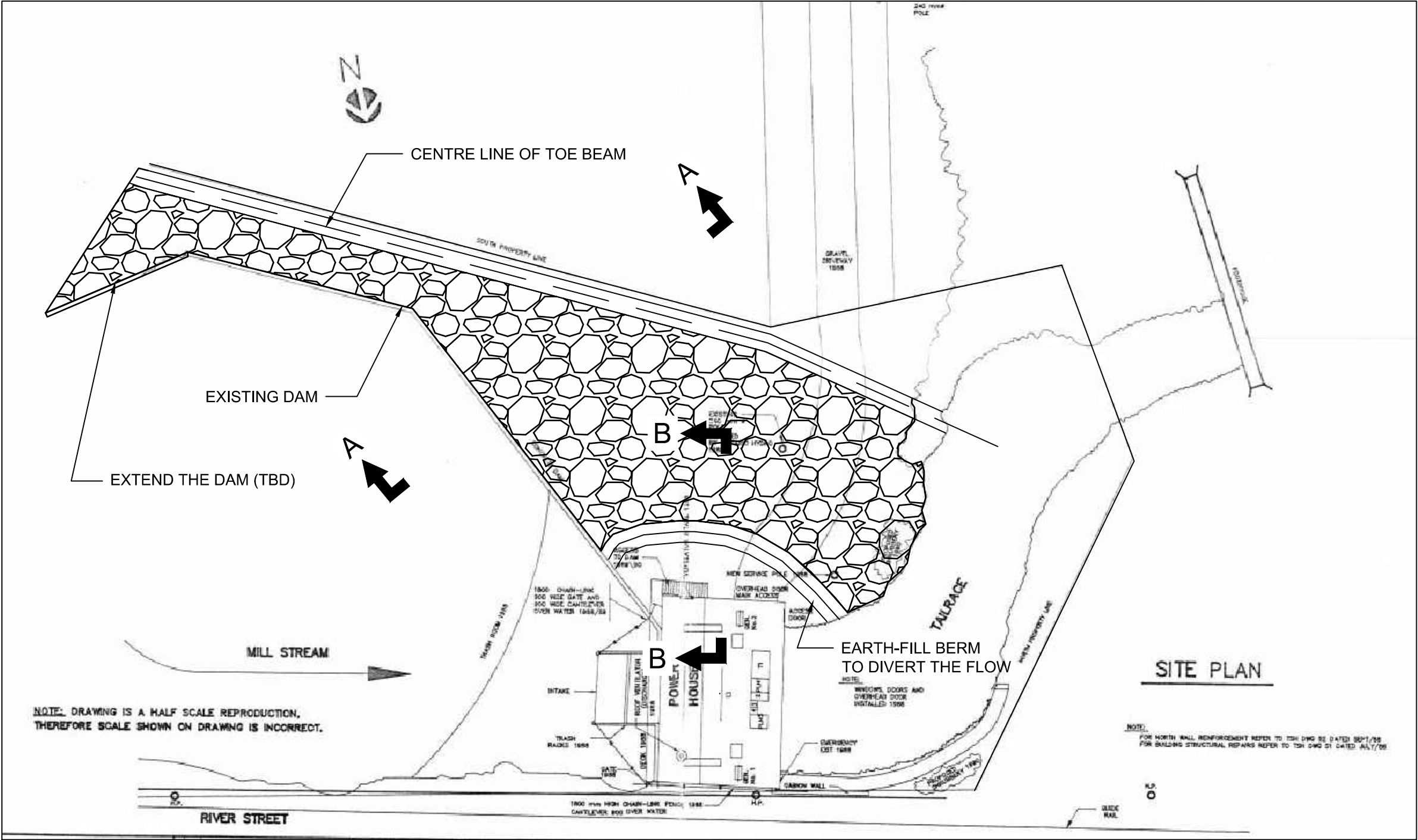
DRAWING NO.
4383-S1

REV.
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APPENDIX G

REMEDICATION OPTIONS FIGURES

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PLAN
N.T.S

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No.	DATE	BY	ISSUES / REVISIONS



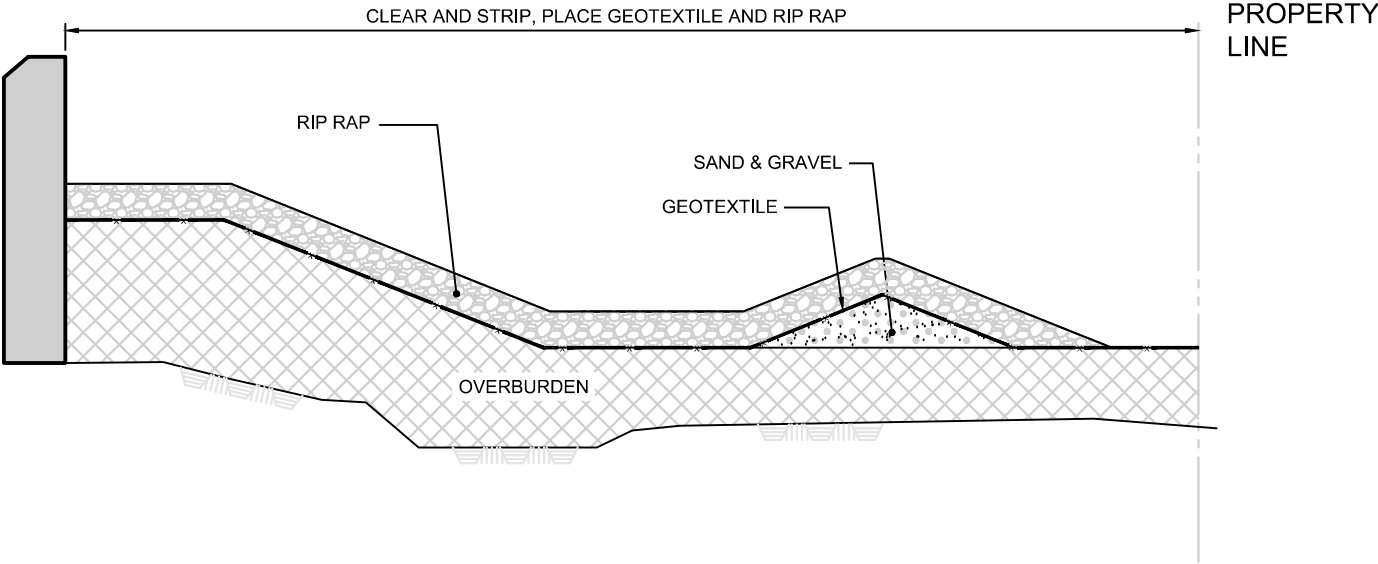
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NON-OVERFLOW DAM SECTION
OPTION N1
UPGRADED DOWNSTREAM FILL
WITH TOE BERM - PLAN

CLIENT:
TOWNSHIP OF
MUSKOKA LAKES
PROJECT:
BURGESS DAM 1
DAM SAFETY ASSESSMENT

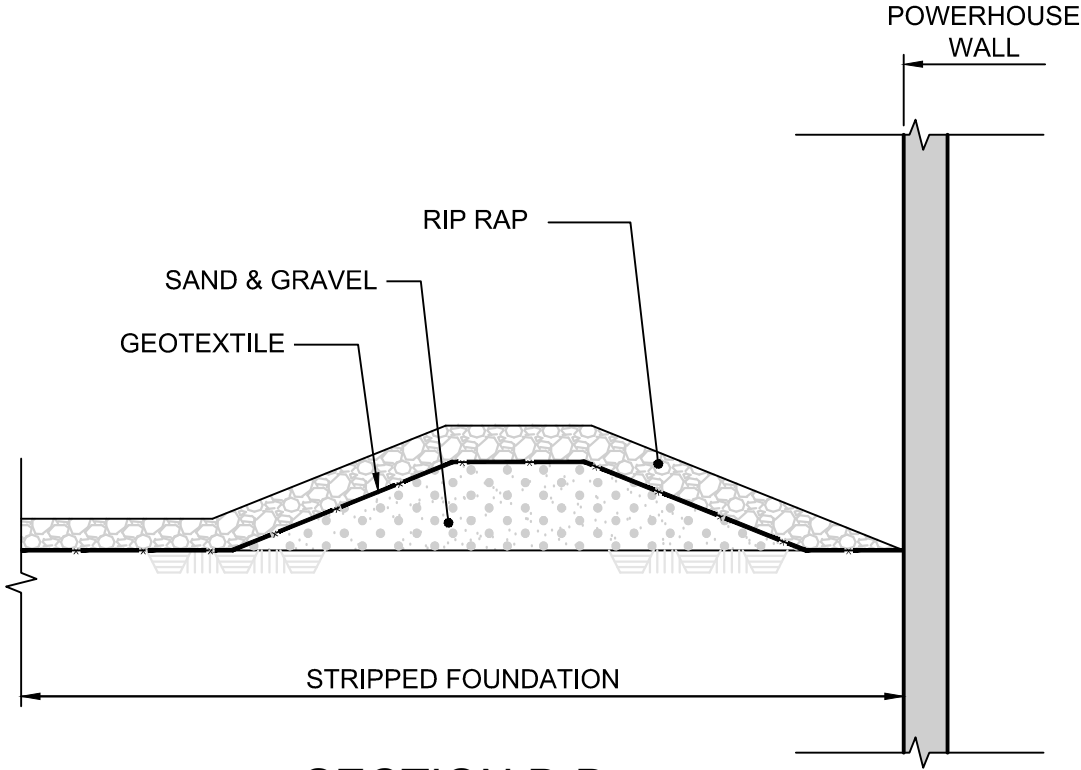
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APPROVED BY: G. LIANG	SCALE: AS NOTED	DATE: 2019-08-07
DRAWING No. 19-1493-C-01		REVISION No. A

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HEADPOND
WATER LEVEL
EL. 225.75



SECTION A-A
N.T.S



SECTION B-B
N.T.S

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No.	DATE	BY	ISSUES / REVISIONS

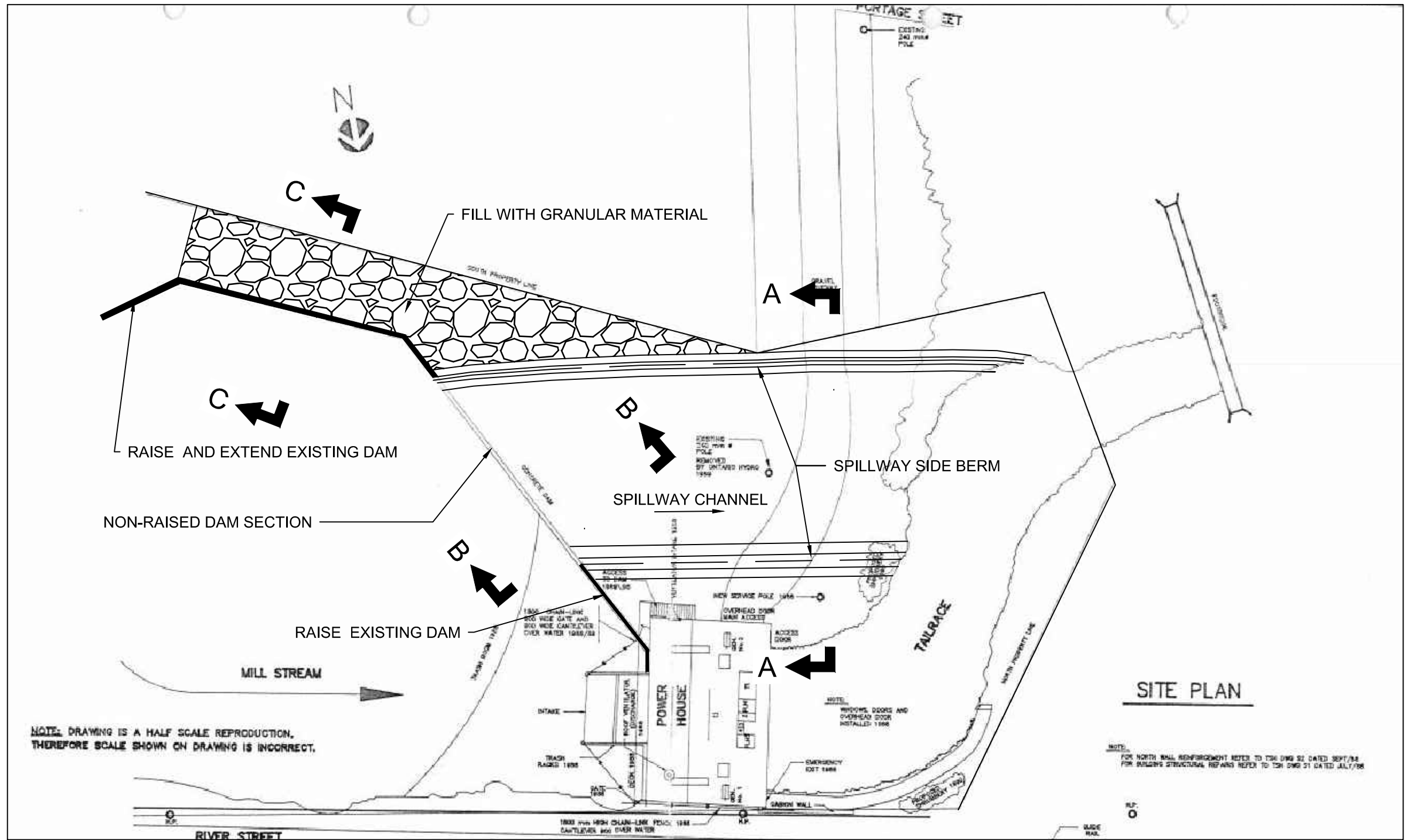


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NON-OVERFLOW DAM SECTION
OPTION N1
UPGRADED DOWNSTREAM FILL
WITH TOE BERM - SECTIONS

CLIENT:
TOWNSHIP OF
MUSKOKA LAKES
PROJECT:
BURGESS DAM 1
DAM SAFETY ASSESSMENT

DRAWN BY: K. KORTEKAAS	CHECKED BY: E. GILES	DESIGNED BY: G. LIANG
APPROVED BY: G. LIANG	SCALE: AS NOTED	DATE: 2019-08-07
DRAWING No. 19-1493-C-02		REVISION No. A

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PLAN
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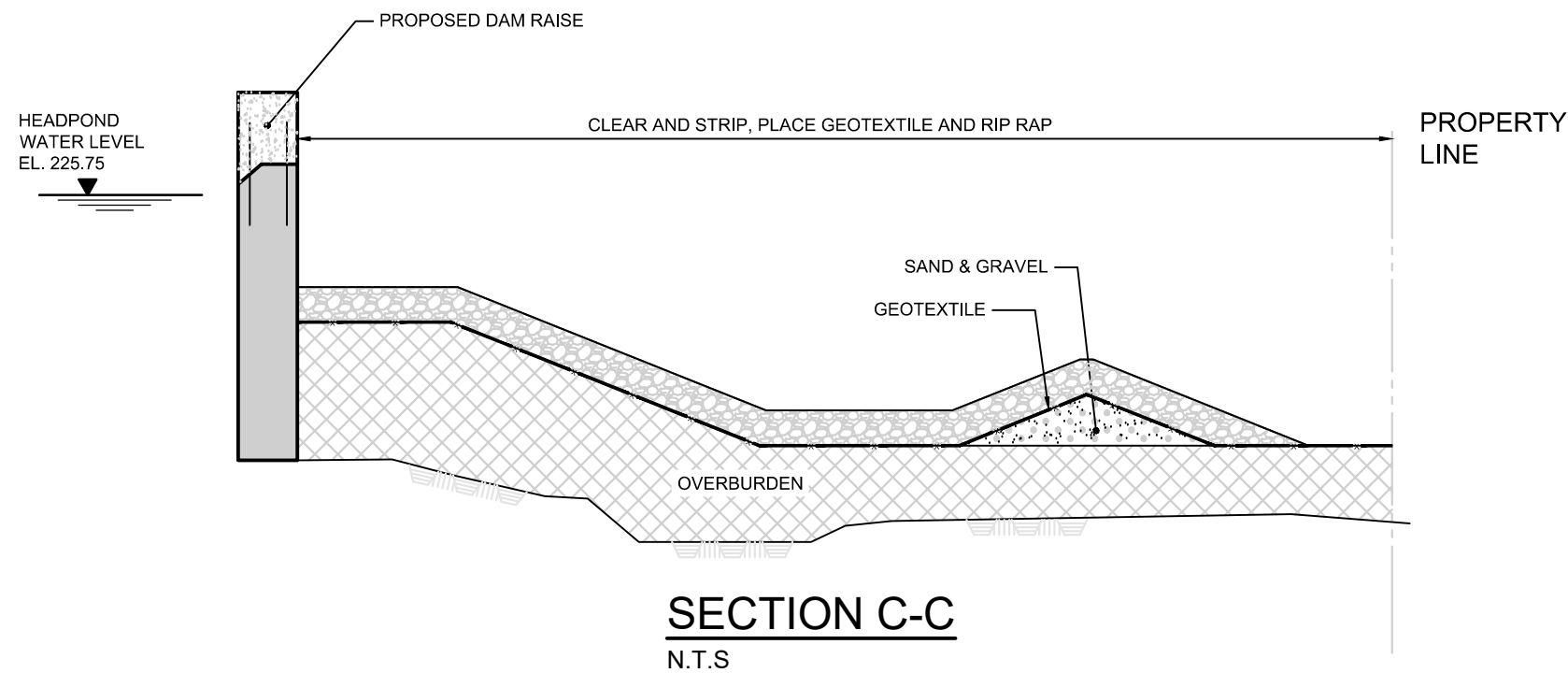
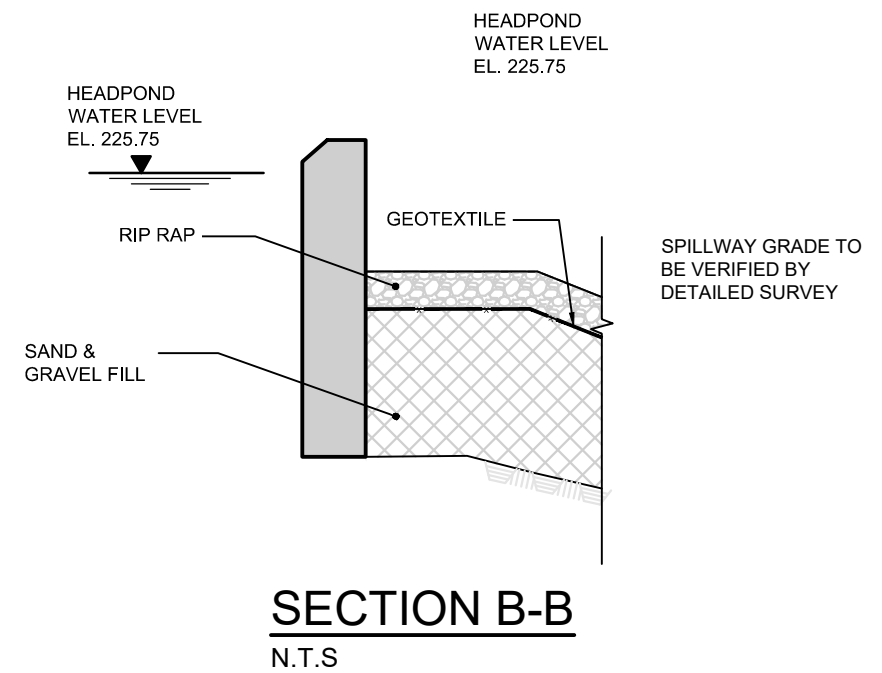
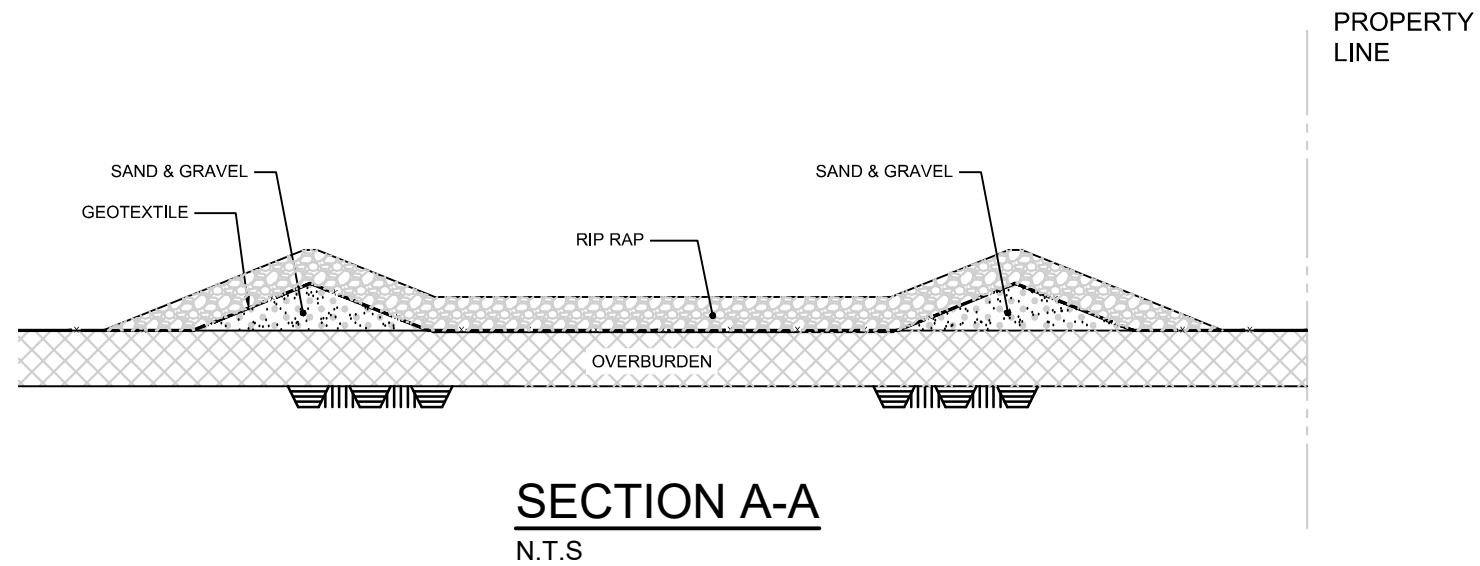


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NON-OVERFLOW DAM SECTION
OPTION N2
UPGRADED DOWNSTREAM FILL
WITH SPILLWAY -PLAN

CLIENT:
TOWNSHIP OF
MUSKOKA LAKES
PROJECT:
BURGESS DAM 1
DAM SAFETY ASSESSMENT

DRAWN BY: K. KORTEKAAS	CHECKED BY: E. GILES	DESIGNED BY: G. LIANG
APPROVED BY: G. LIANG	SCALE: AS NOTED	DATE: 2019-08-07
DRAWING No. 19-1493-C-04		REVISION No. A

No.	DATE	BY	ISSUES / REVISIONS
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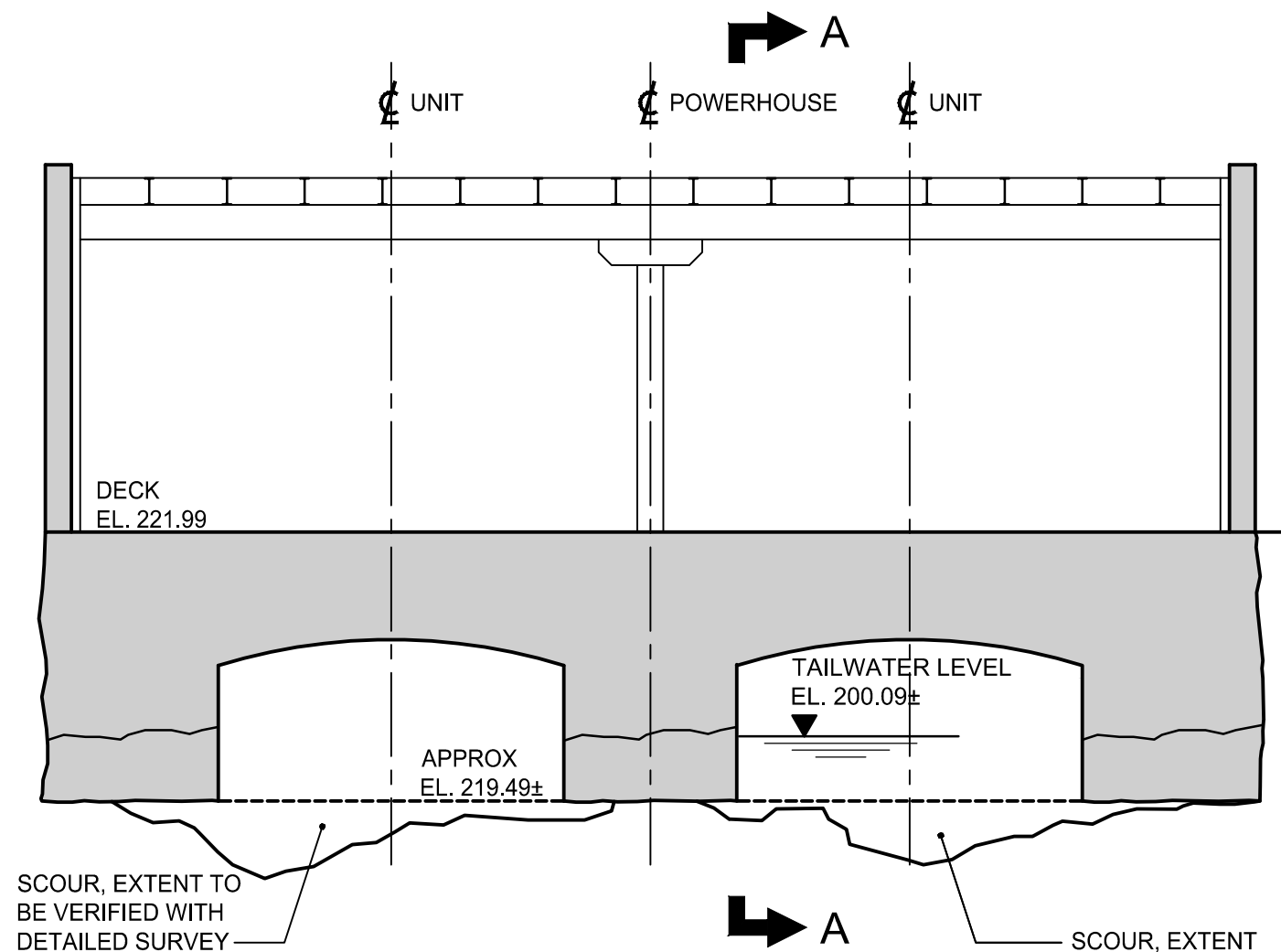


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NON-OVERFLOW DAM SECTION
OPTION N2
UPGRADED DOWNSTREAM FILL
WITH SPILLWAY - SECTIONS

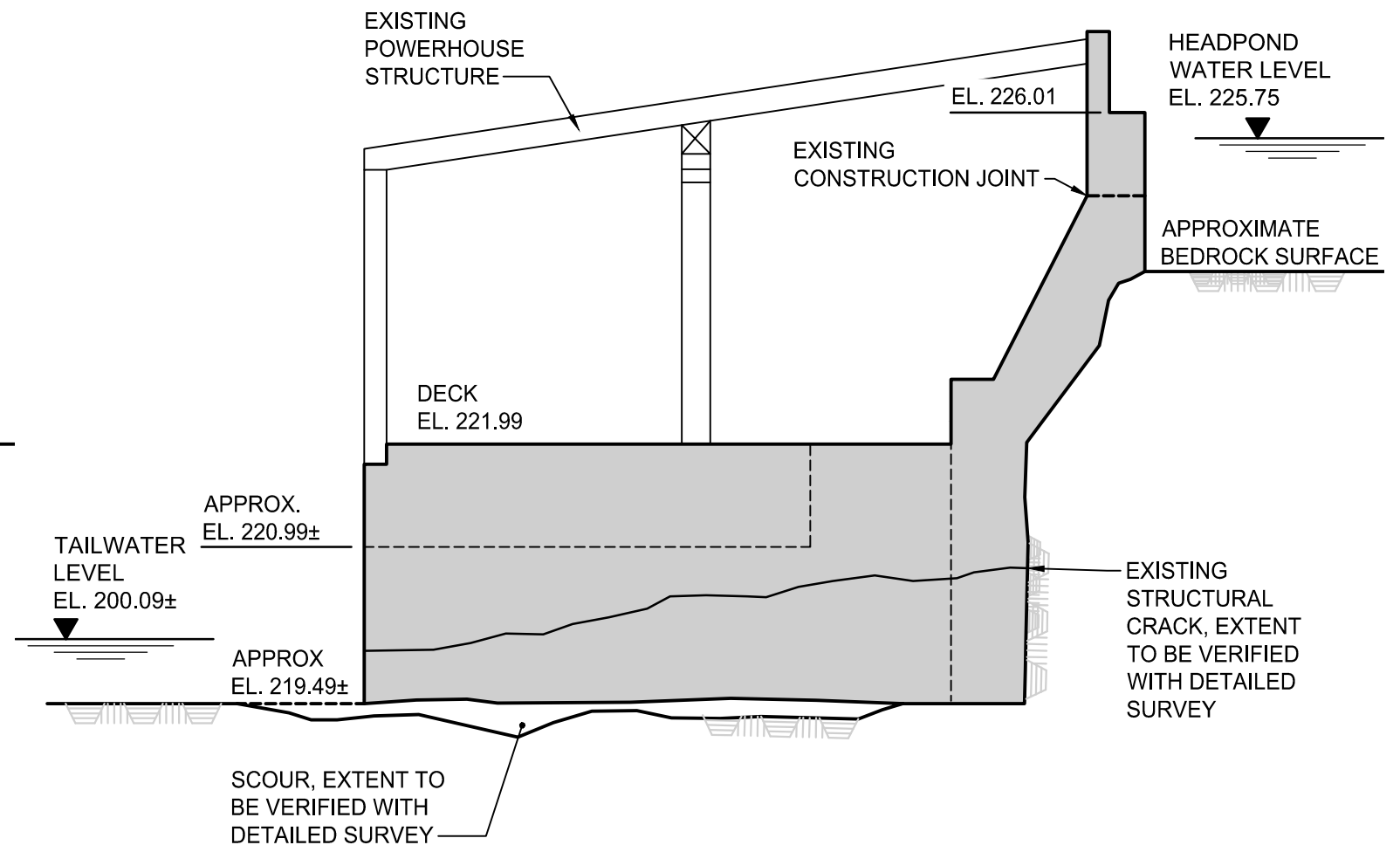
CLIENT:
TOWNSHIP OF
MUSKOKA LAKES
PROJECT:
BURGESS DAM 1
DAM SAFETY ASSESSMENT

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APPROVED BY: G. LIANG	SCALE: AS NOTED	DATE: 2019-08-07
DRAWING No. 19-1493-C-05		REVISION No. A

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PROFILE
DOWNSTREAM FACE
N.T.S



SECTION A-A
N.T.S

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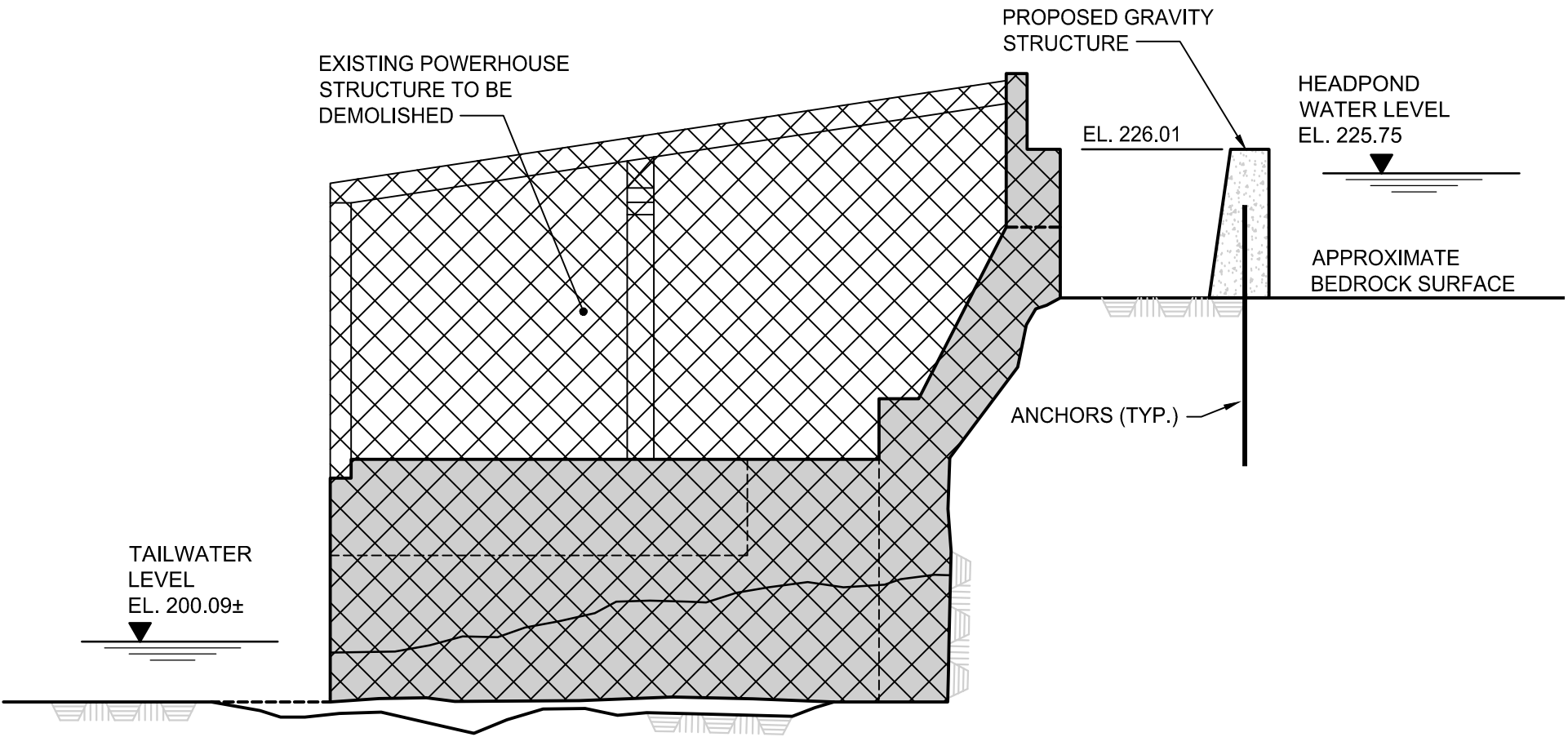


DRAWING:
**POWERHOUSE REMEDIATION
EXISTING CONDITIONS
PROFILE AND SECTION**

CLIENT:
**TOWNSHIP OF
MUSKOKA LAKES**
PROJECT:
**BURGESS DAM 1
DAM SAFETY ASSESSMENT**

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APPROVED BY: G. LIANG	SCALE: AS NOTED	DATE: 2019-08-07
DRAWING No. 19-1493-C-08		REVISION No. A

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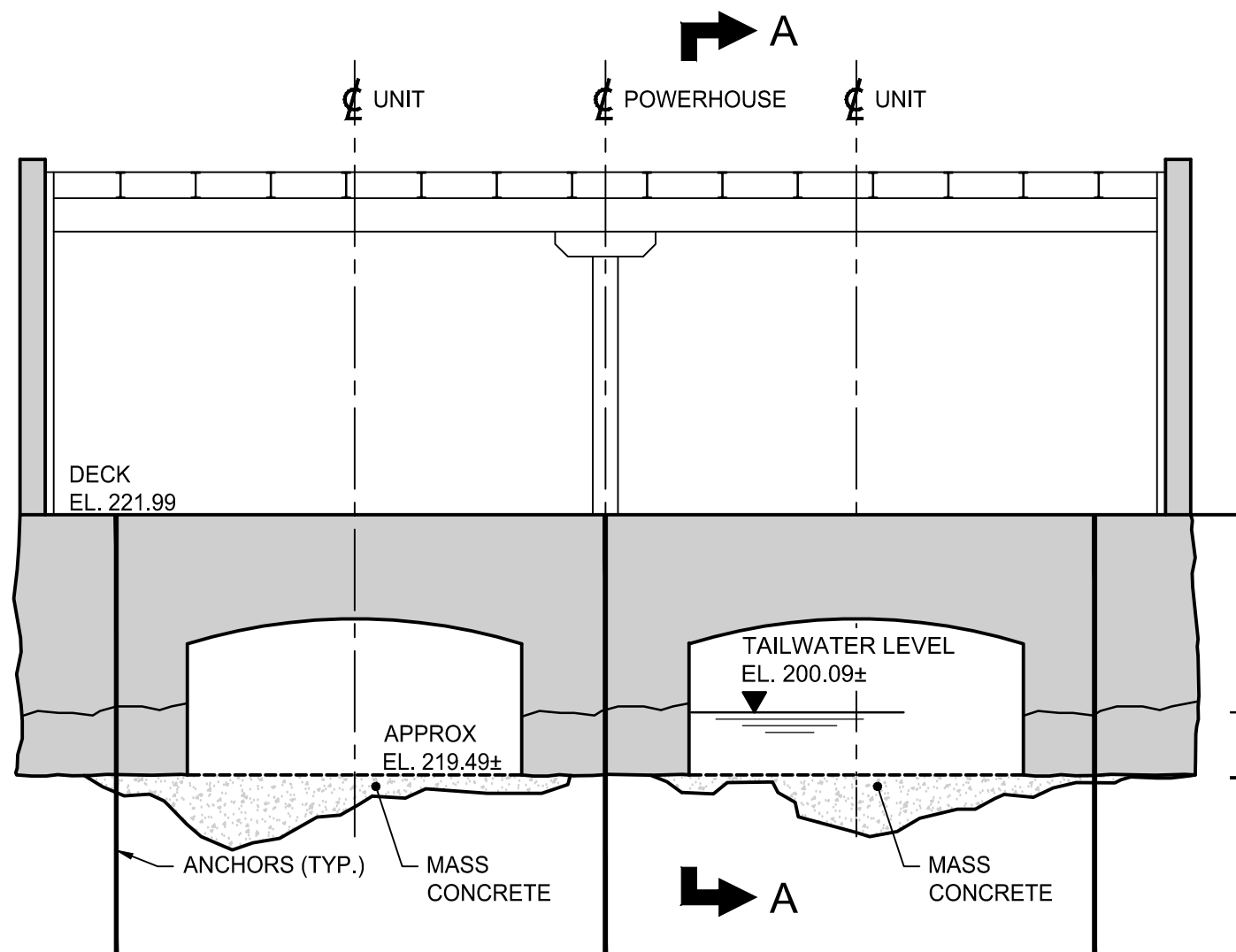
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POWERHOUSE REMEDIATION
OPTION P1
POWERHOUSE REMOVAL
SECTION

CLIENT:
TOWNSHIP OF
MUSKOKA LAKES
PROJECT:
BURGESS DAM 1
DAM SAFETY ASSESSMENT

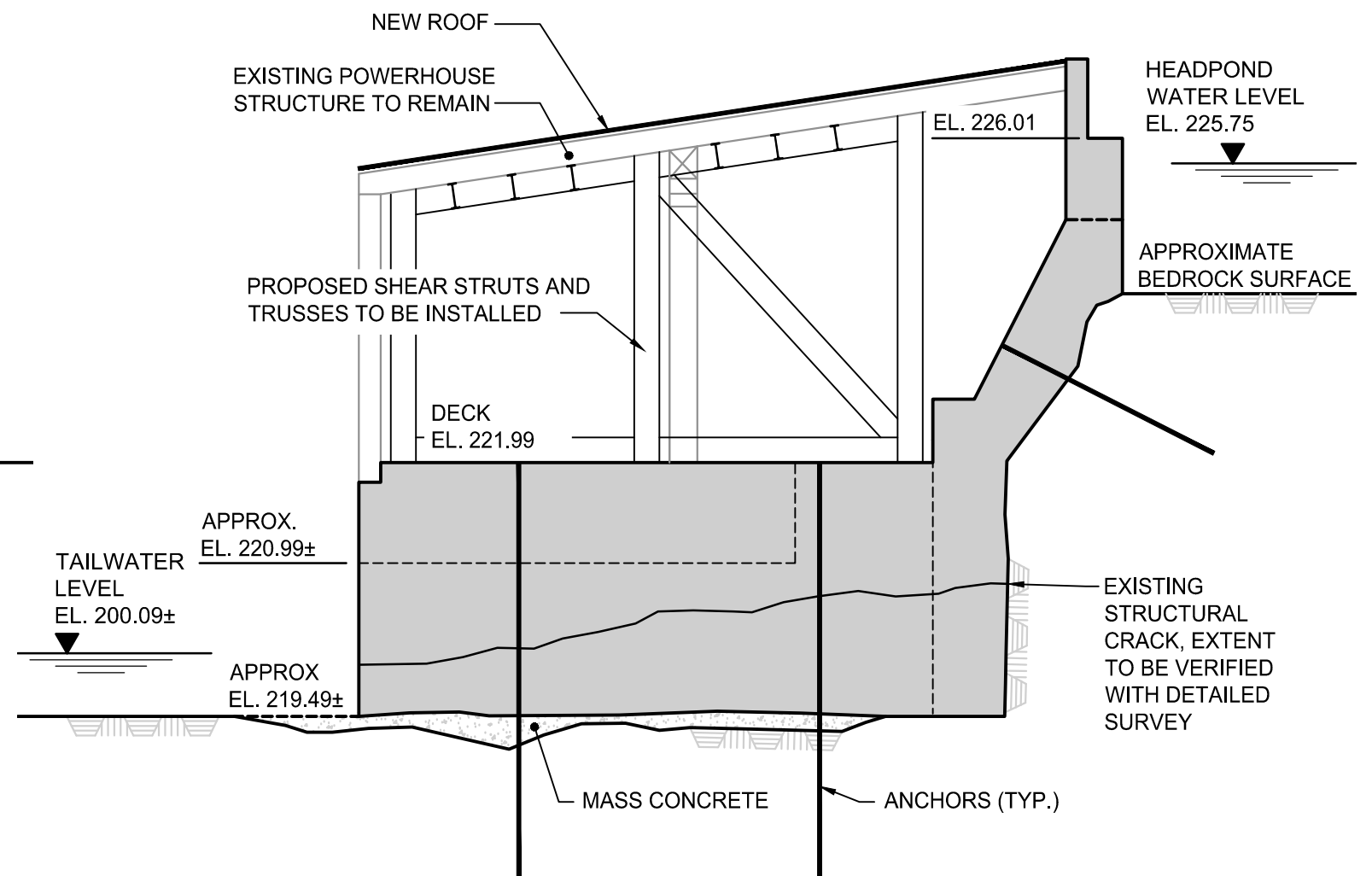
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No.	DATE	BY	ISSUES / REVISIONS

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PROFILE
DOWNSTREAM FACE
N.T.S



SECTION A-A
N.T.S



DRAWING:
POWERHOUSE REMEDIATION
OPTION P2
POWERHOUSE REFURBISHMENT
SECTION

CLIENT:
TOWNSHIP OF
MUSKOKA LAKES
PROJECT:
BURGESS DAM 1
DAM SAFETY ASSESSMENT

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APPROVED BY: G. LIANG	SCALE: AS NOTED	DATE: 2019-08-07
DRAWING No. 19-1493-C-09		REVISION No. A

A	2019-08-13	KK	ISSUED DRAFT FOR CLIENT REVIEW
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APPENDIX H

PRELIMINARY COST TABLES

Table H-1: Burgess 1 Dam Repair
Cost Estimate - Option N1: Downstream Rip Rap Placement and Toe Berm

August, 2019

Item	Description	Estimated	Unit	Unit Price	Total
		Quantity		(\$/Unit)	(\$)
1	Dam Rehabilitation				
1.1	Stripping	900	m2	\$15.00	\$13,500
1.2	Sand and Gravel	150	m3	\$50.00	\$7,500
1.3	Riprap/rockfill	330	m3	\$75.00	\$24,750
1.4	Geotextile	825	m2	\$7.00	\$5,775
1.5	Concrete (dam extension to the south end)	6	m3	\$1,000.00	\$6,000
1.6	Grouting existing dam cracks	40	LS	\$50,000.00	\$50,000
1.7	Anchor Φ25, 1m @ spacing 2m for dam raise	10	LS	\$5,000.00	\$5,000
2	Construction Access Road	1	LS	\$10,000.00	\$10,000
Subtotal					\$122,525
Contingencies					
		40%			\$49,010
	Subtotal Contingencies				\$49,010
Total Estimated Construction Cost					\$171,535

Exclusions:

- Third Party Construction Quality Assurance (CQA)
- Environmental, Engineering, Administration & Site Inspection
- Land acquisition
- Financing / IDC
- Owner's costs
- Bonding and Insurance

Table H-2: Burgess 1 Dam Repair
Cost Estimate - Option N2: Partial Dam Raise and Emergency Spillway

August, 2019

Item	Description	Estimated	Unit	Unit Price	Total
		Quantity		(\$/Unit)	(\$)
1	Dam Rehabilitation				
1.1	Stripping	1,500	m2	\$15.00	\$22,500
1.2	Sand and Gravel	550	m3	\$50.00	\$27,500
1.3	Riprap/rockfill	250	m3	\$75.00	\$18,750
1.4	Geotextile	675	m2	\$7.00	\$5,000
1.5	Concrete (dam extension to the south end and partial raise 0.5m)	14	m3	\$1,000.00	\$13,800
1.6	Grouting existing dam cracks	40	LS	\$50,000.00	\$50,000
1.7	Anchor Φ25, 1m @ spacing 2m for dam raise	35	LS	\$15,000.00	\$15,000
2	Construction Access Road	1	LS	\$10,000.00	\$10,000
Subtotal					162,550
Contingencies					
		40%			\$65,020
	Subtotal Contingencies				\$65,020
Total Estimated Construction Cost					\$227,570

Exclusions:

- Third Party Construction Quality Assurance (CQA)
- Environmental, Engineering, Administration & Site Inspection
- Land acquisition
- Financing / IDC
- Owner's costs
- Bonding and Insurance

Table H-3: Burgess 1 Dam Repair
Cost Estimate - Option P1: Demolish Powerhouse and Replace with New Dam

August, 2019

Item	Description	Estimated	Unit	Unit Price	Total
		Quantity		(\$/Unit)	(\$)
1	Powerhouse Removal				
1.1	D/s and u/s Coffe Dam	1,000	m2	\$500.00	\$500,000
1.2	Removal of Powerhouse/Decommisioning	1	L.S	\$150,000.00	\$150,000
1.3	Removal of the old dam concrete (dam section)	130	m3	\$1,000.00	\$130,000
2	Build New Dam Section				
2.1	New concrete dam section (ONLY, No powerhouse)	55	m3	\$10,000.00	\$550,000
3	Construction Access Road	1	LS	\$10,000.00	\$10,000
4	Right Bank Concrete Retaining wall				
4.1	Drill Drainage holes	1	LS	\$5,000.00	\$5,000
4.2	Excavate Drainage Ditch	1	LS	\$1,000.00	\$1,000
4.3	Granular Material lined Ditch	25	m3	\$50.00	\$1,250
Subtotal					1,346,000
Contingencies					
		40%			\$538,400
	Subtotal Contingencies				\$538,400
Total Estimated Construction Cost					\$1,884,400

Exclusions:

- Third Party Construction Quality Assurance (CQA)
- Environmental, Engineering, Administration & Site Inspection
- Land acquisition
- Financing / IDC
- Owner's costs
- Bonding and Insurance

Table H-4: Burgess 1 Dam Repair
Cost Estimate - Powerhouse Option P2: Powerhouse Refurbishment and Reinforcement

August, 2019

Item	Description	Estimated	Unit	Unit Price	Total
		Quantity		(\$/Unit)	(\$)
1	Powerhouse Retrofit				
1.1	Mass Concrete to fill the undermine area of the powerhouse foundation	30	m3	\$2,500.00	\$75,000
1.2	Foundation Grouting	36	LS	\$50,000.00	\$50,000
1.3	Anchorage the existing concrete slab to bedrock, Φ36mm, 8m long with 6m in rock	1	LS	\$50,000.00	\$50,000
1.4	New powerhouse roof	1	LS	\$100,000.00	\$100,000
1.5	Additional frame and column for powerhouse structure	1	LS	\$50,000.00	\$50,000
1.6	Dam Crack grouting repair	40	m2	\$1,000.00	\$40,000
2	Construction Access Road	1	LS	\$10,000.00	\$10,000
3	Right Bank Concrete Retaining wall				
3.1	Drill Drainage holes	1	LS	\$5,000.00	\$5,000
3.2	Excavate Drainage Ditch	1	LS	\$1,000.00	\$1,000
3.3	Granular Material lined Ditch	25	m3	\$50.00	\$1,250
Subtotal					\$382,250
Contingencies					
		40%			\$152,900
	Subtotal Contingencies				\$152,900
Total Estimated Construction Cost					\$535,150

Exclusions:

- Third Party Construction Quality Assurance (CQA)
- Environmental, Engineering, Administration & Site Inspection
- Land acquisition
- Financing / IDC
- Owner's costs
- Bonding and Insurance

APPENDIX I

NOTICE TO READER

NOTICE TO READER

This report has been prepared by TULLOCH Engineering Ltd. ('TULLOCH') for the sole and exclusive use of the Township of Muskoka Lakes. (the 'Client') to provide analysis with respect to the safety and preliminary remediation of the Burgess 1 Dam located in the Town of Bala, Ontario between Portage and River Street on Bala Bay, (The Site) This report pertains to the above referenced project and site, only, and shall not be used for any other purpose, or provided to, relied upon or used by any third party without the express written consent of TULLOCH.

If this report was prepared to support regulatory compliance, then the Client may authorize its use by the Regulatory Agency as an approved user provided this report is marked "Issued for Use" by TULLOCH, is stamped by a licenced Engineer, and is relevant to the specific project for which a review is being done.

TULLOCH has prepared this report with the degree of care, skill and diligence normally provided by engineers in the performance of comparable services for projects of similar nature subject to the time limits and physical constraints applicable to this work. No other warranty expressed or implied is made. This report contains opinions, conclusions and recommendations made by TULLOCH using professional judgment and reasonable care for the purpose of foundation engineering for the Development. Use of or reliance on this report by the Client is subject to the following conditions:

- a) the report being read in the context of and subject to the terms of the Engineering Services Agreement for the Work (see Proposal #19-0001-179), including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions specified or agreed therein;
- b) the report being read in its entirety. TULLOCH is not responsible for the use of portions of the report without reference to the entire report;
- c) the conditions of the site may change over time or may have already changed due to natural forces or human intervention, and TULLOCH takes no responsibility for the impact that such changes may have on the accuracy or validity of the observations, conclusions and recommendations set out in this report;
- d) the report is based on information made available to TULLOCH by the Client or by certain third parties; and unless stated otherwise in the Engineering Services Agreement for the Work, TULLOCH has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith.