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Technical Memorandum

DATE: September 28, 2016

TO: Kara Zandbergen
Regional District of East Kootenay

FROM: Dwayne Meredith, P.Ag.
Peter Fearon, P.Eng.

RE: **LAKE BAPTISTE DAM UPGRADE**
Conceptual Design
Our File 0257.026

Introduction

The 2013 Dam Safety Review (DSR) determined that the freeboard, spillway, and low level outlet were inadequate on the Lake Baptiste Dam. Kerr Wood Leidal Associates Ltd. (KWL) was retained to provide conceptual level design of the three deficiencies. This technical memorandum provides the design basis, conceptual drawings and probable costs.

The reservoir currently provides 'offline' storage from Macaulay Creek. Water in the reservoir may enter directly from the surrounding watershed or from Macaulay Creek, through a diversion channel via a failed diversion structure. The failed diversion structure allows uncontrolled flow, that is, the entire flow, to enter in to the diversion channel. Incorporating an engineered diversion structure into the design has provided two potential scenarios to consider:

1. The design of an upgraded dam using the entire flow of Macaulay Creek, as currently is the case; and
2. The design of an upgraded dam incorporating an engineered diversion structure on Macaulay Creek allowing the control (ie. reduction) of water entering into the reservoir. This scenario reduces the size of the spillway and allows for a lower crest elevation which is required to convey that additional water downstream.

Regional Hydrology & Design Flows

The regional hydrology was assessed for both the diversion structure and Lake Baptiste spillway. The methodology and data used in the 2013 DSR were applied here. The inflow design flood (IDF) was derived from the Probable Maximum Flood (PMF) and the 1000-year flood estimate. The PMF was calculated using the "PMF Estimator of BC" and the Rational Method while the 1000-year flood was calculated by interpolating between the 100-year flood and the PMF as outlined in the Alberta Transport methodology.

A regional analysis of Water Survey of Canada (WSC) stations was used to derive the 100-year & 200-year return period floods. Design flows for the diversion structure and IDF were then up-scaled by 15% to account for climate change as per the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) professional practice guidelines[1]. The design flows of the dam spillway and diversion structure are listed in Table 1 and Table 2, respectively.

[1] Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC. APEGBC. URL: https://www.apeg.bc.ca/getmedia/18e44281-fb4b-410a-96e9-cb3ea74683c3/APEGBC-Legislated-Flood-Assessments.pdf.aspx

Table 1: Spillway IDF for two scenarios

Flood Event	Peak Discharge 100% Macaulay Inflow (m^3/s)	Peak Discharge No Diversion** (m^3/s)
IDF* + 15% Climate Change Factor	46	17
*IDF is 1/3 between the Q_{1000} and PMF ** assumes scenario of installed diversion structure, closed valve during extreme flood occurring in the watershed.		

Table 2: Macaulay Diversion Design Flood

Flood Event	Peak Discharge (m^3/s)
100-Year Return Period	1.4
200-Year Return Period	1.6

Design Basis

The conceptual designs are provided in the drawings attached to this technical memorandum.

Diversion Structure

The diversion structure was conceptualized to convey the 200-year return period flood into the reservoir with an operational 600 mm valve to eliminate the diversion completely, should it be necessary. The premise provides a close representation to the existing conditions with all normal flows routed to the reservoir. Flood flows in excess of 200-year return, however, would be routed downstream through the pre-existing channel.

The 200-year return period flood event was chosen for the design of the diversion structure; the diversion weir must be able to convey the flow into Macaulay Creek without spilling over the top. Diversion headwalls would be constructed to contain the peak flood; however, there is no accurate topographic data of the diversion structure area.

The existing diversion structure is on private land, but represents a suitable location for the works, particularly with the existing constructed and naturalized channel.

There is limited existing information at this time on the channel reach below the diversion structure. There is a culvert and the utility water line crossing which should be examined during the detailed design phase.

Spillway and Crest

The 2013 DSR identified that the minimum crest elevation should be minimum 1.0 m above full pool to meet the freeboard requirement established by the Province[2]. In addition, the spillway has inadequate capacity to pass the IDF without overtopping the embankment. As a result, the dam must be raised and the spillway widened to safely convey the IDF and withstand wave run-up.

Spillways become more efficient (i.e. convey more flow) with greater water height. However, increased water height can only be achieved by raising the dam. The spillway height and dam raising were analyzed in

[2] Plans Submission Guidelines for the Construction and Rehabilitation of Dams. BC Dam Safety Program. URL: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/dam-safety/plan_submission_requirements_2016_v_12.pdf

combination to optimize the design. The spillway was modelled using HEC-RAS, a hydraulic model developed by the US Army Corps of Engineers. The channel downstream of the spillway will need to be widened to provide the required conveyance to mitigate spillway back-watering and protect the dam from erosion.

The wave run-up design was defined in the DSR (2013) and was deemed sufficient for this parameter. The Canadian Dam Association (CDA) guidelines allow 5% of the 2-year return period wind storm waves to overtop the reservoir at peak water levels during the IDF. The wind wave against the dam was calculated using regional wind data and the reservoir fetch. The resulting 5% wave run-up on the dam is 0.45 m above the peak IDF water level. Therefore, the dam must be raised and the spillway widened to provide a minimum of 0.45 m above the IDF water to safely convey the flood. A summary of the upgrades to Lake Baptiste dam is provided in the following table.

Table 3: Dam Spillway and Crest Raising Summary

	Required Dam Crest Raising Above Existing (m)	
Spillway Width (m)	**100% Macaulay Inflow (without Diversion Structure)***	**With Diversion Structure****
5***	2.60	1.20
10	1.50	0.60
15	1.10	0.40
20	0.85	0.25

Notes
* assumes scenario with no diversion control and 100% of Macaulay Creek entering into the reservoir.
** assumes scenario of installed diversion structure, closed valve during extreme flood occurring in the watershed.
*** approximate current width of the current spillway, marginal increase in width allows for changes in geometry and armouring.

The raising of the dam crest elevation is calculated from water height during the IDF plus wave run up and compared to the existing crest elevation. The spillway control elevation was conceptually designed using concrete lock-blocks, which come standard 0.45 m high (coincidental height).

Estimate of Probable Costs

A conceptual level costs estimate was prepared and attached. The scenarios were narrowed to:

A. Construction of the project with the option including upgrade the dam involving a spillway width of 10 m and a dam crest elevation raise of 1.5 m, no improvements to the diversion structure, would cost $582,000; and

B. Construction of the project with the option including the install a diversion structure, upgrade the dam involving a spillway width of 10 m and a dam crest elevation raise of 0.6 m would cost $523,000.

There is a dependent relationship of the spillway width and crest elevation. The conceptual cost estimates were completed with available information. A detailed topographical survey will be required to refine the costs and determine the optimal design.

Conclusions and Recommendations

Lake Baptiste was found in the 2013 DSR to have an undersized spillway and did not meet the freeboard requirements. It was proposed to improve the diversion structure on Macaulay Creek to mitigate inflow to the Baptiste Lake during extreme floods which would lower the IDF.

The following findings and recommendations are:

1. Installing a diversion structure would reduce the flood runoff catchment area to Lake Baptiste from 13.8 km² to 2.5 km².
2. The updated IDF for a 2.5 km² watershed for Lake Baptiste is 17 m³/s; this includes a 15% factor for climate change.
3. Spillway width of 10 m and corresponding dam crest raise of 0.6 m with the diversion structure appears to provide a cost effective solution. However, the optimal spillway width and crest elevation raise will be determined in conjunction with the topographic survey and detailed design.
4. More detailed information, including a topographic survey, surrounding the dam and diversion structure will be required to create detailed design of the diversion structure and channel.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

Dwayne Meredith, P.Ag.
Project Manager, Dam Safety Specialist

Reviewed by:

PROFESSIONAL ENGINEER
P. W. FEARON
Oct. 1, 2016

Peter Fearon, P.Eng.
Project Engineer

Attachments: Drawings
Cost Estimate

Statement of Limitations

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This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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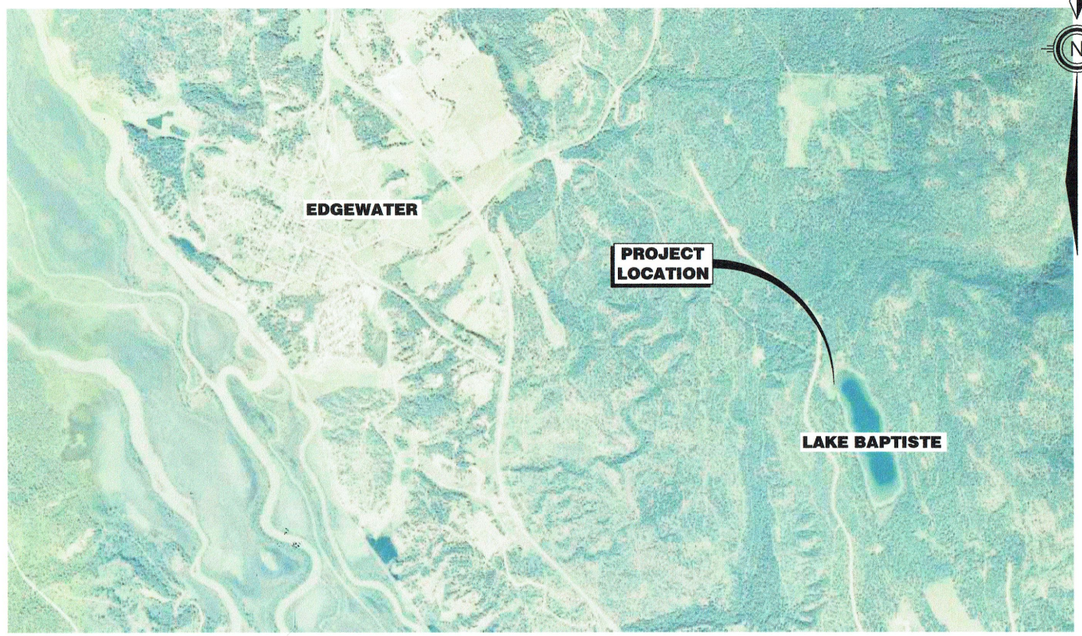
Revision History

Revision #	Date	Status	Revision Description	Author
A	August 19, 2016	Draft	For Client Review	DWM/MS
0	Sept 21, 2016	Final	Issued for Use	DWM
1	Sept 28, 2016	Final	Revision 1	DWM

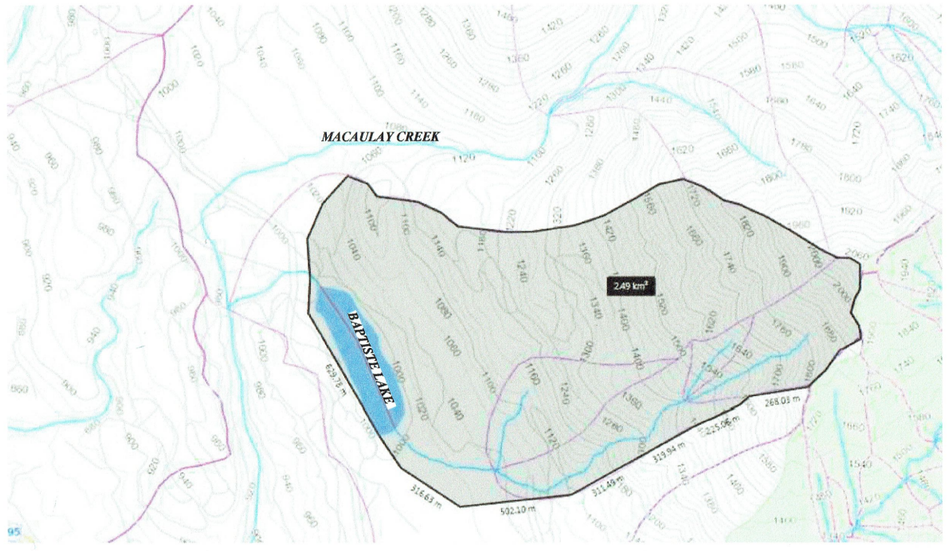
OQM | Organizational Quality Management Program



LOCATION PLAN
Scale: NTS

REGIONAL DISTRICT OF EAST KOOTENAY
LAKE BAPTISTE DAM UPGRADES
REF 0257.026

Drawing List Table	
Drawing Number	**Drawing Title**
G-001	Location Plan & Drawing List
C-101	Dyke and Spillway P&P
C-501	Typical Sections



DIRECT WATERSHED
Scale: NTS

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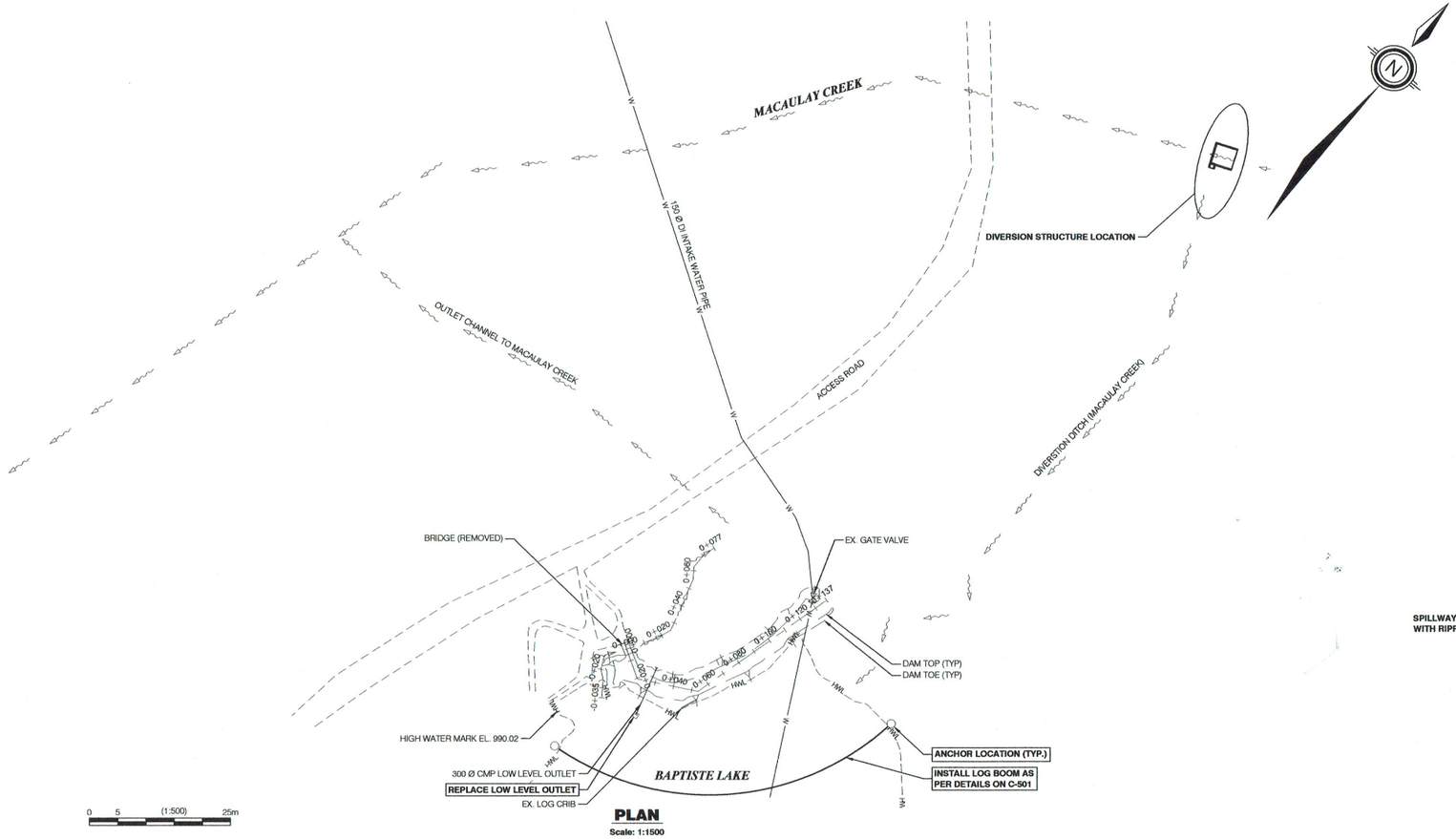
Seal: PROFESSIONAL ENGINEER · F. W. FEARON · BRITISH COLUMBIA · Oct 4, 2016

Rev	Date	Des	Dwn	Chk	Description of Revision
A	2016-08-19	PF	TMIN	PF	ISSUED FOR REVIEW
B	2016-09-22	PF	TMIN	PF	ISSUED FOR CONCEPTUAL PLANNING

REGIONAL DISTRICT OF EAST KOOTENAY
LAKE BAPTISTE DAM UPGRADES

LOCATION PLAN & DRAWING LIST

Project No. 257.026 | Drawing No. G-001 | Rev. B
Group GENERAL



PLAN
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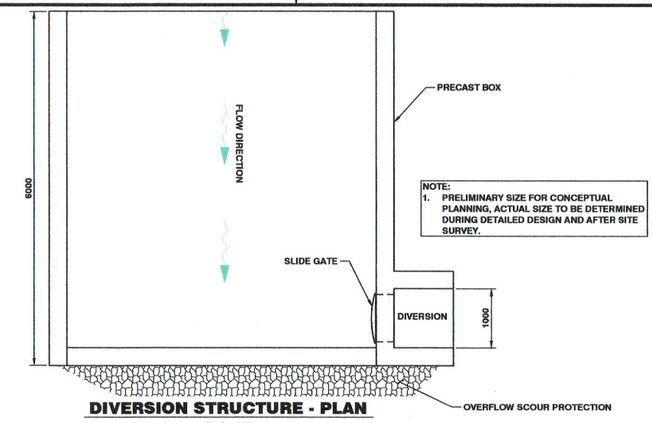

DIVERSION STRUCTURE - PLAN
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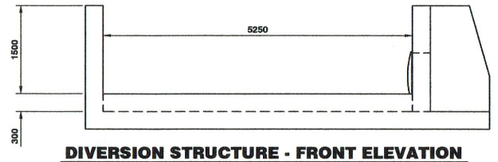

DIVERSION STRUCTURE - FRONT ELEVATION
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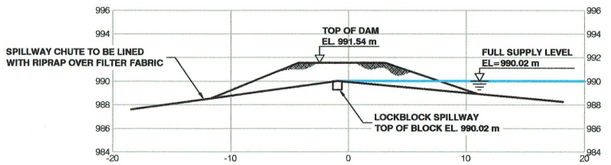

SPILLWAY - CROSS SECTION
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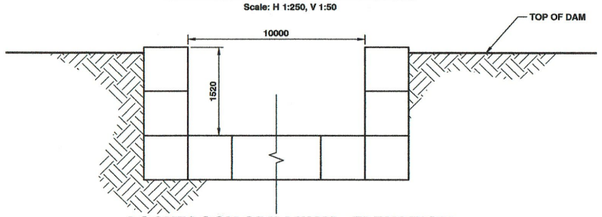

LOCKBLOCK SPILLWAY - ELEVATION
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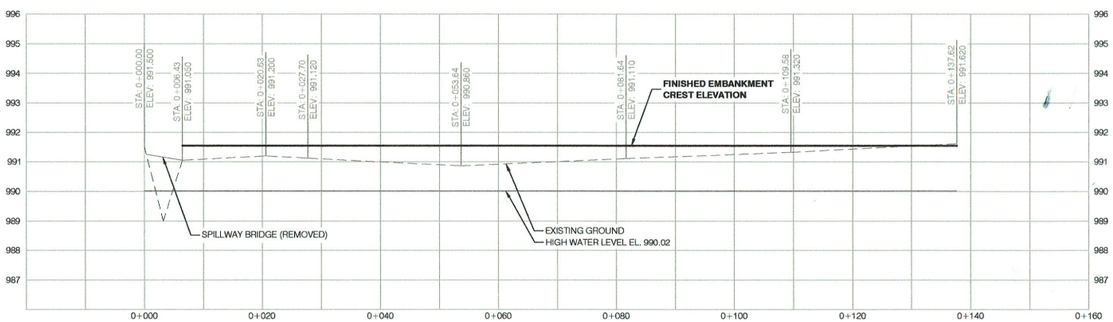

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0 1 (V 1:100) 5m

EMBANKMENT CREST PROFILE
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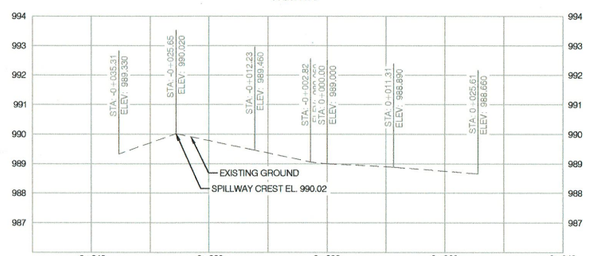

0 5 (H 1:500) 25m
0 1 (V 1:100) 5m

SPILLWAY PROFILE
Scale: H 1:500, V 1:100

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Seal: PROFESSIONAL ENGINEER — P. W. FEARON — Oct. 1, 2016

Rev	Date	Des	Dwn	Chk	Description of Revision
A	2016-08-19	PF	TMIN	PF	ISSUED FOR REVIEW
B	2016-09-22	PF	TMIN	PF	ISSUED FOR CONCEPTUAL PLANNING

REGIONAL DISTRICT OF EAST KOOTENAY
LAKE BAPTISTE DAM UPGRADES
EMBANKMENT CREST AND SPILLWAY PLAN & PROFILE

Project No. 257.026 | Drawing No. C-101 | Rev. B
Group CIVIL

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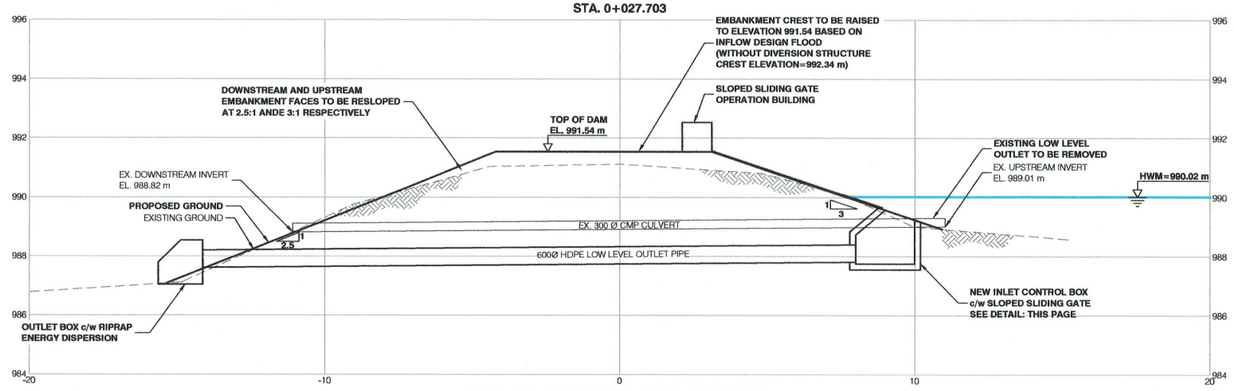

TYPICAL SECTION - EMBANKMENT

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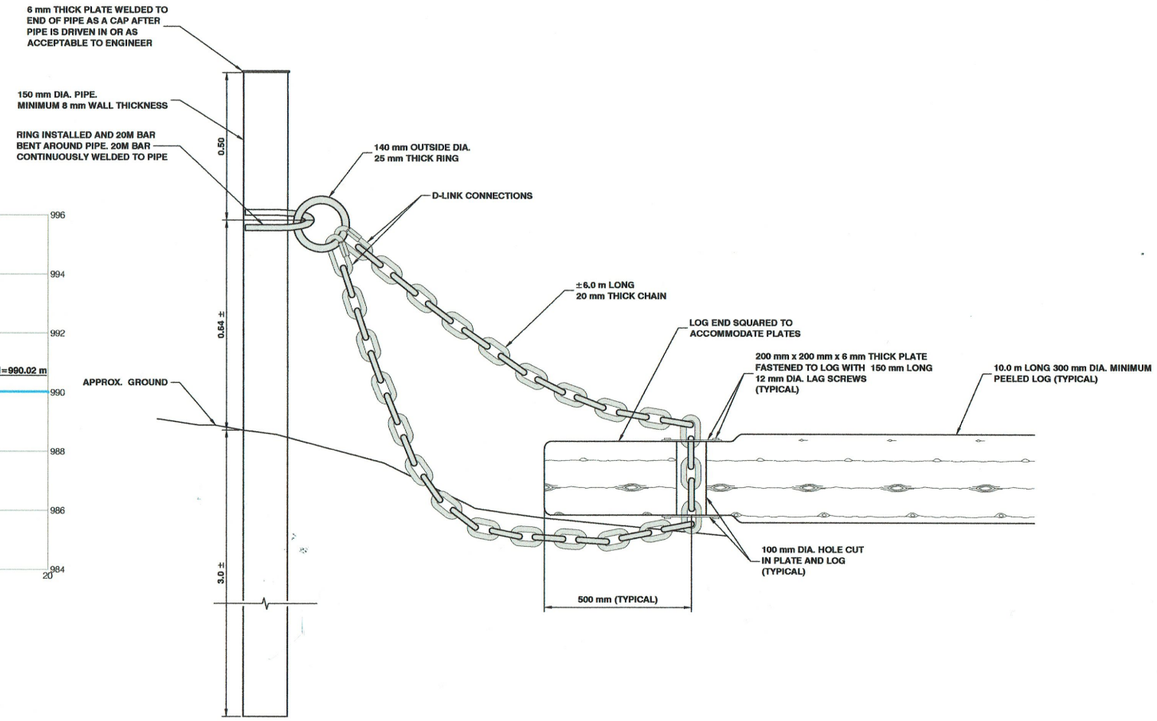

LOG BOOM ANCHOR - DETAIL

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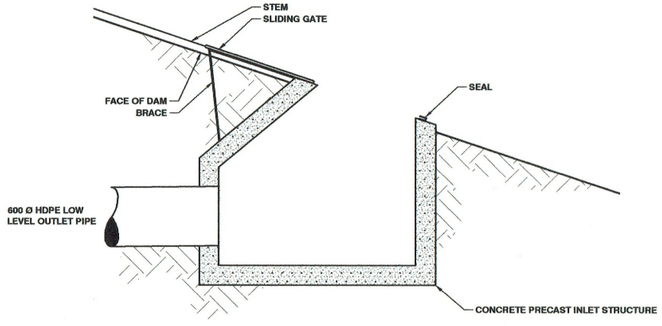

INLET STRUCTURE - DETAIL

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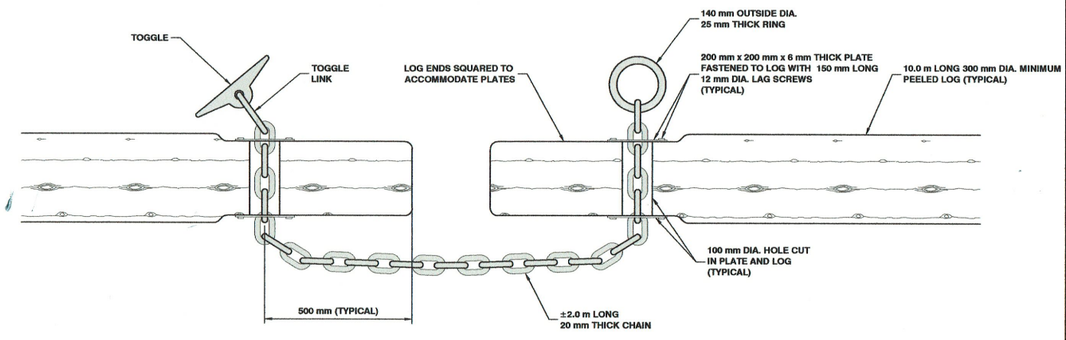

LOG BOOM CONNECTION - DETAIL

Scale: 1:10

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REGIONAL DISTRICT OF EAST KOOTENAY
LAKE BAPTISTE DAM UPGRADES

TYPICAL SECTIONS & LOG BOOM DETAILS

Project No. 257.026
Group CIVIL
Drawing No. C-501
Rev. B

Lake Baptiste Conceptual Design Cost Estimates

Sep 28, 2016

A. Upgrade existing spillway and dam, No Diversion Structure Improvements (all flow goes into lake)

Raise dam 1.5 m, spillway 10 m wide

Item	Description	Unit	Quantity	Unit Cost	Cost	Totals
1	**Mobilization and demob**					
1.1	Mobilization and demob	LS	1	5,000	5,000	
					Subtotal	**5,000**
2	**Embankment - raising**					
2.1	Source borrow	LS	1	500	500	
2.2	Clear and grub borrow area	m2	500	2	1,000	
2.3	Excavate borrow	m3	4500	5	22,500	
2.4	Place and compact borrow	m3	4500	35	157,500	
2.5	Riprap front face of dam	m3	360	50	18,000	
2.6	Finish and re-seed	m2	2175	5	10,875	
					Subtotal	**210,375**
3	**Spillway**					
3.1	Regrade spillway crest, widen to 10 m	m3	200	10	2,000	
3.2	Compact base, replace riprap	m2	100	5	500	
3.3	Install concrete lock block crest and sides	Blocks	25	200	5,000	
3.4	Riprap spillway	m3	350	50	17,500	
3.5	Downstream excavation to match	m3	400	20	8,000	
3.6	Install Log Boom	LS	1	6,000	6,000	
					Subtotal	**39,000**
4	**Low Level Outlet**					
4.1	Excavate embankment, remove LLO	m3	150	30	4,500	
4.2	Compact bed and replace LLO	LS	1	500	500	
4.3	HDPE LLO pipe	m	40	400	16,000	
4.4	Install inlet control	LS	1	5,000	5,000	
4.5	Install outlet structure	LS	1	1,000	1,000	
4.6	Replace fill over LLO	m3	150	20	3,000	
					Subtotal	**30,000**
5	**Site Cleanup**					
5.1	Regrade entire site	m2	2200	2	4,400	
					Subtotal	**4,400**
					Subtotal Construction	**288,775**
6	**Construction Control**					
6.1	Geotechnical Engineering	LS	1	1,500	1,500	
6.2	Hydrotechnical Engineering	LS	1	2,000	2,000	
6.3	Environmental Monitoring	LS	1	2,000	2,000	
6.4	Construction documents	LS	1	2,500	2,500	
6.5	Tendering	day	14	1,500	21,000	
6.6	Construction supervision	LS	1	1,500	1,500	
6.7	Final Reporting	LS	1	1,500	1,500	
					Subtotal	**32,000**
7	**Additional Items**					
7.1	Upgrade d/s culvert	LS	1	5,000	5,000	
7.2	Protect utility lines	LS	1	2,000	2,000	
7.3	Pedestrian Bridge over spillway	LS	1	70,000	70,000	
7.4	Site topographic survey	LS	1	20,000	20,000	
7.5	Final Engineering Design	LS	1	30,000	30,000	
					Subtotal	**127,000**
	Subtotal Items 1-7					**447,775.00**
	Contingency			**30%**		**134,332.50**
	TOTAL					**582,107.50**

B. Install new diversion Structure; upgrade spillway and dam. Sep 28, 2016

Raise 0.6 m, spillway 10 m wide

Item	Description	Unit	Quantity	Unit Cost	Cost	Totals
1	**Mobilization and demob**					
1.1	Mobilization and demob	LS	1	5,000	5,000	
					Subtotal	**5,000**
2	**Embankment - raising**					
2.1	Source borrow	LS	1	500	500	
2.2	Clear and grub borrow area	m2	500	2	1,000	
2.3	Excavate borrow	m3	1300	5	6,500	
2.4	Place and compact borrow	m3	1300	35	45,500	
2.5	Riprap front face of dam	m3	360	50	18,000	
2.6	Finish and re-seed	m2	2175	2	4,350	
					Subtotal	**75,850**
3	**Spillway**					
3.1	Regrade spillway crest, widen to 10 m	m3	200	10	2,000	
3.2	Compact base, replace riprap	m2	100	5	500	
3.3	Install concret lock block crest and sides	Blocks	25	200	5,000	
3.4	Riprap spillway	m3	350	50	17,500	
3.5	Downstream excavation to match	m3	400	20	8,000	
3.6	Install Log Boom	LS	1	6,000	6,000	
					Subtotal	**39,000**
4	**Low Level Outlet**					
4.1	Excavate embankment, remove LLO	m3	150	30	4,500	
4.2	Compact bed and replace LLO	LS	1	500	500	
4.3	HDPE LLO pipe	m	40	400	16,000	
4.4	Install inlet control	LS	1	5,000	5,000	
4.5	Install outlet structure	LS	1	1,000	1,000	
4.6	Replace fill over LLO	m3	150	20	3,000	
					Subtotal	**30,000**
5	**Diversion Structure**					
5.1	Access road	m	200	50	10,000	
5.2	Clear site	m2	600	2	1,200	
5.3	Stockpile organics	m3	200	2	400	
5.4	Install structure - Precast Concrete	LS	1	57,700	57,700	
5.5	Slide gate	LS	1	5,000	5,000	
5.6	Channel cleanout	m	40	20	800	
5.7	Diversion channel cleanout	m	40	20	800	
					Subtotal	**75,900**
6	**Site Cleanup**					
6.1	Regrade entire site	m2	2200	2	4,400	
					Subtotal	**4,400**
					Subtotal Construction	**230,150**
7	**Construction Control**					
7.1	Geotechnical Engineering	LS	1	1,500	1,500	
7.2	Hydrotechnical Engineering	LS	1	2,500	2,500	
7.3	Environmental Monitoring	LS	1	2,000	2,000	
7.4	Construction documents	LS	1	2,000	2,000	
7.5	Tendering	LS	1	2,500	2,500	
7.6	Construction supervision	day	20	1,500	30,000	
7.7	Final Reporting	LS	1	1,500	1,500	
					Subtotal	**42,000**
8	**Ancillary Costs**					
8.1	Upgrade d/s culvert	LS	1	5,000	5000	
8.2	Protect utility lines	LS	1	2,000	2000	
8.3	Pedestrian Bridge over spillway	LS	1	70,000	70000	
8.4	Site topographic survey	LS	1	20,000	20000	
8.5	Final Engineering Design	LS	1	30,000	30000	
8.6	Agreements for Private Land	LS	2	1,500	3000	
					Subtotal	**130,000**
	Subtotal Items 1-8					**402,150**
	Contingency			**30%**		**120,645**
	TOTAL					**522,795**