Regional District of Okanagan-Similkameen

ISSUED FOR USE

HYDROTECHNICAL ASSESSMENT OF THE NARAMATA DAMS

K13101459.002

December 20, 2010

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1.0 INTRODUCTION

1.1 GENERAL

EBA, A Tetra Tech Company (EBA) was engaged by the Regional District of Okanagan-Similkameen (RDOS) to undertake dam safety reviews of its four Naramata area dams, namely;

- Big Meadow Lake Dam
- Elinor Lake North (Saddle) Dam
- Elinor (Eleanor) Lake South Dam
- Naramata Lake Dam

The four dams form three interconnected reservoirs that have provided a historical upland source of potable water to the Township of Naramata. The dams were originally constructed during the first half of the twentieth century by the Naramata Irrigation District (NID), which has been subsequently incorporated into the RDOS. With the recent commissioning of a new water treatment facility in the township that draws water from Lake Okanagan, the dams are no longer required for the supply of potable water and the RDOS is considering maintaining these facilities for irrigation purposes only.

This report addresses the hydrotechnical issues pertaining to the dams. These issues include a regional flood frequency assessment to determine the appropriate Inflow Design Flood (IDF), a hydraulic analysis to assess the capacities of the dams to pass the IDF and some additional comments on the downstream effect of decommissioned dams on the Robinson Creek watershed. The technical dam safety findings for each individual dam are presented in the dam safety review companion reports.

The Dam Safety Review was undertaken in accordance with the requirements of the British Columbia Water Act (1998), the British Columbia Ministry of Environment (BC MoE) Dam Safety Review Guidelines (May 2010), the Canadian Dam Association (CDA) Dam Safety Guidelines (2007), the Interim Consequence Classification Policy For Dams in British Columbia (February 2010) and the BC Dam Safety Regulations (February 2000). Note that the BC Dam Safety Regulations take precedence over the CDA Guidelines.

1.2 SITE DESCRIPTIONS

Big Meadow Lake Dam is situated within a bowl shaped feature near the headwaters of the Chute Creek catchment, approximately 13 km to the northeast of the Naramata Township. The Big Meadow Dam has a spillway crest elevation of approximately 1612.09 m (based on field measurements), a crest length of 5.8 m (based on design drawings) and a maximum dam crest elevation of 1613.92 m (based on the storage capacity table provided). A plan of the Big Meadow Lake is shown on Figures 2 & 3. Note that spillway crest length is measured parallel to the dam crest and at right angles to the flow direction, as is the convention in hydraulics.

Downstream of the Big Meadow Lake Dam is a diversion structure that diverts flow from Chute Creek into the downstream Elinor Lake reservoir. This structure can pass flow in two directions. One side of the diversion structure contains two slide gates of 762 mm (high) by 914 mm (wide) and a spillway set at a height of 2.36 m above the creek bed, which direct flows towards the Elinor Lake diversion channel. At right angles to these gates are two spillways and a slide gate of 610 mm by 610 mm, which allow flow to continue in Chute Creek. Figure 9 illustrates the details of the diversion structure. For the purpose of this study the 610 mm by 610 mm gate for the Chute Creek diversion was assumed to be closed to obtain a more conservative (higher) flood flow in the Elinor Lake Channel.

Elinor Lake North (Saddle) and South Dams are situated downstream of the diversion. There is limited information available with respect to the design of the north dam. The hydrotechnical assessment was based on the assumption that the dam does not overtop under design flood conditions and overflows are discharged at the Elinor Lake South Dam. The Elinor Lake South Dam has a spillway crest elevation of approximately 1276.41 m (based on the storage capacity table), crest length of 3.0 m (based on field notes) and a maximum dam crest elevation of 1278 m (based on scaling off drawings). A plan of the Elinor Lake Reservoir and section of the south dam embankment at its maximum height is shown on Figures 4 & 5.

Naramata Lake Dam, being the most downstream dam, is situated at the confluence of two valleys. The dam has a spillway crest elevation of 1271.50 m, crest length of 4.6 m, and a maximum dam crest elevation of 1273.15 m. Details of the Naramata Lake Dam are shown on Figures 6, 7 and 8.

A location plan showing the locations of the dams relative to the township is attached as Figure 1.

2.0 HYDROTECHNICAL ASSESSMENT

2.1 INFLOW DESIGN FLOOD

All the dams are classified as being in the High (Low) consequence category according to the BC Dam Safety Regulation, under the Water Act of BC (2000). The BC Dam Safety Regulation defines four dam consequence classifications, but splits them into five for the purpose of comparison with the Canadian Dam Association (CDA) guidelines of 2007. These guidelines describe five consequence classifications and that corresponding to the BC High (Low) category is High. The previous version of the CDA guidelines (1999) describes only four consequence classifications and according to the Interim Consequence Classification Policy for Dams in British Columbia of February 2010 of the BC Ministry of Environment, for the purpose of Dam Safety Reviews of dams constructed before 2008, dams should be classified under both the BC Dam Safety Regulation and the 1999 CDA Guidelines. The latter suggest that the Inflow Design Flood (IDF) for a High consequence dam should have a peak discharge between the 1000-year and the Probable Maximum

Flood (PMF) event. For the purpose of this review, the IDF was estimated as 1/3 of the way between the 1000-year flood and the Probable Maximum Flood (PMF) as suggested in the 2007 CDA Guidelines for a High consequence classification, as owners are encouraged to work towards this standard.

The PMF was evaluated based on the following equation for the Okanagan region (Abrahamson, 2010):

$$Q = 2.1086A^{0.9240}$$

Where Q is the probable maximum flood in m^3/s;

A is the area of the watershed in km^2 ($A<8,320\ km^2$);

To estimate the 1000-year flood, a regional flood frequency analysis was completed. The following Water Survey of Canada gauging stations were chosen for use in the regional analysis on the basis of proximity, length of record and drainage area.

TABLE 13: REGIONAL ANALYSIS GAUGING STATIONS

Name	STA ID	Period of Record	Years of Record	Area (km^2)	Comments
Two Forty Creek near Penticton	08NM240	1983-2010	28	5	Active
Dennis Creek near 1780 m Contour	08NM242	1985-2010	26	3.73	Active
Penticton Creek above Dennis Creek	08NM168	1970-1999	30	35.5	Discontinued
Bellevue Creek near Okanagan Mission	08NM035	1920-1986	67	73.3	Discontinued

Frequency analyses were conducted on the maximum instantaneous flows at these hydrometric stations using Environment Canada's Consolidated Frequency Analysis (CFA) software. The results are summarized in Table 14. Peak flows were plotted as a function of drainage area (Figure 10), in order to establish the return period flows for the total cumulative drainage area (24.94 km^2) at Naramata Lake Dam, the most downstream of the three reservoirs. Regression equations were determined for each return period and flows for the drainage area being investigated were calculated and plotted (Figure 11) to determine the extrapolated 1000-year flood for the total cumulative drainage area. Table 15 summarizes the peak flows, PMF and estimated IDF used in this study.

TABLE 14: REGIONAL ANALYSIS MAXIMUM INSTANTANEOUS FLOWS

T (years)	Flows (m^3/s)			
	08NM242 3.73 km^2	08NM240 5.00 km^2	08NM168 35.50 km^2	08NM035 73.30 km^2
2	1.02	1.07	1.34	6.80
5	1.26	1.45	2.18	10.04
10	1.43	1.72	2.77	12.70

TABLE 14: REGIONAL ANALYSIS MAXIMUM INSTANTANEOUS FLOWS				
T (years)	Flows (m^3/s)			
	08NM242 3.73 km^2	08NM240 5.00 km^2	08NM168 35.50 km^2	08NM035 73.30 km^2
20	1.59	1.98	3.36	15.60
50	1.82	2.34	4.14	20.08
100	2.00	2.61	4.74	23.95
200	2.19	2.89	5.36	28.33
500	2.47	3.28	6.21	35.13

TABLE 15: EXTREME FLOWS AT NARAMATA LAKE DAM	
Return Period (years)	Peak Flow (m^3/s)
2	1.6
5	2.2
10	2.7
20	3.1
50	3.7
100	4.3
200	4.8
500	5.5
1000	5.9
PMF	41.2
IDF	17.7

The IDF for Naramata Lake Dam was estimated to be 17.7 m^3/s. Corresponding peak flows for the drainage areas contributing to Big Meadow Lake and Elinor Lake South Dams were determined from this flow on the basis of drainage area ratios. The diversion structure upstream of Elinor Lake was also included in this analysis, where runoff from the upstream area (11.66 km^2) and outflow from the upstream Big Meadow Lake Dam can be divided between Chute Creek and Elinor Lake. Figure 12 illustrates the sub-catchments investigated and the corresponding IDFs for each sub-catchment are as follows:

TABLE 16: ESTIMATED IDF FOR SUBCATCHMENTS UPSTREAM OF NARAMATA LAKE DAM				
Structure	Local Area (km^2)	Cumulative Area (km^2)	Local IDF (m^3/s)	Cumulative IDF (m^3/s)
Big Meadow Lake Dam	7.80	7.80	5.5	5.5
Diversion Structure	11.66	19.46	8.3	13.8
Elinor Lake North Dam	0.23	19.69	0.16	14.0
Elinor Lake South Dam	0.88	20.56	0.62	14.6
Naramata Lake Dam	4.38	24.94	3.1	17.7

2.2 ADEQUACY OF SPILLWAYS

Flood routing was done using the US Army Corps of Engineers program HEC-HMS, which includes a routing component for flows through reservoirs. The simulation addressed the routing of the IDF through each reservoir and its spillway, assuming that all other outlets were closed. The spillways were assumed to act as broad-crested weirs. This is a good assumption for Big Meadow Lake Dam and a reasonable one for Naramata Lake Dam, both of which have a concrete spillway structure that forms a hydraulic control. In the case of Elinor Lake South Dam, there is a small concrete structure that has held stoplogs in the past, situated on the dam axis but in a channel in the left abutment. The channel entrance or the channel itself may control the flow in this situation, however the broad-crested weir assumption is considered conservative. The discharge calculations for the spillways were based on the following broad-crested weir equation (Smith, 1985):

$$Q = CLH^{1.5}$$

Where:

Q is discharge in m^3/s;

C is the discharge coefficient, assumed to be 1.65;

L is effective crest length in m; and

H is the head above the spillway crest in m.

Using the elevation versus storage capacity tables provided in Appendix A and the discharge equation above, rating curves (elevation vs. discharge) were determined for each spillway. The spillway crests for all three dams modelled were taken as the spillway sills with no stoplogs in place. For the flood routing analysis, the initial water surface elevation in each reservoir was set at the spillway crest elevation and time-series flow data were input to each reservoir to represent the upstream runoff. For Elinor Lake (South) and Naramata Lake Dams, the model routed the local drainage and the reservoir outflow from the previous dam upstream. The event of May 25, 1985 at the Water Survey of Canada station 08NM035 (Bellevue Creek near Okanagan Mission) was used to represent the distribution of flow in a typical runoff hydrograph due to snowmelt, which generates the annual peak flows locally. The flows for each sub-catchment were scaled to match the peak flows determined in the regional analysis. The simulation and results for passing the IDF through each reservoir are included in Table 17.

TABLE 17: FLOOD ROUTING RESULTS

Reservoir	Spillway Crest Elev. (m)	Spillway Crest Length (m)	Dam Crest Elev. (m)	Peak Inflow (m^3/s)	Peak Water Elev. (m)	Freeboard Elev. (m)	Peak Storage Volume (m^3)	Peak Outflow (m^3/s)
Big Meadow Lake	1612.09	5.8	1613.92	5.53	1612.7	1.22	481,600	4.86
Elinor Lake	1276.41	3.0	1278.00	6.90	1277.6	0.40	383,700	6.90
Naramata Lake	1271.50	4.6	1273.15	10.00	1272.7	0.45	917,000	9.61

The analysis of routing flows through all the dams indicates that the existing spillways for Big Meadow Lake, Elinor Lake South and Naramata Lake Dams are all able to pass the routed IDF. The freeboard (the vertical distance between the maximum water level and the dam crest) calculated for Big Meadow Lake Dam is greater than the minimum BC Dam Safety Guidelines requirement of 1.0 m, however, the freeboards for Elinor Lake South Dam and Naramata Lake Dam were both found to be less than 1.0 m.

This analysis is based on the assumption that the diversion from Chute Creek to Elinor Lake is operational during the design flood event. The flows reaching Elinor Lake Dam and Naramata Lake Dam are limited in the flood routing modelling by the capacity of the two gates in the diversion structure. The diversion structure allows continuous flows to Chute Creek at all times. Flood flows at Elinor Lake South Dam and Naramata Lake Dam could be reduced by 90% and 65% respectively if the diversion to the Elinor Lake Channel was closed and all upstream flows were fully diverted to Chute Creek during the design flood event. The simulation with the diversion gates closed is included in Table 18.

TABLE 18: FLOOD ROUTING RESULTS FOR SCENARIO WITH CLOSED DIVERSION GATES

Reservoir	Spillway Crest Elev. (m)	Spillway Crest Length (m)	Dam Crest Elev. (m)	Peak Inflow (m^3/s)	Peak Water Elev. (m)	Freeboard Elev. (m)	Peak Storage Volume (m^3)	Peak Outflow (m^3/s)
Big Meadow Lake	1612.09	5.8	1613.92	5.53	1612.7	1.22	481,600	4.86
Elinor Lake	1276.41	3.0	1278.00	0.78	1276.7	1.30	293,500	0.68
Naramata Lake	1271.50	4.6	1273.15	3.78	1272.1	1.05	828,300	3.37

The analysis of the routing flows through all the dams with the diversion gates closed concluded that all the dams are able to pass the routed IDF with the minimum required freeboard of 1.0 m.

2.3 EFFECTIVENESS OF THE DAMS IN REDUCING PEAK FLOWS DOWNSTREAM

As discussed above, the IDF at Naramata Lake Dam is estimated to be 17.7 m^3/s without considering any regulating effects of the dams and assuming that the total drainage area upstream of the diversion structure is directed to Naramata Lake Dam. With the regulating effects of the dams and some diversion to Chute Creek, the peak outflows at Naramata Lake Dam and Chute Creek are estimated to be 9.61 m^3/s and 6.82 m^3/s respectively.

For the scenario where all three dams are decommissioned and the diversion gates continue to divert a portion of the flow to Elinor Lake, the peak outflow at Naramata Lake Dam is estimated to be 10.25 m^3/s. This is a relatively small increase (6%) reflecting the relatively small volume of storage available in the reservoirs compared to the volume of an IDF runoff event. The peak flow diverted into Chute Creek for the scenario where Big Meadow Lake Dam is decommissioned was found to increase by 8% to 7.42 m^3/s. If the point of interest is transferred downstream, where there are residences near the mouth of Robinson Creek, this effect is reduced further as the difference would be a smaller percentage of the estimated flood at a point downstream. The IDF at the mouth of Robinson Creek, where the local drainage area is about 16.72 km^2 is estimated to be 22.9 m^3/s and a reduction of 0.65 m^3/s as a result of attenuation in the upstream storage represents only about 3% of the flood flow at the mouth. It is concluded therefore that were the dams to be breached or otherwise decommissioned, the increase in peak flows near the mouth would be small. The impact could be reduced further or eliminated by decommissioning the Chute Creek diversion and removing the catchment area upstream of the diversion from Robinson Creek. A flood analysis should be undertaken for Chute Creek to address the impact of the increased peak flow, if the diversion were decommissioned.

3.0 CONCLUSIONS

- A hydrotechnical assessment has been conducted as part of the Dam Safety Review for the Big Meadow Lake Dam, Elinor Lake North (Saddle) Dam, Elinor Lake South Dam and Naramata Lake Dam. The study involved a regional frequency analysis to determine the Inflow Design Flood (IDF), a flood routing and hydraulic analysis to assess the capacity of the spillways to pass the IDF and an analysis of the effect of decommissioning the dams on peak flows.
- It is understood that all four dams are classified in the High (Low) consequence category according to the BC Dam Safety Regulation, under the Water Act of BC (2000). In accordance with the 2007 CDA Guidelines, the IDF for the dams was chosen to be 1/3 between the 1000-year flood and the Probable Maximum Flood (PMF).
- In this analysis, the spillways for the Big Meadow Lake Dam, Elinor Lake South Dam and Naramata Lake Dam were modelled with no stoplogs in place.

- Flood routing was performed to assess the capacity of the dams to pass the IDF. The flood routing observations are presented as follows:

  Big Meadow Lake Dam

  – Analysis indicates that the existing dam is able to pass the IDF with an available freeboard of 1.22 m, which is greater than the minimum requirement of 1.0 m.

  Elinor Lake North (Saddle) Dam

  – No design information was available for the Elinor North Dam. The HEC-HMS modelling was based on the assumption that the dam does not overtop under design flood conditions. Overflows are discharged at the Elinor Lake South Dam.

  Elinor Lake South Dam

  – Analysis indicates that the existing dam is able to pass the IDF with an available freeboard of 0.40 m, which is lower than the minimum requirement of 1.0 m. However, there are uncertainties with regard to the dam crest elevation.

  – If the diversion upstream of Elinor Lake is closed, the available freeboard is estimated to be 1.30 m.

  Naramata Lake Dam

  – Analysis indicates that the existing dam is able to pass the IDF with an available freeboard of 0.45 m, which is lower than the minimum requirement of 1.0 m.

  – If the diversion upstream of Elinor Lake is closed, the available freeboard is estimated to be 1.05 m, which is greater than the minimum requirement.

- The analysis of decommissioning the dams indicates that the increase in peak flow at the mouth of Robinson Creek would be small. The peak outflow at Naramata Dam increased by 6% which reflects the relatively small volume of storage available in the reservoirs compared to the volume of the IDF runoff event.

4.0 RECOMMENDATIONS

The priority (high, medium and low) for each item is given in brackets after each recommendation.

- If the water levels in the Elinor Lake and Naramata Lake reservoirs reach the spillway crest elevation, the upstream diversion gates should be closed to direct all flow into Chute Creek (High).
- If stoplogs are to be utilized, the design flood calculations should be revised. It is recommended that stoplogs are not in place during the spring freshet (High).
- RDOS should commission a study of the diversion structure to determine whether it can be modified and/or the gates automated to divert flows down Chute Creek in the event of a significant flood (Medium).

- The crest elevation of the Elinor Lake South Dam in the flood routing analysis was based on scaling off the drawings and the crest elevation of the Elinor Lake North Dam is unknown. RDOS should commission a topographical survey to confirm the crest elevation of both dams to ensure sufficient freeboard to pass the IDF (Medium).

5.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of the Regional District of Okanagan-Similkameen and their agents. EBA does not accept any responsibility for the accuracy of any of the data, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than the Regional District of Okanagan-Similkameen, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the Terms and Conditions stated in EBA's Services Agreement and in the General Conditions provided in Appendix B of this report.

6.0 CLOSURE

EBA trust this report meets your present requirement. Do not hesitate to contact either of the undersigned should there be any questions or comments.

EBA Engineering Consultants Ltd.

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REFERENCES

Abrahamson, B.T., 2010. Probable Maximum Flood Estimator for British Columbia.

British Columbia Ministry of Environment, 1998. Dam Safety Guidelines – Inspection and Maintenance of Dams.

British Columbia Ministry of Environment, 2010. Dam Safety Review Guidelines. – Version 2.

British Columbia Ministry of Environment, 2008. Draft document - Interim Consequence Classification Policy for Dams in British Columbia.

Canadian Dam Association, 1997. Dam Safety Guidelines.

Canadian Dam Association, 2002. Dam Safety Review Workshop, 2002 CDA Conference, Victoria, British Columbia.

Canadian Dam Association, 2004. Public Safety Around Dams Workshop, 2004 CDA Conference, Ottawa, Ontario.

Canadian Dam Association, 2007. Dam Safety Guidelines.

Canadian Dam Association, 2007. Technical Bulletin – Dam Safety Analysis and Assessment.

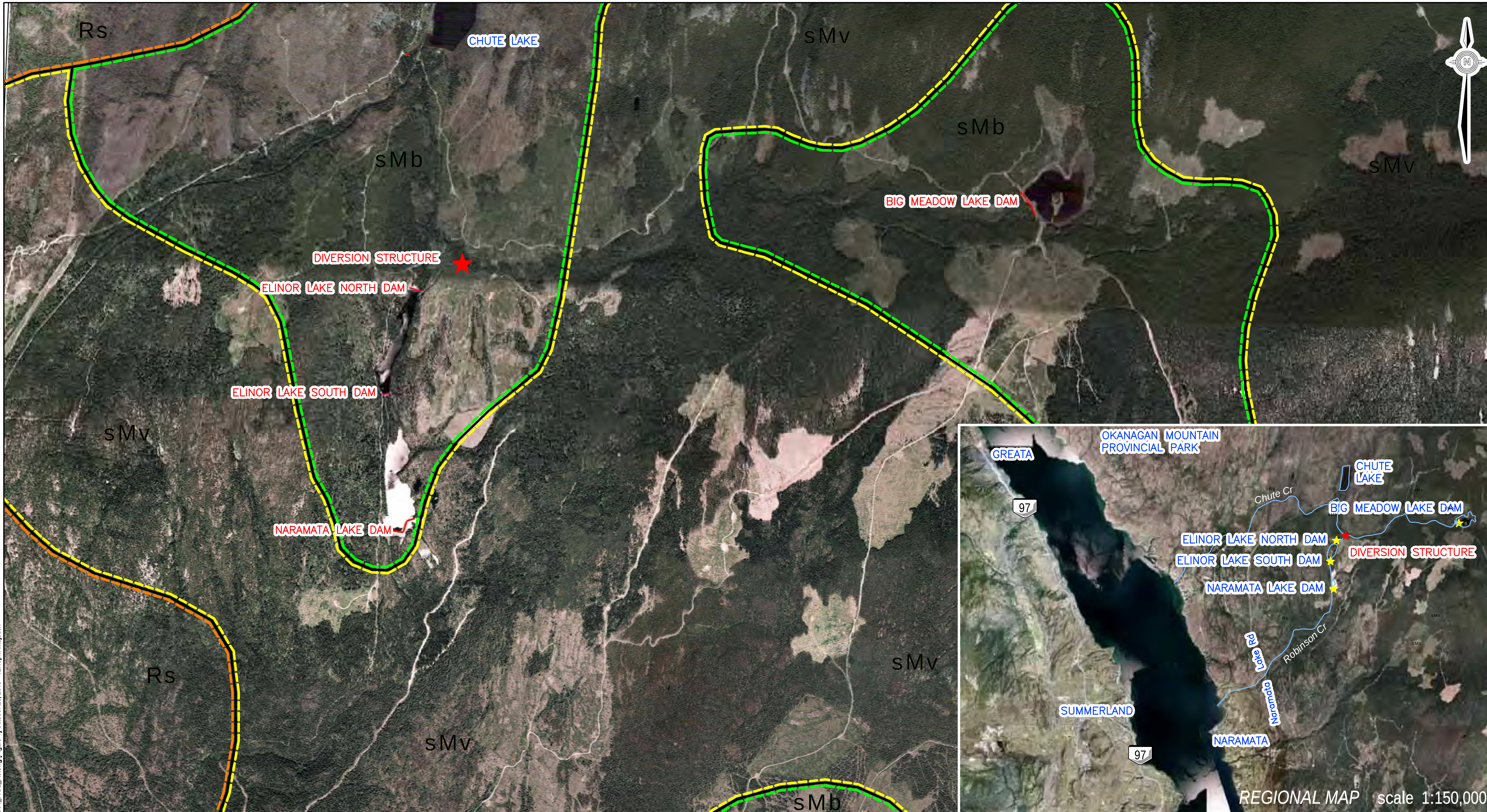
Canadian Dam Association, 2007. Technical Bulletin – Hydrotechnical Considerations for Dam Safety.

Canadian Dam Association, 2007. Technical Bulletin – Inundation, Consequences and Classification for Dam Safety.

Queen's Printer, 2003. Water Act – British Columbia Dam Safety Regulation, BC Reg. 44/2000.

Smith, C.D., 1985. Hydraulic Structures

FIGURES



NOTES

Image from Google Earth Pro
Imagery Dates March 4, 2004 - September 26, 2005
Surficial Geology from GEOLOGICAL SURVEY OF CANADA (1984)
Surficial Geology (1984)
Map Kootenay Lake

SCALE 1:30,000

200 0 200 600m 1.2km

SURFICIAL GEOLOGY

Rs , ROCK: Crystalline metamorphic, acidic igneous, quartzite, argillite, marble, greenstone, phyllite, greywacke, limestone, dolomite and sandstone. Areas mapped as rock consist dominantly of rock at the surface but include minor areas of rock covered by a veneer of colluvium and till. Rs: Rock characterized by steep slopes or exposed by modern stream.

sMb ,sMv, SANDY TILL: Olive grey, grey and pale grey, weakly calcareous to non-calcareous loamy sand, sandy loam and loam. Generally gravelly, cobbly or bouldery. Mainly massive but locally contains lenses of stratified sediments. Clast lithologies reflect local bedrock which is chiefly crystalline metamorphic and granitic in character. Locally includes unmapped areas of alluvial, glaciofluvial and glaciolacustrine deposits and areas of rock. Locally in valley bottoms till may be as thick as 30 m but generally it is no more than 5 m thick. Occurs as a blanket with surface relief due to the general shape of the underlying surface or deposit; sMb: thickness up to 5 m; sMv: thin and discontinuous with thickness up to 2 m.

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NARAMATA DAMS SAFETY REVIEW

LOCATION PLAN & SURFICIAL GEOLOGY

PROJECT NO.	DWN	CKD	REV
K13101459.001	LM	MJL	0
OFFICE	DATE		
EBA-KELOWNA	October 22, 2010		

Figure 1

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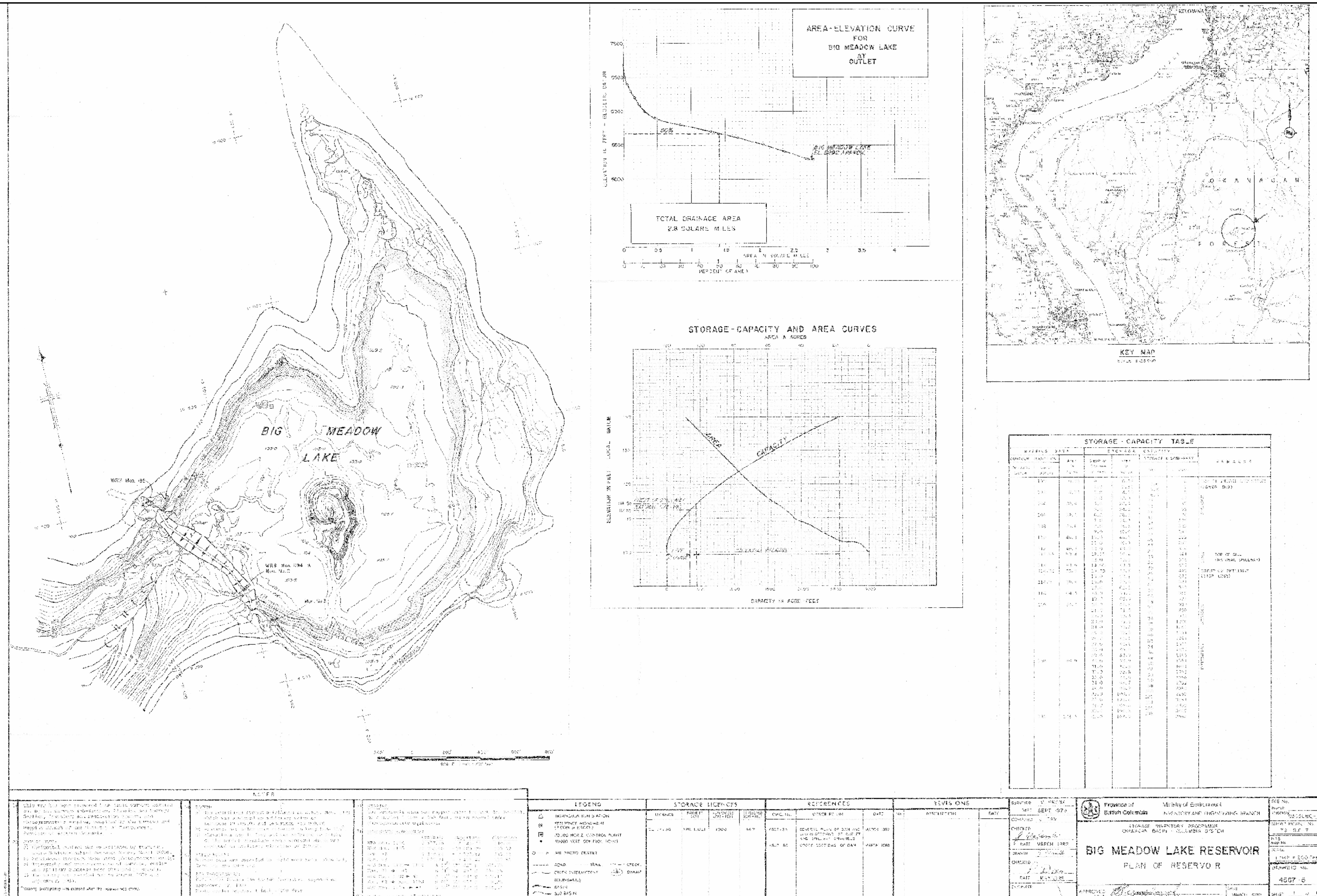

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NARAMATA DAMS SAFETY REVIEW

BIG MEADOW LAKE DAM
PLAN OF RESERVOIR

PROJECT NO.	DWN	CKD	REV	
K13101459.001	LM	MJL	0	Figure 2
OFFICE	DATE			
EBA-KELOWNA	October 18, 2010			

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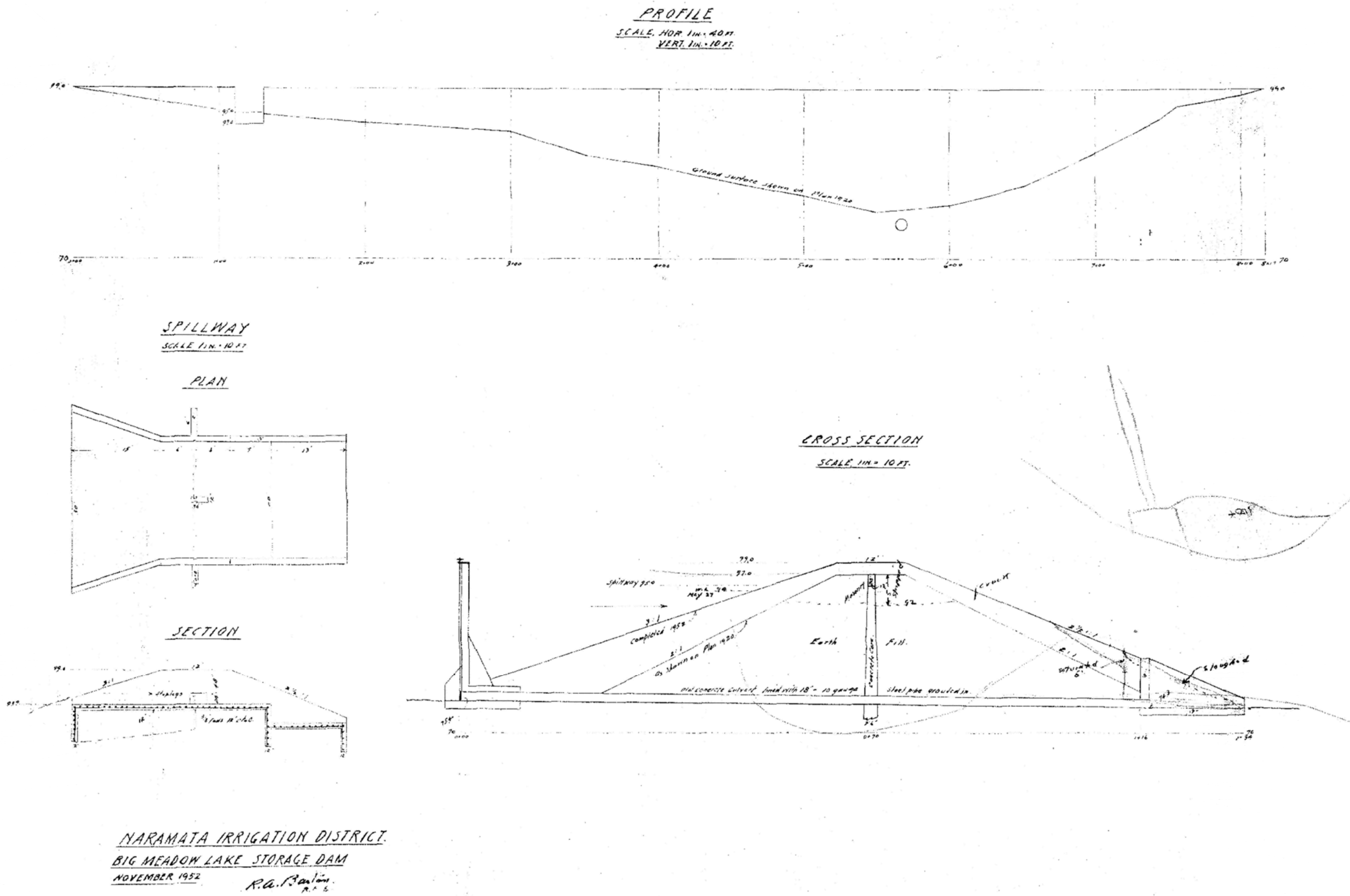

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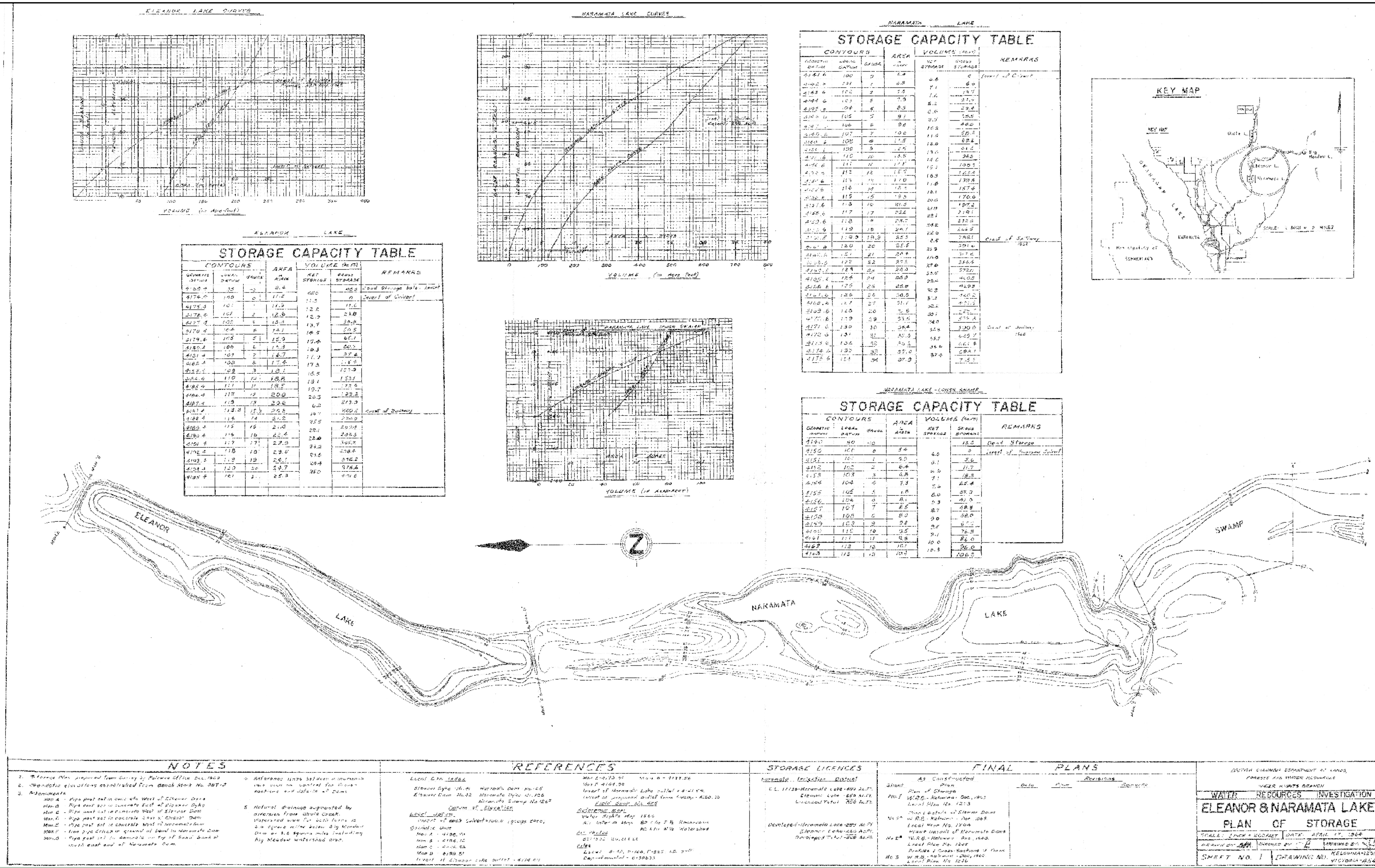
NARAMATA DAMS SAFETY REVIEW

BIG MEADOW LAKE DAM
PROFILE, EMBANKMENT SECTION & SPILLWAY DETAILS

PROJECT NO.	DWN	CKD	REV	
K13101459.001	LM	MJL	0	Figure 3
OFFICE	DATE			
EBA-KELOWNA	October 18, 2010			



NOTES

Narmata Lake Dam raised in 1967

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NARAMATA DAMS SAFETY REVIEW

ELINOR & NARAMATA LAKE DAMS
PLAN OF RESERVOIRS

PROJECT NO.	DWN	CKD	REV
K13101459.001	LM	MJL	0

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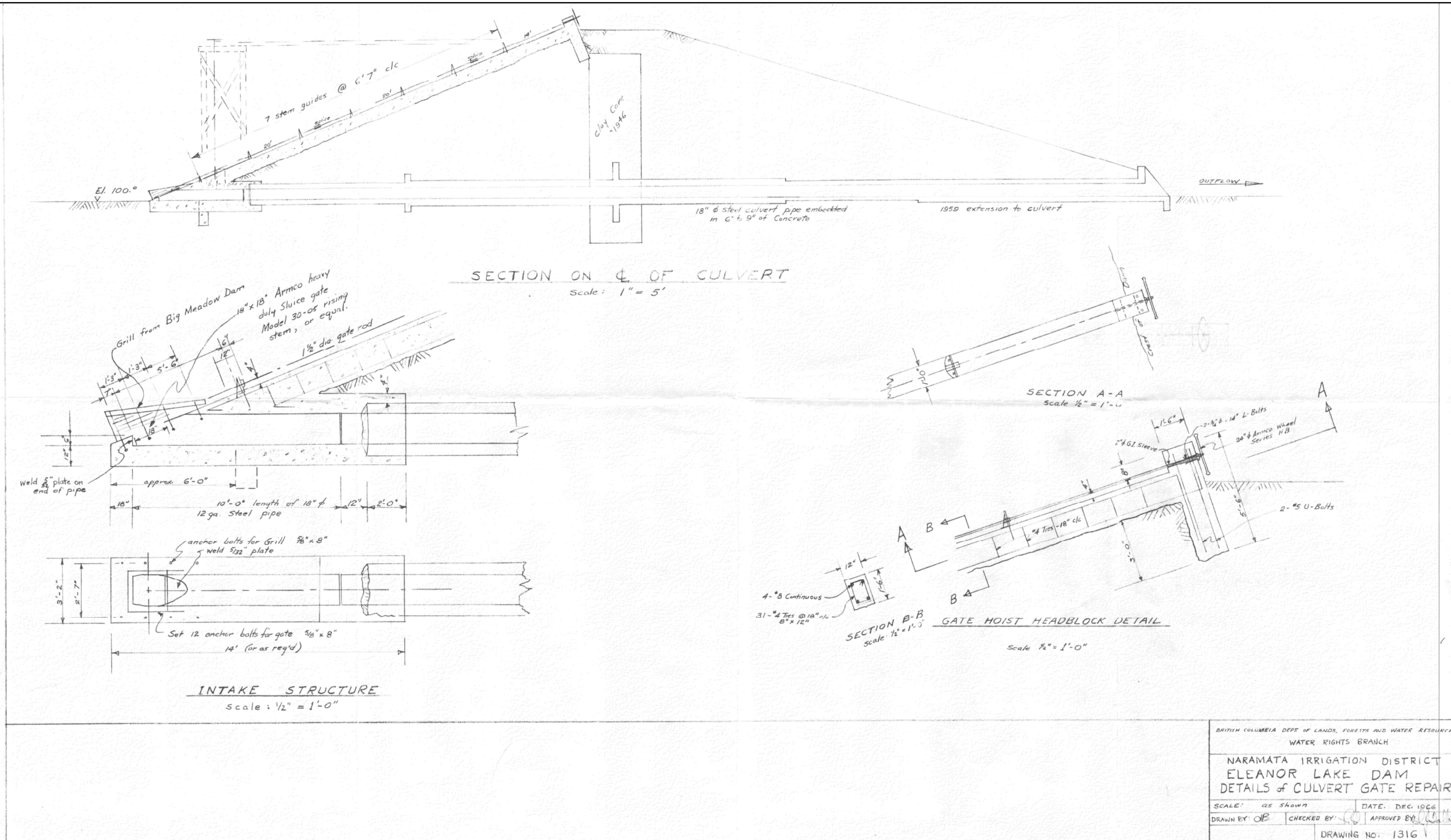
Figure 4



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NARAMATA DAMS SAFETY REVIEW

ELINOR LAKE SOUTH DAM
EMBANKMENT SECTION, DETAILS OF
CULVERT GATE REPAIRS

PROJECT NO.	DWN	CKD	REV	
K13101459.001	LM	MJL	0	Figure 5
OFFICE	DATE			
EBA-KELOWNA	October 18, 2010			

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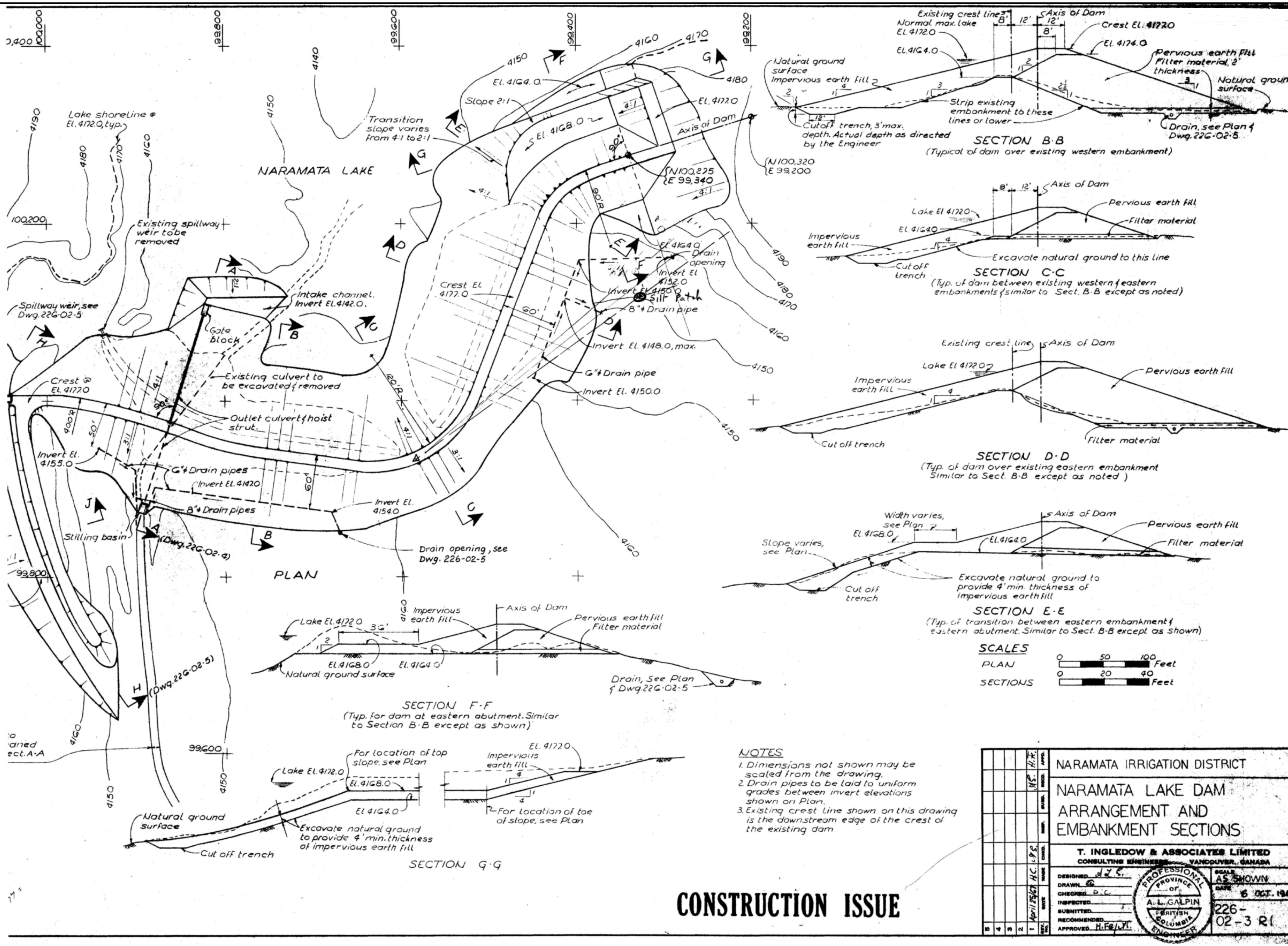

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NARAMATA DAMS SAFETY REVIEW

NARAMATA LAKE DAM
ARRANGEMENT AND EMBANKMENT SECTIONS

PROJECT NO.	DWN	CKD	REV	
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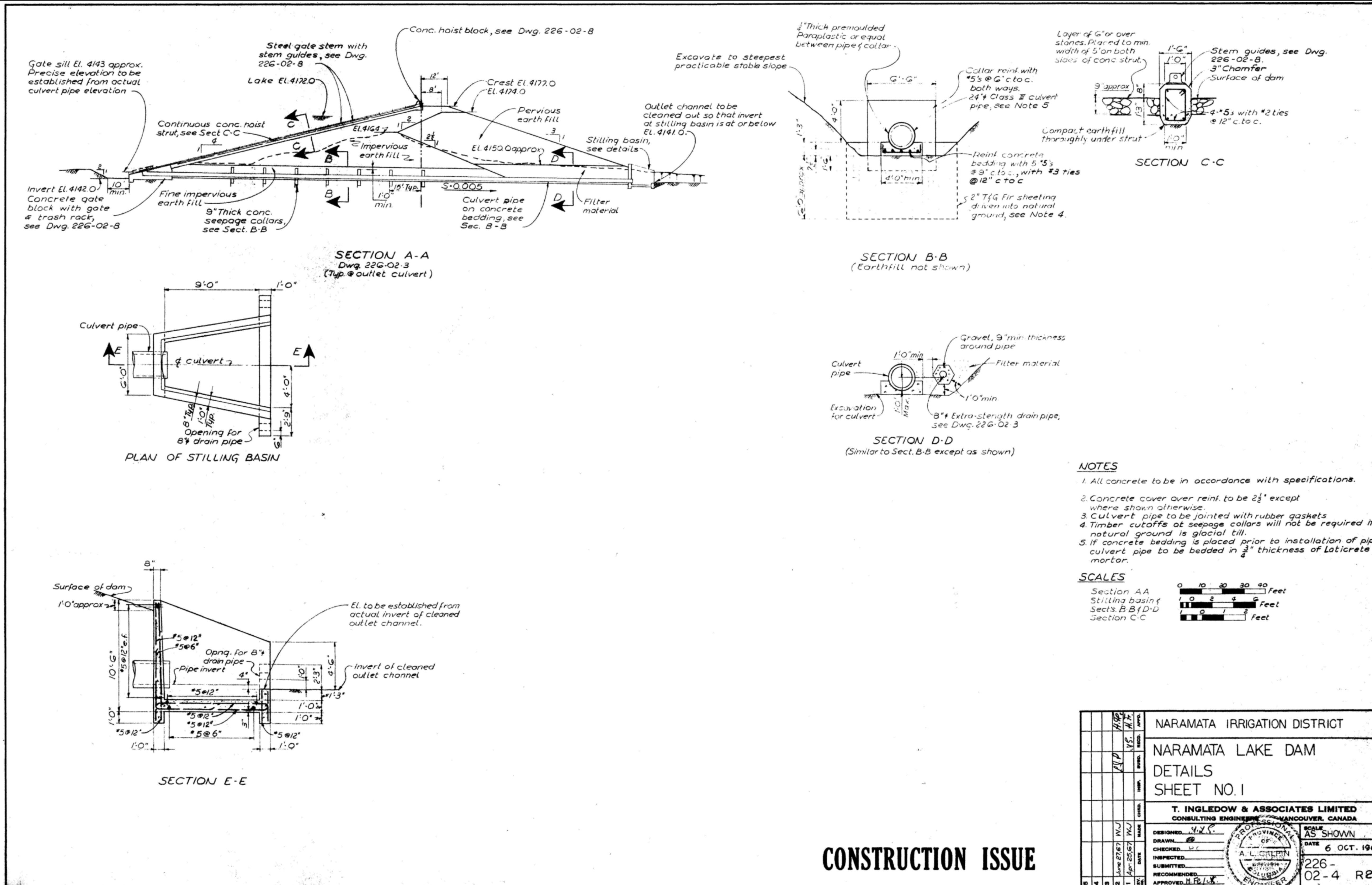
OFFICE	DATE			
EBA-KELOWNA	October 18, 2010			



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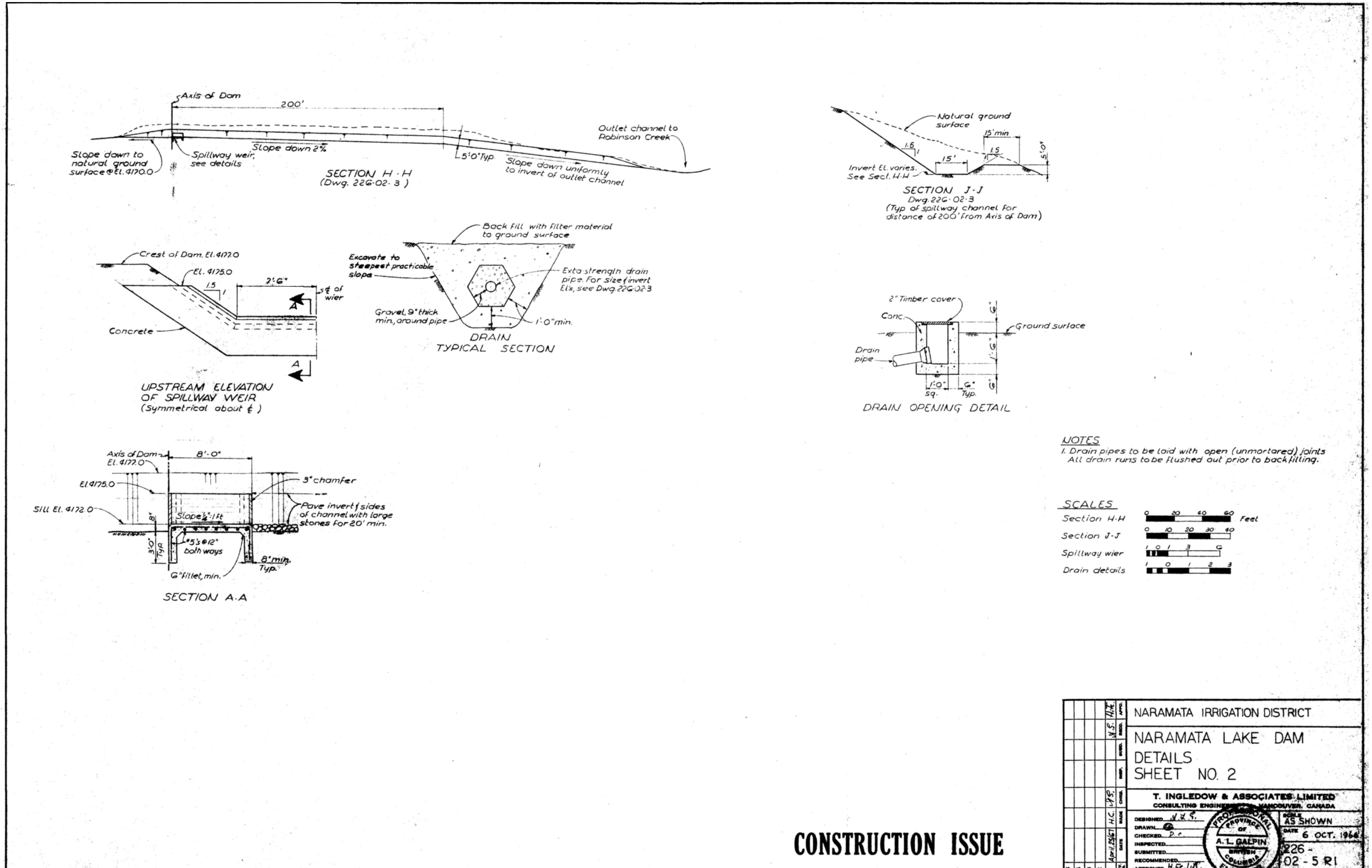
NARAMATA DAMS SAFETY REVIEW

NARAMATA LAKE DAM
LOW LEVEL OUTLET EMBANKMENT
SECTION & DETAILS

PROJECT NO.	DWN	CKD	REV	
K13101459.001	LM	MJL	0	Figure 7
OFFICE	DATE			
EBA-KELOWNA	October 18, 2010			



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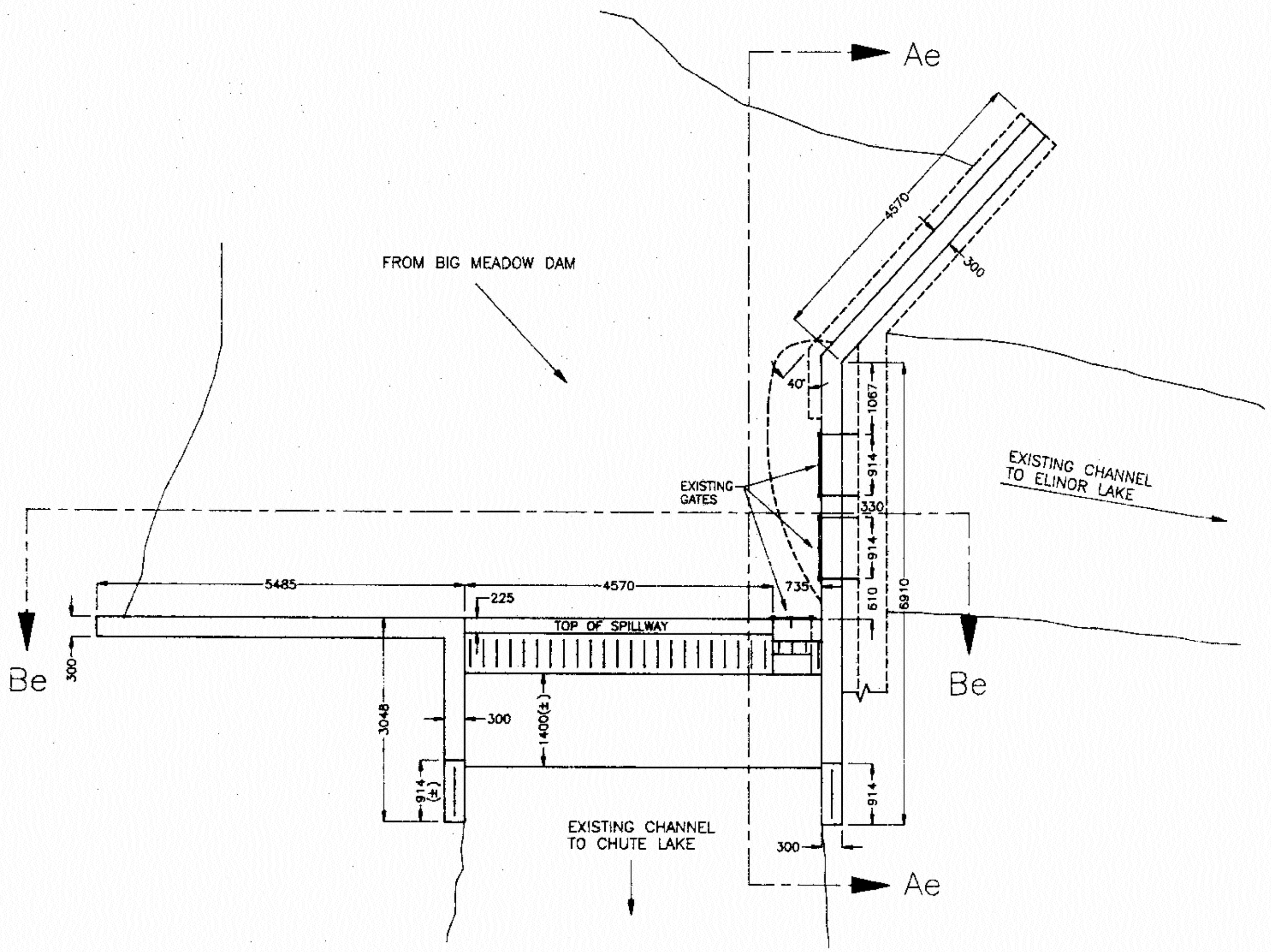
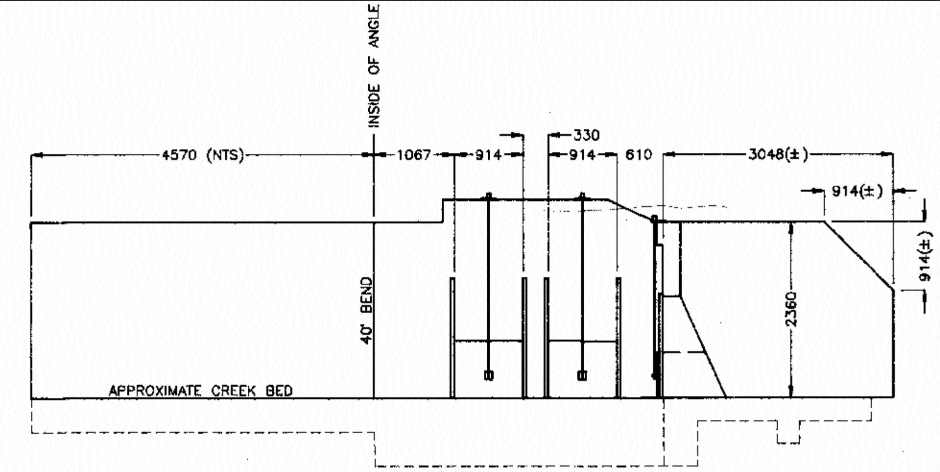
NARAMATA DAMS SAFETY REVIEW

NARAMATA LAKE DAM
SPILLWAY SECTION & DETAILS

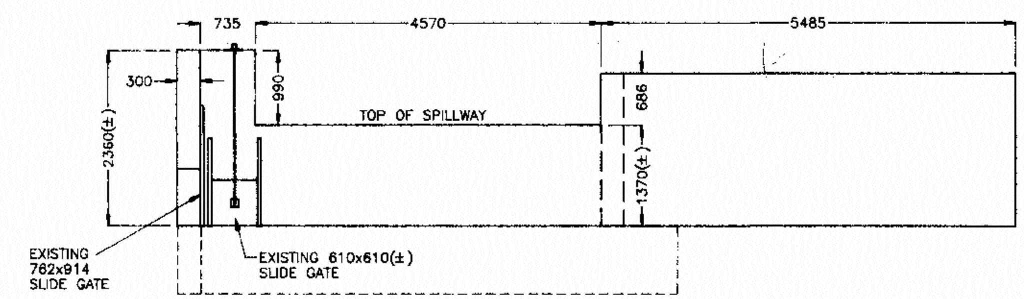
PROJECT NO.	DWN	CKD	REV	
K13101459.001	LM	MJL	0	Figure 8
OFFICE	DATE			
EBA-KELOWNA	October 18, 2010			



PLAN VIEW
EXISTING STRUCTURE



SECTION Ae
EXISTING STRUCTURE



SECTION Be
EXISTING STRUCTURE

NOTE:

DIMENSIONS AND SHAPE OF EXISTING CONCRETE BASE & FOOTINGS ARE UNKNOWN

ALL EXISTING DIMENSIONS ARE APPROXIMATE

ISSUED
OCT 2 9 1993
STANLEY ASSOCIATES ENGINEERING LTD.

NO.	DATE	DESCRIPTION	BY	APPROVED	NO.	DESCRIPTION	DATE	APPROVED
6								
5					5	PLAN OF RECORD		
4					4	APPROVAL FOR CONSTRUCTION		
3					3	FOR TENDER		
2					2	FOR APPROVAL		
1					1	PRELIMINARY		
REVISIONS					DRAWING STATUS			

SEAL

Stanley
STANLEY ASSOCIATES ENGINEERING LTD.

DESIGNED BY: CWH	APPROVED BY
DRAWN BY: MBV	CHECKED BY: CWH
SCALE: 1:50	PLOT DATE:
	DATE: OCT 93

CLIENT: NARAMATA IRRIGATION DISTRICT

TITLE: CHUTE LAKE DIVERSION EXISTING STRUCTURE

FILE NAME 40511S01
SHEET
JOB NO. 2516-91-405-01-01
REVISION
STATUS NO.
DRAWING NO. 1

CLIENT
REGIONAL DISTRICT RDOS OKANAGAN-SIMILKAMEEN

EBA Engineering Consultants Ltd.

NARAMATA DAMS SAFETY REVIEW

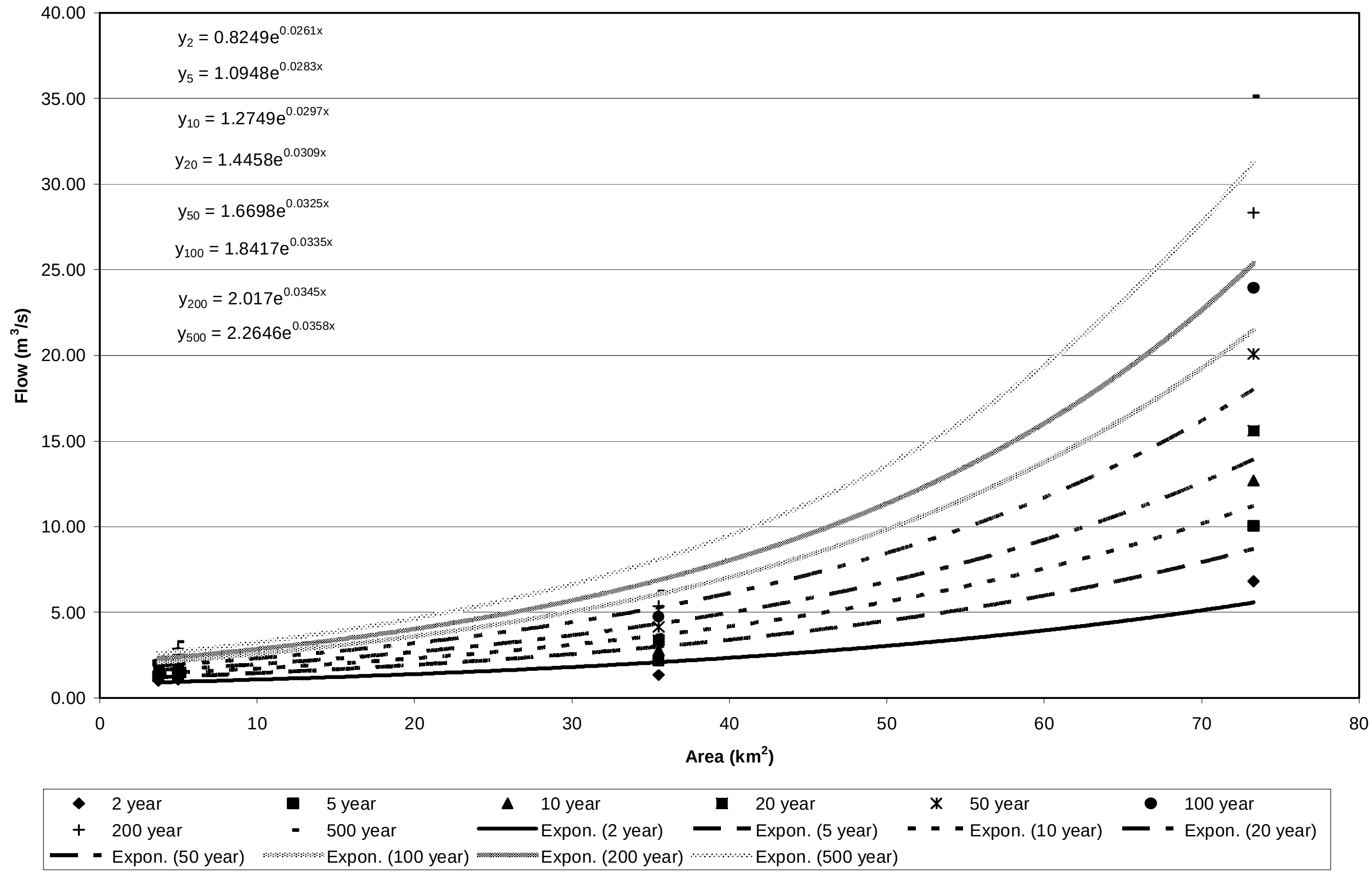
DIVERSION STRUCTURE FOR CHUTE LAKE

PROJECT NO.	DWN	CKD	REV
K13101459.001	LM	SP	0

OFFICE	DATE
EBA-KELOWNA	December 14, 2010

Figure 9

Q:\Kelowna\Drafting\k131\K13101459.001\K13101459.001_FIGS_R0.dwg [Figure 9] December 14, 2010 - 2:58pm imajeich



NOTES

CLIENT

REGIONAL DISTRICT RDOS OKANAGAN-SIMILKAMEEN

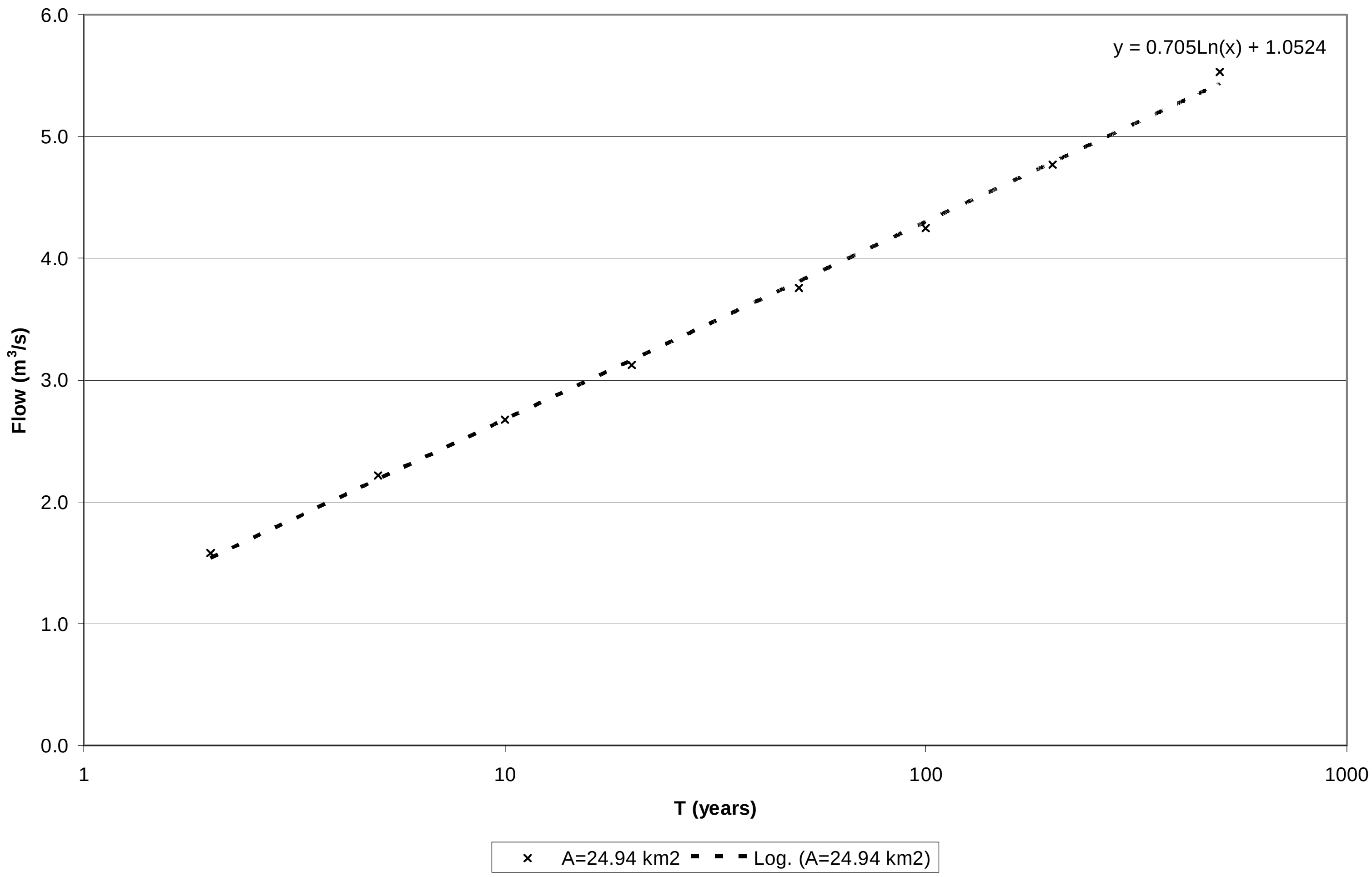
EBA Engineering Consultants Ltd.

NARAMATA DAMS SAFETY REVIEW

Regression Analysis Using Regional Maximum Instantaneous Flows

PROJECT NO.	DWN	CKD	REV
K13101459	SPB		0
OFFICE	DATE		
EBA-KELOWNA	October 25, 2010		

Figure 10



NOTES

CLIENT

EBA Engineering Consultants Ltd.

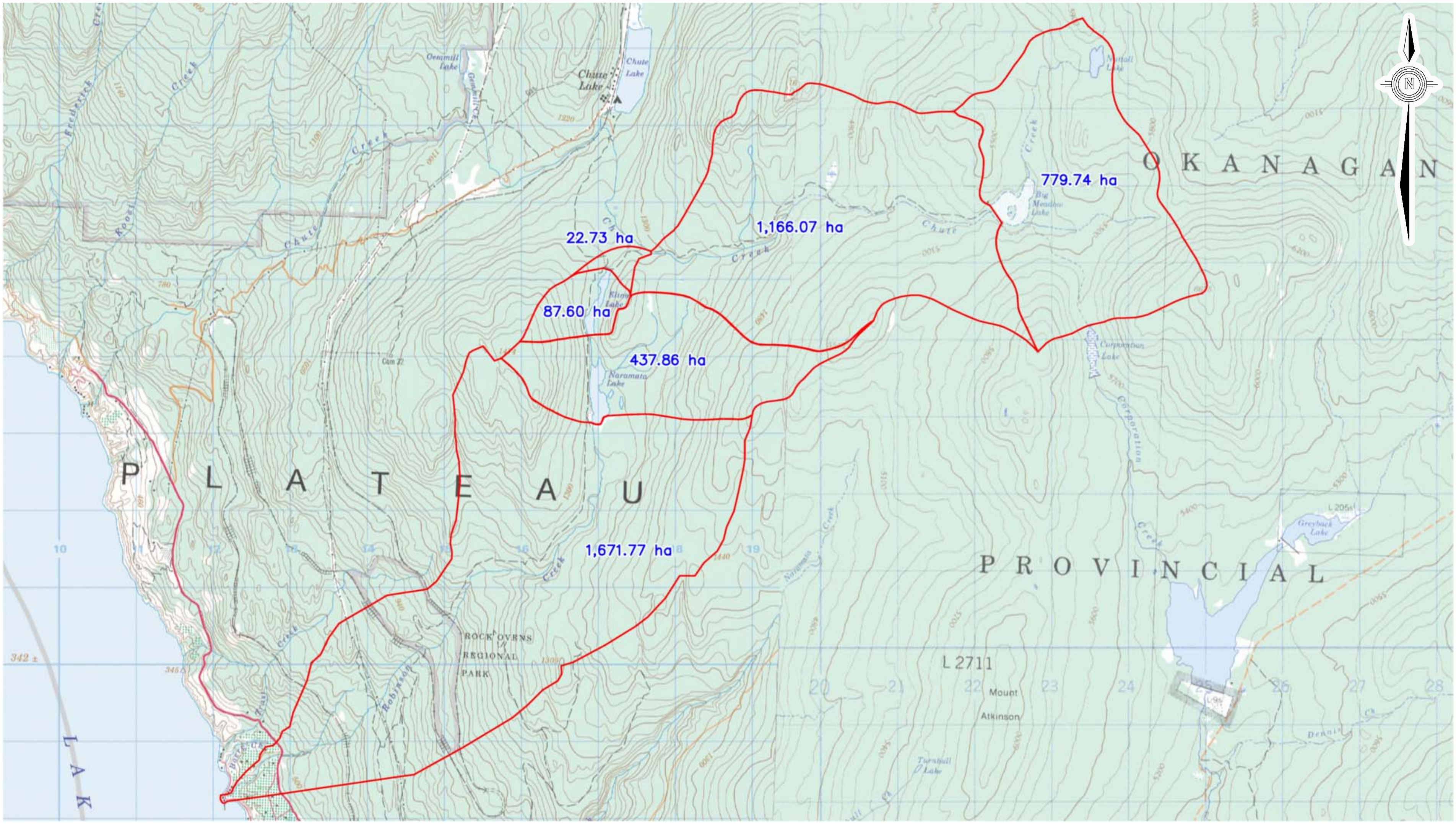
NARAMATA DAMS SAFETY REVIEW

1000-Year Flood Extrapolation for the Naramata Dam Watershed

PROJECT NO.	DWN	CKD	REV
K13101459	SPB		0

OFFICE	DATE
EBA-KELOWNA	October 25, 2010

Figure 11



SCALE 1:75,000

0.5 0 0.5 1.5 3.0km

CLIENT

REGIONAL DISTRICT RDOS OKANAGAN-SIMILKAMEEN

EBA Engineering Consultants Ltd.

eba

NARAMATA DAMS SAFETY REVIEW

NARAMATA DAMS CATCHMENT AREAS

PROJECT NO.	DWN	CKD	REV	
K13101459.001	LM	MJL	0	Figure 12
OFFICE	DATE			
EBA-KELOWNA	November 2, 2010			

PHOTOGRAPHS

Photo 1
Big Meadow Lake Dam — Spillway structure with Stop logs removed

Photo 2
Big Meadow Lake Dam — Spillway structure downstream view

Photo 3
Elinor Lake North (Saddle) Dam — Upstream Face from right abutment

Photo 4
Elinor Lake North (Saddle) Dam — Upstream Face from left abutment

Photo 5
Elinor Lake South Dam — Upstream Face

Photo 6
Elinor Lake South Dam — Wood debris in spillway channel

Photo 7
Naramata Lake Dam — Upstream Face right half of embankment

Photo 8
Naramata Lake Dam — Spillway Weir, stop logs removed

Photo 9
Chute Creek Outlet

Photo 10
Robinson Creek Outlet

APPENDIX A

APPENDIX A DESIGN STORAGE CAPACITY TABLES

STORAGE INVENTORY PROGRAMME

STORAGE CAPACITY TABLE

BIG MEADOW RESERVOIR

OKANAGAN BASIN-COLUMBIA SYSTEM

INDEX MAP NO. 4567A-2 Latitude: 49-41 Longitude: 119-27 REFERENCE MAPS: 1:50,000 - 82E/11W

STORAGE CAPACITY: Licenced 1000 acre-feet. Developed 420 acre-feet

STORAGE LICENCES: C 17736

LICENSEE: Naramata Irrigation District

SOURCE OF STORAGE DATA: Dwg. No. 1114 Date April/63 Description Plan of Storage prepared by Kelowna Regional Office, W.R.B.

DRAINAGE DATA: Dwg. No. ______ Date ______ Watershed Area 3.1 Square miles

Tributary Streams Chute (Lequime) Creek

REMARKS: Mapping compiled from field survey plan No. 635 and Air Photo B.C. 1243-58

DATE PREPARED April 26, 1979

MAPPING DATA			STORAGE CAPACITY				REMARKS
CONTOUR ELEVATION		Area in Acres	Depth of Storage in Feet	Area in Acres	STORAGE IN ACRE-FEET		
Geodetic Datum	Local Datum				Net	Gross	
5273	100.0	0.0	0	0.0		0	Original invert of gate.
5276.5	103.5	0.1	3.5	0.10	.2	0	Invert of new gate.
5277	104	0.10	4	0.10	.1	0	
5278	105	4.60	5	4.60	2.4	3	
5279	106	7.30	6	7.30	6.0	9	
5280	107	9.30	7	9.30	8.4	17	
5281	108	11.9	8	11.9	10	27	
5282	109	15.3	9	15.3	13	41	
5283	110	20.2	10	20.2	18	59	
5284	111	26.1	11	26.1	23	82	
5285	112	36.9	12	36.9	32	113	
5286	113	38.7	13	38.7	38	152	
5287	114	42.5	14	42.5	41	193	Present Operating Level
5288	115	45.3	15	45.3	44	236	
5289	116	48.1	16	48.1	46	283	LIVE STORAGE
5290	117	50.0	17	50.0	49	331	
5291	118	52.3	18	52.3	51	382	
5291.7	118.7	56.3	18.7	52.3	38	420	Crest of Spillway
5295.0	122	69.5	22	69.5	208	628	Crest of Dam
5300.0	127	77.7	27	77.7	368	996	
5305.0	132	83.2	32	83.2	402	1398	

Rating of Data: Fair

Gauge:

PREPARED BY
SURVEYS SECTION
PLANNING AND SURVEYS DIVISION
WATER INVESTIGATIONS BRANCH

W.I.-01

STORAGE INVENTORY PROGRAMME

STORAGE CAPACITY TABLE

BIG MEADOW RESERVOIR

OKANAGAN BASIN-COLUMBIA SYSTEM

INDEX MAP NO. 4567A-2 Latitude: 49-41 Longitude: 119-27 REFERENCE MAPS: 1:50,000 - 82E/11W

STORAGE CAPACITY: Licenced 1000 acre-feet. Developed 420 acre-feet

STORAGE LICENCES: C 17736

LICENSEE: Naramata Irrigation District

SOURCE OF STORAGE DATA: Dwg. No. 1114 Date April/63 Description Plan of Storage prepared by Kelowna Regional Office, W.R.B.

DRAINAGE DATA: Dwg. No. ____ Date ____ Watershed Area 3.1 Square miles

Tributary Streams Chute (Lequime) Creek

REMARKS: Mapping compiled from field survey plan No. 635 and Air Photo B.C. 1243-58

DATE PREPARED April 26, 1979

MAPPING DATA			STORAGE CAPACITY				REMARKS
CONTOUR ELEVATION		Area in Acres	Depth of Storage in Feet	Area in Acres	STORAGE IN ACRE-FEET		
Geodetic Datum	Local Datum				Net	Gross	
5273	100.0	0.0		0.0		0	Original invert of gate
5276.5	103.5	0.1		0.10	.2	0	Invert of new gate.
5277	104	0.10		0.10	.1	0	
5278	105	4.60		4.60	2.4	3	
5279	106	7.30		7.30	6.0	9	
5280	107	9.30		9.30	8.4	17	
5281	108	11.9		11.9	10	27	
5282	109	15.3		15.3	13	41	
5283	110	20.2		20.2	18	59	
5284	111	26.1		26.1	23	82	
5285	112	36.9		36.9	32	113	
5286	113	38.7		38.7	38	152	Present Operating Level
5287	114	42.5		42.5	41	193	
5288	115	45.3	15	45.3	44	236	LIVE STORAGE
5289	116	48.1	16	48.1	46	283	
5290	117	50.0	17	50.0	49	331	
5291	118	52.3	18	52.3	51	382	
5291.7	118.7	56.3	18.7	52.3	38	420	Crest of Spillway
5295.0	122	69.5	22	69.5	208	628	Crest of Dam
5300.0	127	77.7	27	77.7	368	996	
5305.0	132	83.2	32	83.2	402	1398	

Rating of Data: Fair | Gauge:

PREPARED BY
SURVEYS SECTION
PLANNING AND SURVEYS DIVISION
WATER INVESTIGATIONS BRANCH

WI-01

Reservoir Inventory No 21

STORAGE INVENTORY PROGRAMME

STORAGE CAPACITY TABLE

ELEANOR LAKE RESERVOIR

OKANAGAN BASIN-COLUMBIA SYSTEM

INDEX MAP NO. 4567A-2 Latitude: 49-40 Longitude: 119-32 REFERENCE MAPS: 1:50,000-82E/12E

STORAGE CAPACITY: Licenced 250 acre-feet. Developed 220 acre-feet

STORAGE LICENCES: C17736

LICENSEE: Naramata Irrigation District

SOURCE OF STORAGE DATA: Dwg. No. 1203 Date April/64 Description Plan of Storage prepared by Kelowna Regional Office, W.R.B.

DRAINAGE DATA: Dwg. No. ______ Date ______ Watershed Area ______ Square miles

Tributary Streams Robinson & Chute (Lequime) Creeks

REMARKS: Plan prepared from stadia survey.
Dam raised and repaired 1959.

DATE PREPARED August 17, 1979

MAPPING DATA			STORAGE CAPACITY				REMARKS
CONTOUR ELEVATION		Area in Acres	Depth of Storage in Feet	Area in Acres	STORAGE IN ACRE-FEET		
Geodetic Datum	Local Datum				Net	Gross	
4170		8.68	-4.4	8.68		44	LOW POINT OF LAKE
					3.5		
			-4	8.92		40	DEAD
					9.2		
			-3	9.51		31	STORAGE
					9.8		
			-2	10.1		21	
					10		
			-1	10.7		11	
					11		
4174.4		11.3	0	11.3		0	INVERT OF INTAKE
					7		
4175		12.0					
					4.9		
			1	12.3		12	
					13		
			2	13.1		25	
					13		
			3	13.8		38	LIVE STORAGE
					14		
			4	14.6		52	
					15		
			5	15.4		67	
					9.4		
4180		15.8					
					6.4		
			6	16.1		83	
					16		
			7	16.9		99	
					17		
			8	17.5		116	
					18		
			9	18.3		134	
					19		
			10	19.0		153	
					12		
4185		19.5					
					7.8		
			11	19.7		173	
					20		
			12	20.3		193	
					21		
			13	20.9		214	
					6.3		
4187.7		21.1	13.3	21.1		220	CREST OF SPILLWAY
					15		
			14	21.6		235	POTENTIAL
					22		
			15	22.3		257	
					14		
4190		22.7					STORAGE
					9.1		
Rating of Data: Good			Gauge:				

PREPARED BY
SURVEYS SECTION
PLANNING AND SURVEYS DIVISION
WATER INVESTIGATIONS BRANCH

WI-01

STORAGE INVENTORY PROGRAMME

STORAGE CAPACITY TABLE

ELEANOR LAKE RESERVOIR

MAPPING DATA			STORAGE CAPACITY				REMARKS
CONTOUR ELEVATION		Area in Acres	Depth of Storage in Feet	Area in Acres	STORAGE IN ACRE-FEET		
Geodetic Datum	Local Datum				Net	Gross	
			16	23.0		280	POTENTIAL STORAGE
			17	23.5	23	303	
			18	24.1	24	327	
			19	24.7	24	351	
			20	25.3	25	376	
4195			20.6	25.7	15	391	

STORAGE INVENTORY PROGRAMME

STORAGE CAPACITY TABLE

NARAMATA LAKE RESERVOIR

OKANAGAN BASIN-COLUMBIA SYSTEM

INDEX MAP NO. 4567A-2 Latitude: 49-39 Longitude: 119-32 REFERENCE MAPS: 1:50,000-82E/12E

STORAGE CAPACITY: Licenced 600 acre-feet. Developed 604 acre-feet

STORAGE LICENCES: C17736

LICENSEE: Naramata I.D.

SOURCE OF STORAGE DATA: Dwg. No. 1203 Date Apr./64 Description Plan of Storage, prepared by Kelowna Regional Office, W.R.B.

DRAINAGE DATA: Dwg. No. ______ Date ______ Watershed Area ______ Square miles

Tributary Streams Robinson Creek

REMARKS: Reservoir drawing prepared from stadia survey.

DATE PREPARED June 29/79

MAPPING DATA			STORAGE CAPACITY				REMARKS
CONTOUR ELEVATION		Area in Acres	Depth of Storage in Feet	Area in Acres	STORAGE IN ACRE-FEET		
Geodetic Datum	Local Datum				Net	Gross	
4141.6		5.02	0	5.02		0	INVERT OF INTAKE
					5.5		
			1	6.03		6	
					6.5		
			2	7.05		12	
					7.6		
			3	8.06		20	
					3.3		
4145		8.47					
					5.2		
			4	8.89		28	
					9.2		
			5	9.58		37	
					10		
			6	10.3		47	
					11		
			7	11.0		58	
					11		
			8	11.7		69	
					5		
4150		11.9					LIVE STORAGE
					7		
			9	12.7		81	
					13		
			10	13.9		94	
					14		
			11	15.0		108	
					16		
			12	16.2		124	
					17		
			13	17.4		141	
					7		
4155		17.9					
					11		
			14	18.7		159	
					20		
			15	20.0		179	
					21		
			16	21.4		200	
					22		
			17	22.7		222	
					23		
			18	24.0		245	
					10		
4160		24.6					
					15		
			19	25.3		270	
					23		
4161.5		26.4					
					3		
			20	26.5		296	
Rating of Data: Fair			Gauge:				

PREPARED BY
SURVEYS SECTION
PLANNING AND SURVEYS DIVISION
WATER INVESTIGATIONS BRANCH

STORAGE INVENTORY PROGRAMME

STORAGE CAPACITY TABLE

NARAMATA LAKE RESERVOIR

MAPPING DATA			STORAGE CAPACITY				REMARKS
CONTOUR ELEVATION		Area in Acres	Depth of Storage in Feet	Area in Acres	STORAGE IN ACRE-FEET		
Geodetic Datum	Local Datum				Net	Gross	
			21	27.3	27	323	LIVE STORAGE
			22	28.1	28	351	
			23	28.9	29	380	
4165		29.2			12		
			24	29.8	18	410	
			25	30.7	30	440	
			26	31.6	31	471	
			27	32.6	32	503	
			28	33.5	33	536	
4170		33.9			13		
			29	34.4	20	569	
4171.6			30	35.2	35	604	CREST OF SPILLWAY
			31	36.0	35	639	POTENTIAL STORAGE
			32	36.8	36	675	
			33	37.6	37	712	
4175		37.9	33.4	37.9	15	727	

W.I.- 02

APPENDIX B

APPENDIX B GEOTECHNICAL REPORT – GENERAL CONDITIONS

GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's Client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's Client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA's instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgemental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

8.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

9.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

10.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

11.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

12.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

13.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

14.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

15.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.