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Stump Lake Water Balance and Outlet Conceptual Design

Final Report
October 5, 2020
KWL Project No. 2755.008-300

Prepared for:

THOMPSON-NICOLA
REGIONAL DISTRICT

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Executive Summary

Stump Lake has elevated water levels not seen in recent memory. From a few years ago, the lake surface elevation has come up several metres and flooded homes and property around the lake. Following a series of meetings with affected residents, impacted businesses, communities downstream, and senior government regulators, the Thompson-Nicola Regional District (TNRD) retained Kerr Wood Leidal (KWL) to determine if an improved lake outlet channel could reduce the potential for flooding around the lake and not exacerbate flooding downstream. Previous options including inter-basin water transfer to the north through a tunnel and, secondly, additional upland storage through construction of dams or other means were ruled out as too expensive and too onerous to meet management objectives.

The study focused on answering whether the risk of flooding could be minimized around the lake, and if so, what would the outlet conditions. Following the completion of watershed hydrology, a lake water balance and the development of a conceptual design, the lake level control was technically possible by lowering the lake elevation outlet channel and controlling freshet flows through a low-level pipe situated lower than the channel. With this concept, there will be environmental implications that would need to be addressed; this is the focus of a second technical memorandum, which will be released following this report. In addition, there would be downstream implications to the property and infrastructure on Stumplake Creek between Stump Lake and Nicola Lake. On Nicola Lake and downstream, the excess volume of water was controlled by releasing water after freshet at times when natural receding hydrographic limbs were occurring and the risk of flooding would be reduced.

Stumplake Creek from the lake outlet to the lower flats area is poorly defined. The area typically sees water during the freshet and is broadcast across the pasture field of Guichon Ranch. The naturally occurring increased flows from Stumplake Creek and Peter Hope Creek are deteriorating the pasture field and making the management objective for the two DUC dams and Guichon dam challenging to impossible to achieve. The increased through-put of water conveyed over a longer period of time from an improved Stump Lake outlet would further change the composition of vegetation and soil chemistry that is already occurring. As a result, the study conceptualized the development of a conveyance channel below Peter Hope Creek and into the upper Ducks Unlimited Canada Flat Meadow or Canal Reservoirs.

The resulting Class D cost to improve the 410 m Stump Lake outlet channel and install a low-level outlet pipe was $2.2 million; and the Class D cost to construct an approximate 4600 m channel through the Guichon pasture is $2.8 million.

1. Introduction

Stump Lake is located in the south-central interior, approximately 40 km northeast of Nicola Lake near Merritt, BC. Since 2017, lake levels have risen to elevations not seen in the recent past. The continuous increase of lake levels in this year has also resulted in the outlet channel experiencing flow after several decades of being dry. The elevation of the existing outlet channel cannot maintain lake levels below the elevation of some developments around the lake, resulting in flooding of dwellings and property.

To understand the changing dynamics of the lake system and understand the ability to minimize the potential for flooding around the lake, the Thompson-Nicola Regional District (TNRD) retained Kerr Wood Leidal Associates Ltd. (KWL) to develop a water balance for the lake and provide a conceptual design of an improved lake outlet that can safely release flows downstream.

2. Background

Although Stump Lake water level has a history of having large fluctuations, the lake water level was naturally maintained lower than the outlet channel elevation for the last several decades, presumably through sufficient infiltration and evaporation. The lake has been steadily rising over the last four consecutive years (2017 to 2020). The main inflow sources feeding the lake are surface runoff and groundwater generated within the lake's watershed including the main tributary, Stumplake Creek, and precipitation onto the lake surface. Water has exited the lake via evaporation and infiltration/seepage until recently when the existing outlet channel at the southeast end of the lake started flowing as the lake level rose. The flow in the outlet channel commenced when the lake level exceeds the high point in the channel invert (El. 744.77 m CGVD28, 2020-02-05 MOTI Survey) located 350 m downstream of the edge of the lake.

A site visit in 2019 indicated that the lake water level was approximately 1 m lower than the outlet channel invert. The rising lake water during this year's freshet resulted in flow in the outlet channel (also known as Stumplake Creek) starting in April 2020. The 2020 freshet has also resulted in flooding of some of the properties along the lakeshore.

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Thompson Nicola Regional District

Stump Lake Water Balance and Conceptual Outlet Design

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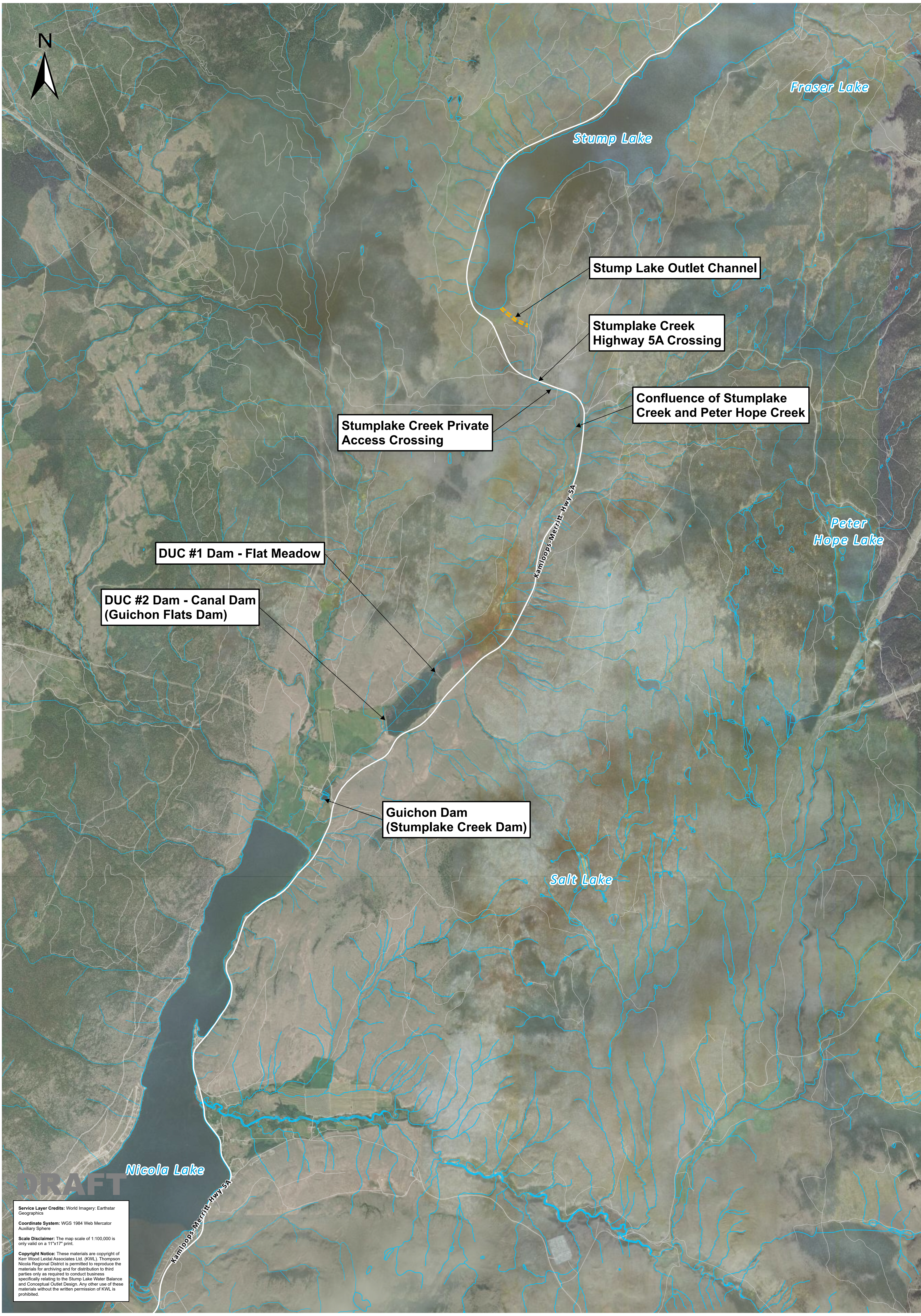

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Project No. 2755-008

Date September 2020

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Areas of Interest

Figure 2-1

3. Scope of Work

The following tasks summarize the work undertaken:

- Stump Lake water balance calibration (current outlet);
- Stump Lake water balance 'what-if' scenarios (current outlet);
- Stump Lake water balance with low-level outlet (improved outlet);
- Conceptual design for improved outlet;
- Conceptual design for the downstream conveyance channel; and
- Reporting (this document).

4. Stump Lake Water Balance – Existing Outlet

The Stump Lake watershed has an area of approximately 197 km^2 and a mean elevation of 1,111 m. A mean annual runoff of about 90 mm has been estimated for the lake based on regional runoff curves[1] developed for the southern interior watersheds in hydrological zone15.

Assumptions

Data available to carry out a water balance of Stump Lake was very limited, no hydrometric stations, and therefore no discharge records are available within the lake watershed. As such, the following assumptions and simplifications were required to account for the main hydrological components of the lake; and to develop and assess the water balance:

- The lake water balance is simulated on a daily basis based on water entering the lake (estimated inflow discharge) and water leaving the lake (estimated losses in the form of evaporation and infiltration as well as outflow through the outlet).
- Daily inflows into the lake were based on the entire watershed, including the lake, therefore they include precipitation onto and runoff/groundwater into the lake.
- Daily evaporation values for the lake were generated using published climate data from NASA and applying the Penman-Monteith method.
- Daily infiltration was unknown and therefore it was set as a calibration parameter for the water balance simulation.
- Daily channel outflows from the lake were simulated using the discharge-elevation rating curve of the lake's outlet. For the current outlet, the curve was obtained from hydraulic modelling results from the Stump Lake hydrotechnical assessment[2] carried out by KWL in 2019. For the proposed outlet, a new discharge-elevation rating curve was developed to meet the proposed design criteria.
- Due to the lack of bathymetric data, a constant lake area was assumed in the range of water levels simulated. The lake's nominal area of 7.63 km^2 was used.

[1] Obedkoff, W. Streamflow in the Lower Mainland and Vancouver Island. Report prepared for the Province of British Columbia, Ministry of Sustainable Resource Management, April 2003.

[2] KWL, 2019. Highway 5A Reprofiling at Stump Lake – Stump Lake Hydrotechnical Assessment. Report prepared for the Ministry of Transportation and Infrastructure. KWL File No. 0767.058.

4.1 Water Balance Calibration

The water balance to assess the lake's current condition and existing outlet was simulated in an Excel spreadsheet. The simulation period includes the last three freshet periods from Jan 1, 2018 to July 18, 2020.

Inflow Data

Total inflow discharge data entering the lake was estimated using recorded flow data of the Water Survey of Canada (WSC) hydrometric stations listed in Table 4-1.

Table 4-1: WSC Hydrometric Stations and Site Parameters

WSC Station Name	WSC Station ID	Drainage Area (km^2)	Record Available	Mean Annual Discharge (MAD) m^3/s
Moore Creek near Quilchena	08LG011	215	1915 to 1921	0.54
Criss Creek near Savona	08LF007	479	1912 to 2020	1.70
Quilchena Creek at Quilchena	08LG017	787	2019 to 2020	1.60
Site (Stump Lake)	N/A	197	N/A	0.49

Moore Creek (WSC 08LG011) is the closest station to the site and therefore it was used to estimate the Mean Annual Discharge (MAD) per unit area for the Stump Lake Watershed.

The MAD ratio between Stump Lake and Quilchena Creek (WSC 08LG017) was applied to the Quilchena Creek daily recorded flows for the available period of record, from April 2, 2019 to July 18, 2020, to scale and obtain the daily flow series to Stump Lake.

Criss Creek (WSC 08LF007), located a longer distance from the site, is the station with the longest daily flow data set. A two-step process was used to convert Criss Creek flows to Stump Lake inflows. First, a correlation between Moore Creek and Criss Creek flows was developed using the 1915 to 1921 period of overlapping records. Second, this relationship and the relationship between Moore Creek and Stump Lake (MAD ratio) were to scale the Criss Creek daily flows for the period between Jan 1, 2018 and April 1, 2019 to Stump Lake inflows.

The final daily flow series scaled for Stump Lake is a synthetic composite flow series from different nearby hydrometric stations that were able to capture the spring freshet events and seasonal rainfall events from January 2018 to July 2020.

Existing Outlet Rating Curve

Daily outflows exiting the lake were calculated based on the geometry of the existing outlet channel which has an invert elevation at the control section (high point) of 744.77 m (CGVD28). The discharge-elevation curve for the existing outlet as shown on Figure 4-1 below was developed as part of KWL's 2019 hydrotechnical study done for the Ministry of Transport and Infrastructure (MOTI).

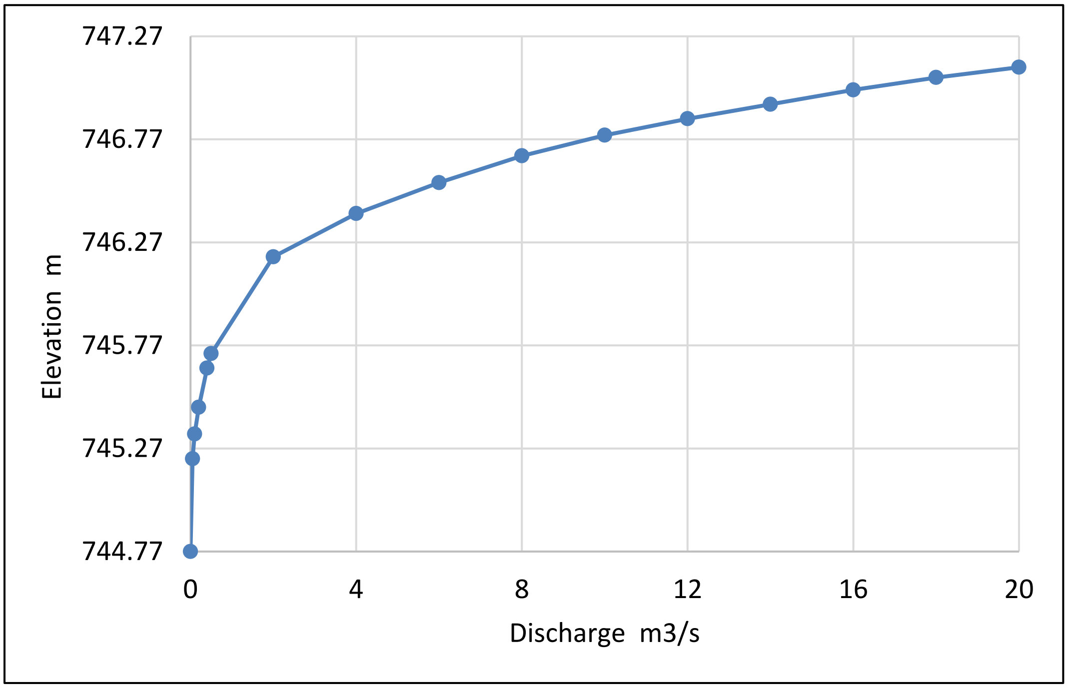


Figure 4-1: Discharge- Elevation Curve for the Current Outlet Condition

Evaporation Data

Lake evaporation was estimated using the Penman-Montieth calculation on NASA satellite daily data of temperature, relative humidity, wind speed, and insolation values (available at https://power.larc.nasa.gov/). This method of estimating evaporation has been found to be much more suitable and accurate than simply using available monthly average evaporation values.

Recorded Lake Water Levels

The following sets of water elevations have been recorded in the lake and used for calibration:

Year 2018: water elevations recorded by the Ministry of Transportation and Infrastructure (MOTI) using a staff gauge. Measurements of daily increases were reported in metric units (metres).

Year 2020: water elevations recorded by Stump Lake's resident Mike Kidd using a tape measure. Measurements of daily water elevations reported in Imperial units (inches) were converted to metres.

Both sets of measurements were converted to CGVD28 vertical datum by comparing to surveyed lake levels on the same days as the manual measurements.

Water Balance Calibration Data

The lake water balance simulation was calibrated by simulating existing conditions of the lake. Calibration parameters such as initial water elevation and daily infiltration were adjusted until the simulated water levels matched the recorded water levels.

Initial conditions for the calibration assumed that the lake elevation started at 743.86 m on January 1, 2018 which provided a simulated lake elevation equal to the first recorded water elevation on April 27, 2018.

In addition to the initial lake elevation, the daily infiltration rate of 1.1 mm/day was proven to provide a good calibration of the water balance when comparing simulated versus recorded water elevations. This infiltration value was subsequently used for the rest of the water balance analysis to simulate other scenarios (described in sections below).

Water Balance Results

The maximum water elevation resulting from simulating the lake components for the last three years of data is 746.0 m. The lake reached this peak elevation on June 20 of 2020 and lasted for about 5 days before starting to recede. The corresponding maximum flow exiting the lake through the existing outlet channel during this period is estimated to be 1.36 m^3/s based on the outlet rating curve. Key results are summarized in Table 4-2 below.

Table 4-2: Peak Stump Lake Parameters for Existing Outlet Conditions

Parameter	Maximum Inflow (m^3/s)	Maximum Outflow (m^3/s)	Maximum Water Elevation (m)	Time of Occurrence
Simulated	3.85	1.36	746.0	June 20, 2020
Recorded	N/A	N/A	746.0	July 6, 2020

Figure 4-2 shows the inflow and outflow hydrographs as well as the simulated versus recorded lake water elevations for current outlet conditions. As shown, the simulated lake level does not perfectly match with the recorded points. This is because the inflow is a synthetic hydrograph comprised of scaled flows from two separate stations and cannot be expected to perfectly reflect actual inflows into Stump Lake. The key metric for calibration was to generally match the rising lake level trends and peak lake levels in 2018 and 2020, which was achieved. Therefore, this water balance was accepted for use in the following 'what-if' scenarios and improved outlet design. Additional fine-tuning of the calibration could be undertaken in the future if monitoring data on Stump Lake inflows and outflow is collected.

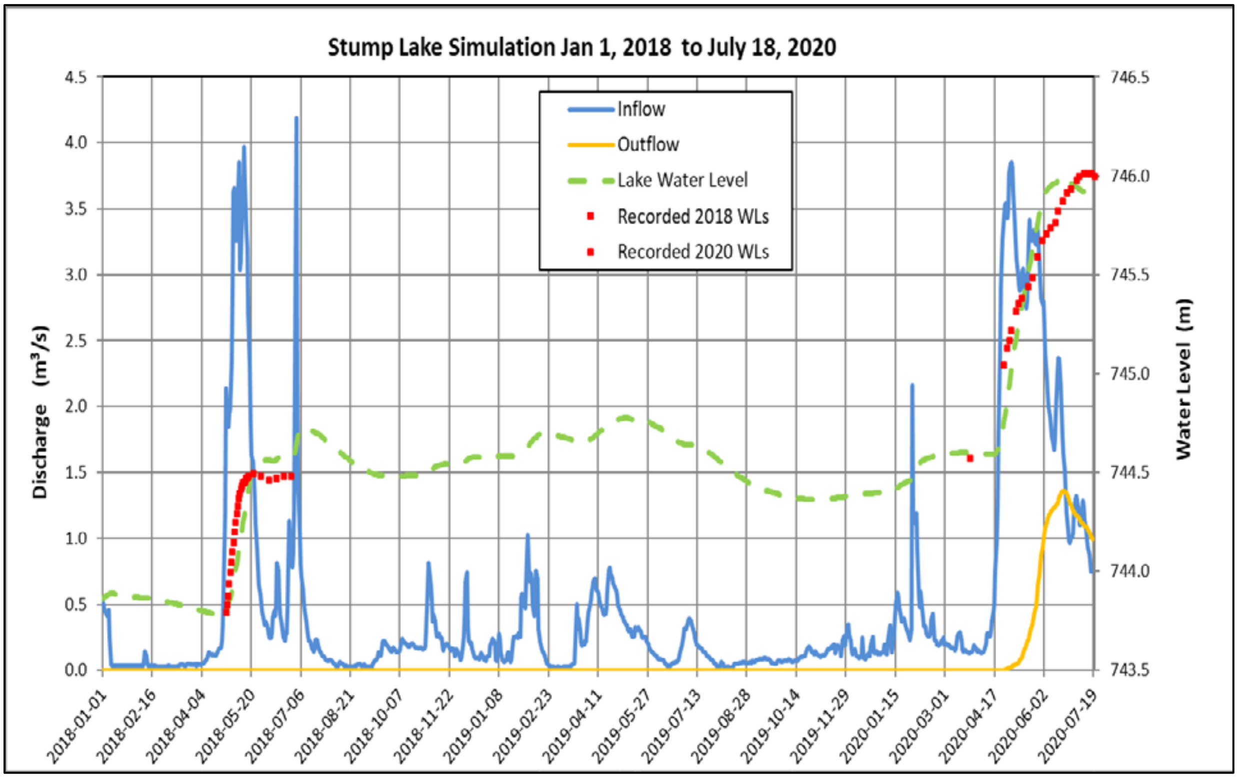


Figure 4-2: Stump Lake Water Balance Results for Current Outlet

4.2 Water Balance for 2021 Freshet 'What-if' Analyses

Although upgrading the lake outlet may be a possible ultimate solution to reduce flooding on properties around Stump Lake, construction may take time and therefore such an outlet may not be available to lower the lake elevation sufficiently prior to the year 2021 freshet. Understanding this reality, simulations of the year 2021 freshet 'what-if' scenarios to predict how high the lake water elevations could reach under four potential freshet scenarios and assuming no change to the existing lake outlet were undertaken.

These scenarios have been built using the water balance model for existing outlet conditions and therefore include two years of data preceding the freshet of interest to estimate the initial lake level at the start of the hypothetical year 2021 freshet. For this purpose, the lake inflows in the period from January 1, 2018 to April 1, 2020 were used, however the flows in the period from April 1, 2019 to July 18, 2019 were replaced with the year 2020 freshet to better represent the lake levels going into year 2021. The four hypothetical 2021 freshet simulations have a peak daily flow and freshet volume that corresponds to the 2-year, 10-year, 20-year, and 200-year return period.

Although the actual magnitude of next year freshet is unknown, these water level predictions will be able to guide decision making if the existing outlet was not modified and/or upgraded and no other lake level lowering (e.g. pumping) was undertaken.

Water Balance Data

For each hypothetical freshet scenario, an inflow hydrograph with the peak daily 2021 freshet flow and freshet volume was developed to predict the resulting peak water elevation of the lake. The peak daily flows to be used in this analysis are those derived from the 2019 KWL study.

Prediction of the expected freshet volume was estimated by carrying out a flood frequency analysis (FFA) of the freshet volumes for hydrometric stations WSC 08LG017 and WSC 08LF007. The freshet period selected for the analysis was from April 1 to July 31. The HYFRAN software was used to perform the FFA using the average of three statistical distributions:

- Generalized Extreme Value (GEV): fitted by Method of Weighted Moments,
- Three Parameter Lognormal (3PLN): fitted by Maximum Likelihood method, and
- Log Pearson III (LP3): fitted by US Water Resources Council method.

Based on visual observations of the FFA result plots provided by HYFRAN computer software, all distributions were proven to provide an acceptable fit based on the freshet volumes for both stations.

Volumes of the spring freshet for the different return period events for Stump Lake were estimated from the FFA results at WSC 08LG017 and WSC 08LF007 by using the following scaling relationship between the volumes and the watershed areas for both sites:

$$\textbf{Freshet Volume}_{\text{Stump Lake}} = \textbf{Freshet Volume}_{\text{WSC}} * (\textbf{Area}_{\text{Stump Lake}} / \textbf{Area}_{\text{WSC}})$$

Freshet volumes from the FFA results at WSC 08LG017 were scaled to the site and used as validation volumes given than they provided a significantly better approximation than the FFA results at WSC 08LF007; this was not surprising since WSC 08LG017 is in closer proximity to the site.

As shown on figure below, each freshet inflow hydrograph was developed by scaling the 2020 flow series estimated for Stump Lake from April 1 to July 18 and extrapolating the recession tail to July 31. The scaling factors were adjusted to roughly match the freshet volume at the site and include the corresponding peak daily flow defining each of the potential freshet events. It was found that the peak lake level was governed by the freshet inflow volume rather than the peak daily inflow.

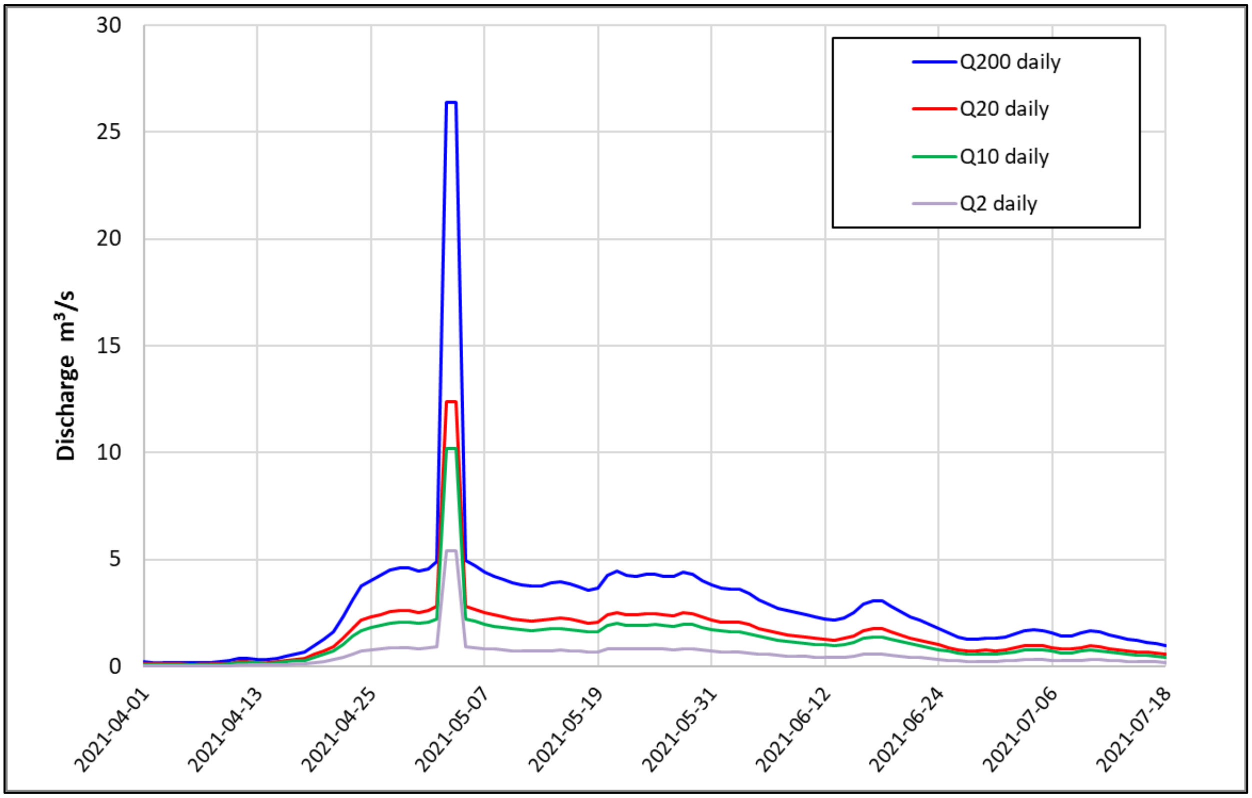


Figure 4-3: Predicted Freshet Scenarios for Current Outlet

Water Balance Results

The lake outflow predictions were estimated from the existing discharge-elevation rating curve also documented in the 2019 KWL study. The initial water elevation of the lake at the start of each hypothetical year 2021 freshet (on April 1) was estimated to be 745.3 m based on the preceding 2-year simulated period. As described above, this 2 year period features the 2018 freshet followed by the 2020 freshet (the low 2019 freshet was removed and replaced by the 2020 freshet) which results in a much higher predicted water level on April 1, 2021 than the recorded level on April 1, 2020, given that the 2020 freshet is much larger than the 2019 freshet.

Table 4-3 below provides the results of the estimated lake parameters for the hypothetical year 2021 freshet return periods.

Table 4-3: Estimated Stump Lake Parameters for Potential Freshet Condition (Existing Outlet)

Year	Return Period	Freshet Vol. (Mm^3)	Maximum Daily Inflow (m^3/s)	Maximum Outflow (m^3/s)	Maximum Lake Water Level (m)
2020	> 20-Year	18.2	3.8	1.4	746.0
2021	2-Year	5.3	5.4	0.3	745.5
	10-Year	12.0	10.2	1.2	745.9
	20-Year	15.1	12.4	1.6	746.1
	200-Year	27.4	26.4	3.9	746.4
Note: Mm^3 means million cubic metres.					

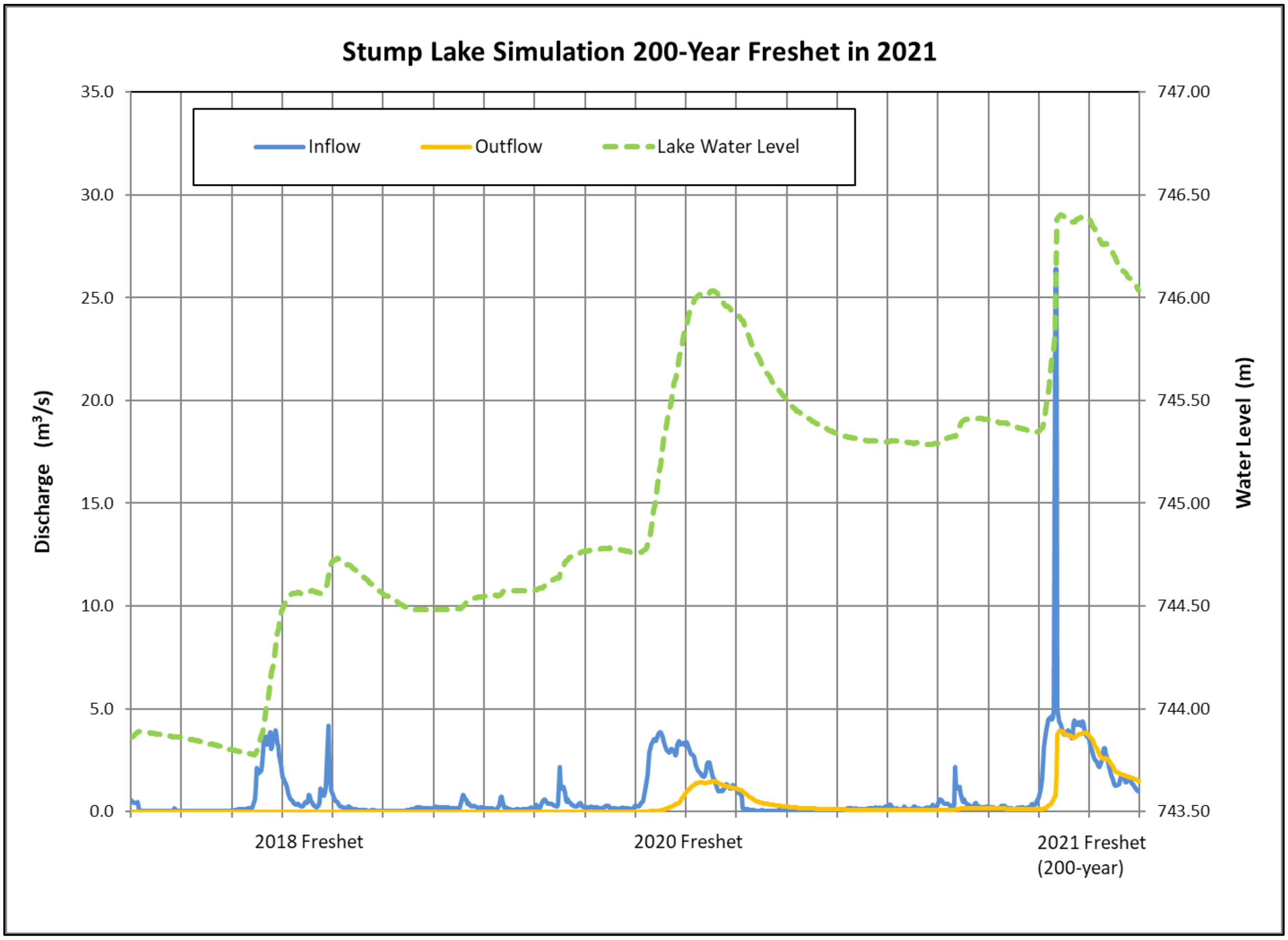


Figure 4-4: Stump Lake Water Balance Results for Hypothetical 200-year 2021 Freshet

5. Water Balance for Potential Improved Outlet

5.1 Design Criteria

KWL understands that the proposed outlet would be designed to maintain a maximum lake water elevation equal to 743.5 m during a 200-year freshet. This was the approximate lake water elevation for the 1998 freshet period.

The design criteria also include considerations for the flow rate leaving the lake through the improved outlet. One potential approach would be to size the improved outlet so that the 200-year return period freshet volume can be released from the lake in the period of time from the end of the freshet to the start of the following year's freshet (approximately 9 months). In the preceding section the 200-year freshet volume was estimated to be approximately 27 Mm^3 (million cubic metres). This results in an average outflow rate of 1 m^3/s over the 9-month period. Note that the 1 m^3/s flow rate is an average and would likely be exceeded during the peak of the freshet. When designing new culverts or culvert upgrades downstream of Stump Lake, an appropriate return period (such as the 200-year) design flow should be used.

The new lake outlet should also limit the flow so that it can be safely conveyed through the structures located downstream of the lake, between Stump Lake and Nicola Lake. KWL understands that there are four key structures to be evaluated as described in the following section.

Capacity of Downstream Structures

Highway 5A Culvert

The Highway 5A circular culvert (D = 900 mm) has the capacity to pass a flow rate of 1 m^3/s with little to no surcharging. With a 1.9 m^3/s flow rate (see significance of this flow rate below), the culvert would be surcharged with water 0.9 m above the crown (H/D=2). It is understood that this culvert was twinned in the fall of 2020 and the second culvert placed at a slightly higher elevation.

Private Road

The private road circular corrugated metal culvert (D = 600 mm) would need to be upsized to safely pass a flow rate greater than or equal to 1 m^3/s. It is expected that this culvert can be easily upgraded to a bigger size to pass the design flow.

Peter Hope Lake Creek Confluence

Peter Hope Creek exits Peter Hope Lake Dam through a spillway reconstructed in 2016. The spillway was designed for a 1:1000 year event of 6.0 m^3/s (per com, Darren Bennett, 2020). The creek channel is well-defined below the dam to the Highway 5A crossing, and below that, it meets Stumplake Creek. However, the channel below the confluence is poorly-defined as it runs through the private pasture fields on the Guichon Ranch. It is assumed that the poorly-defined channel is a consequence of no water exiting Stump Lake and minimal water leaving Peter Hope Creek. Further, given the climatic conditions of the region, any water migrating through the pasture fields would return to ground or evapotranspirate leaving the pasture dry through the summer months. Unfortunately, the excess water from both creeks are saturating the fields for an extended period of time changing the grass composition and presumably the soil characteristics. This was confirmed through discussion with the Guichon Ranch managers.

Duck's Unlimited Canada Dams

The upper Duck's Unlimited Canada (DUC) dam structure called Flat Meadow Dam. It is an earth embankment with a 5 m wide earth-cut spillway at the left abutment. There is a sump near the right abutment used to pump down the reservoir in June to allow the surrounding area to drain and become usable pasture land.

The lower DUC dam is called Canal Dam and is sometimes referred to as Guichon Flats Dam (Provincial Dam File D130215). It features a 6.6 m wide weir type spillway at an elevation of 642.46 m with a maximum head of 0.54 m (assuming that all the stoplogs are installed). This spillway can pass a flow rate of 1 m^3/s with a 0.2 m head as well as a 1.9 m^3/s flow rate with a 0.3 m head. If the stoplogs were removed the capacity would be even greater.

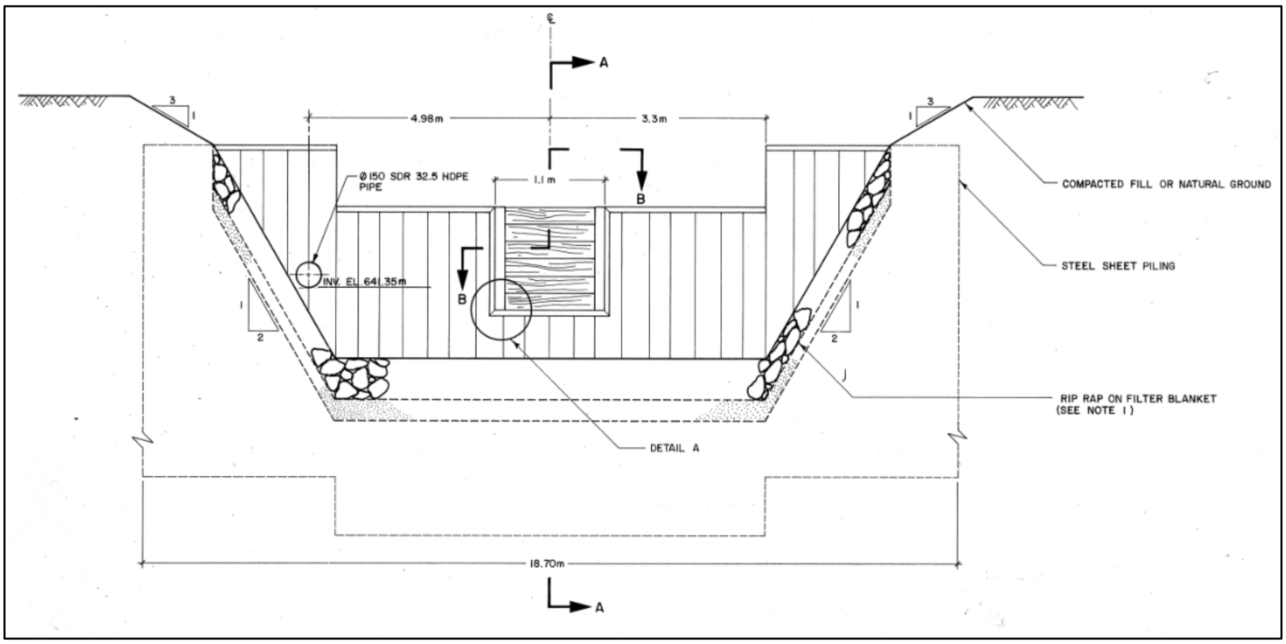


Figure 5-1: Canal Dam Outlet Looking Upstream

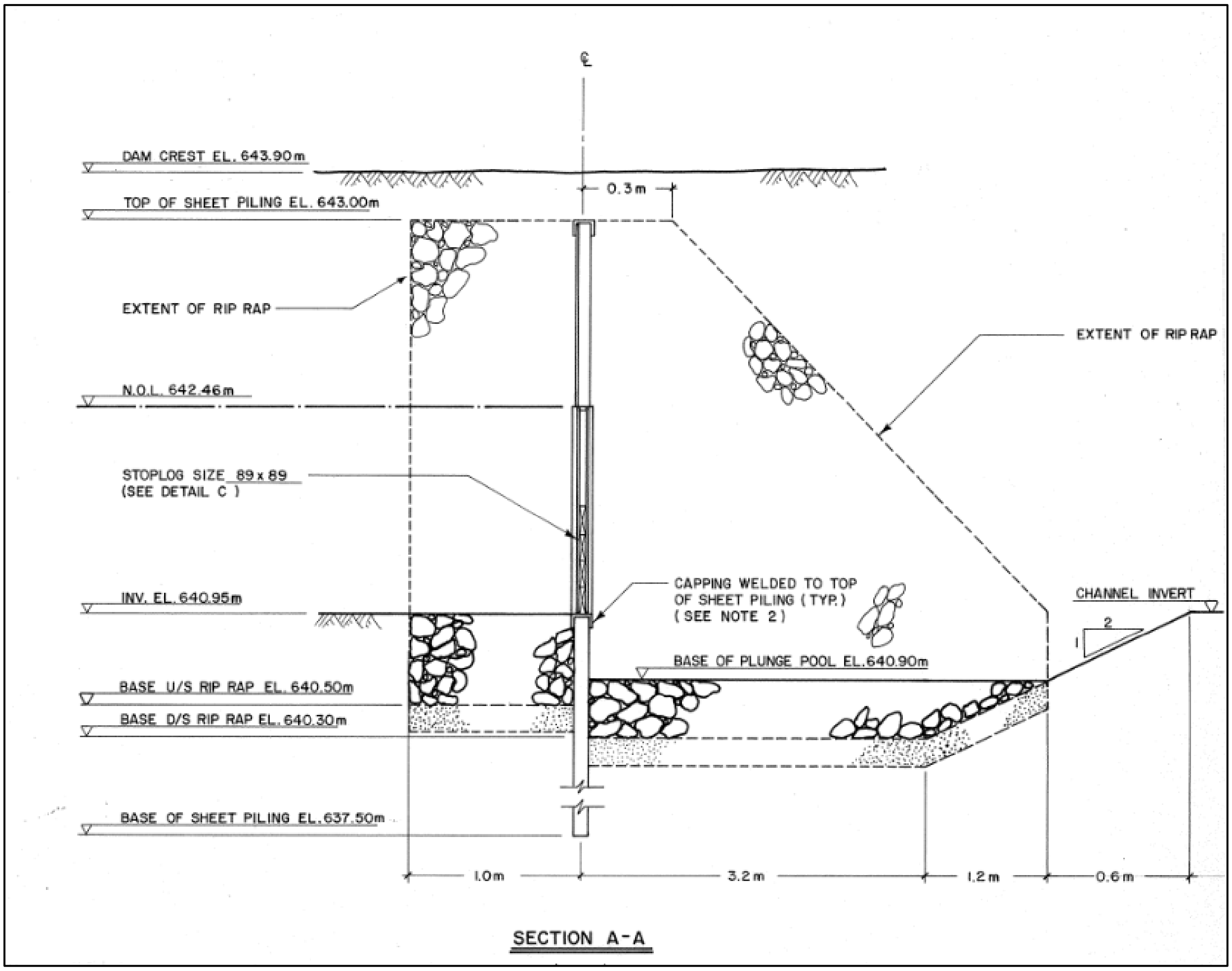


Figure 5-2: Canal Dam Section Side View

Guichon Dam

The Guichon Dam (Provincial Dam File D130220) has two outlets, the left weir-type spillway conveys water to Stumplake Creek downstream of the dam and the right spillway diverts water to Moore Creek. Both spillways divert water for flood irrigation of the lower field. The spillway parameters and capacities were estimated assuming that all the stoplogs were removed as per the provided markups (see below). The left spillway is lower than the right spillway by approximately 0.42 m.

The left spillway features a two-stage weir. The lower section is 1.04 m wide and 0.61 m high (to the invert of the upper weir, but the water level can rise higher than this) and assumed to be sharp-crested as indicated on Figure 5-3 below. The upper section is a broad-crested weir of 3.15 m width and 0.33 m height if measured without the middle portion accounted for by the lower weir.

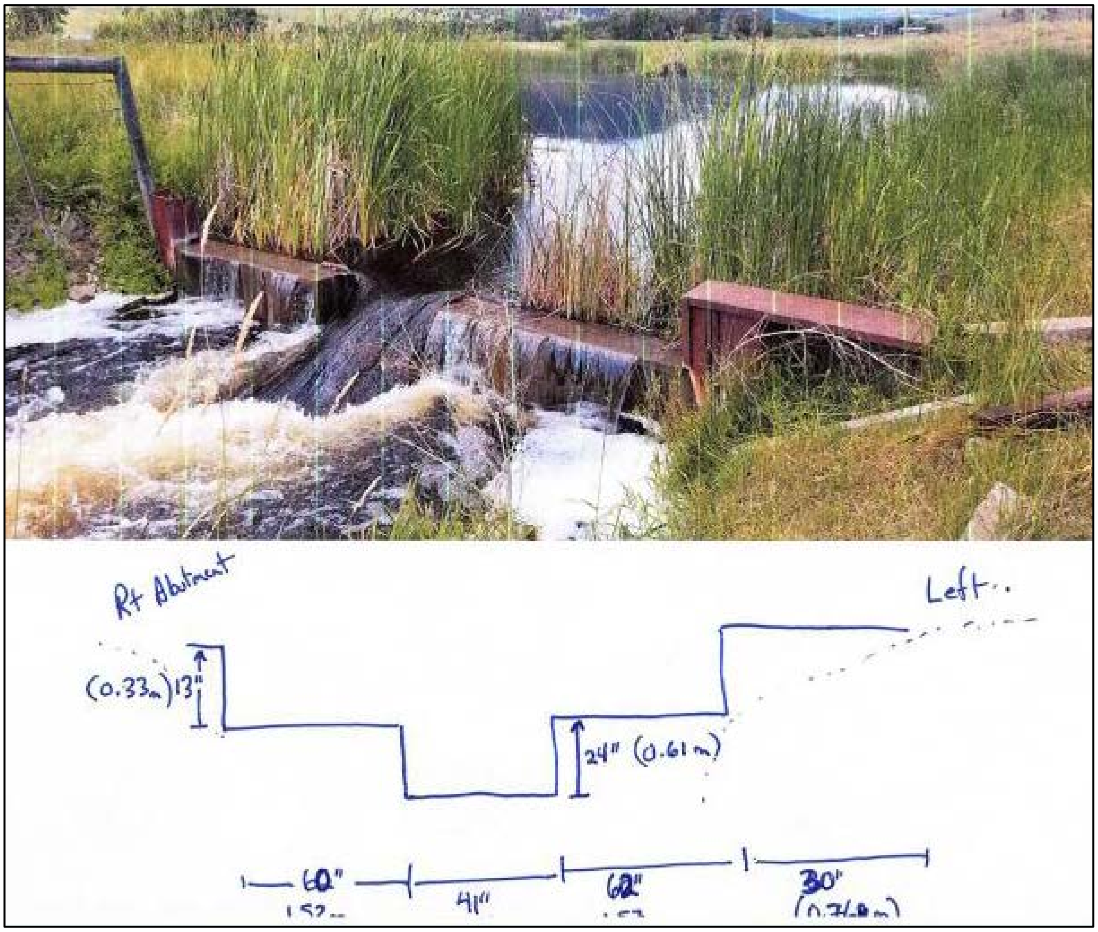


Figure 5-3: Guichon Dam Left Outlet Channel (continuation of Stumplake Creek)

The right spillway features a 1.02 m wide and 0.76 m high weir which is assumed to be sharp-crested as indicated on Figure 5-4 below.

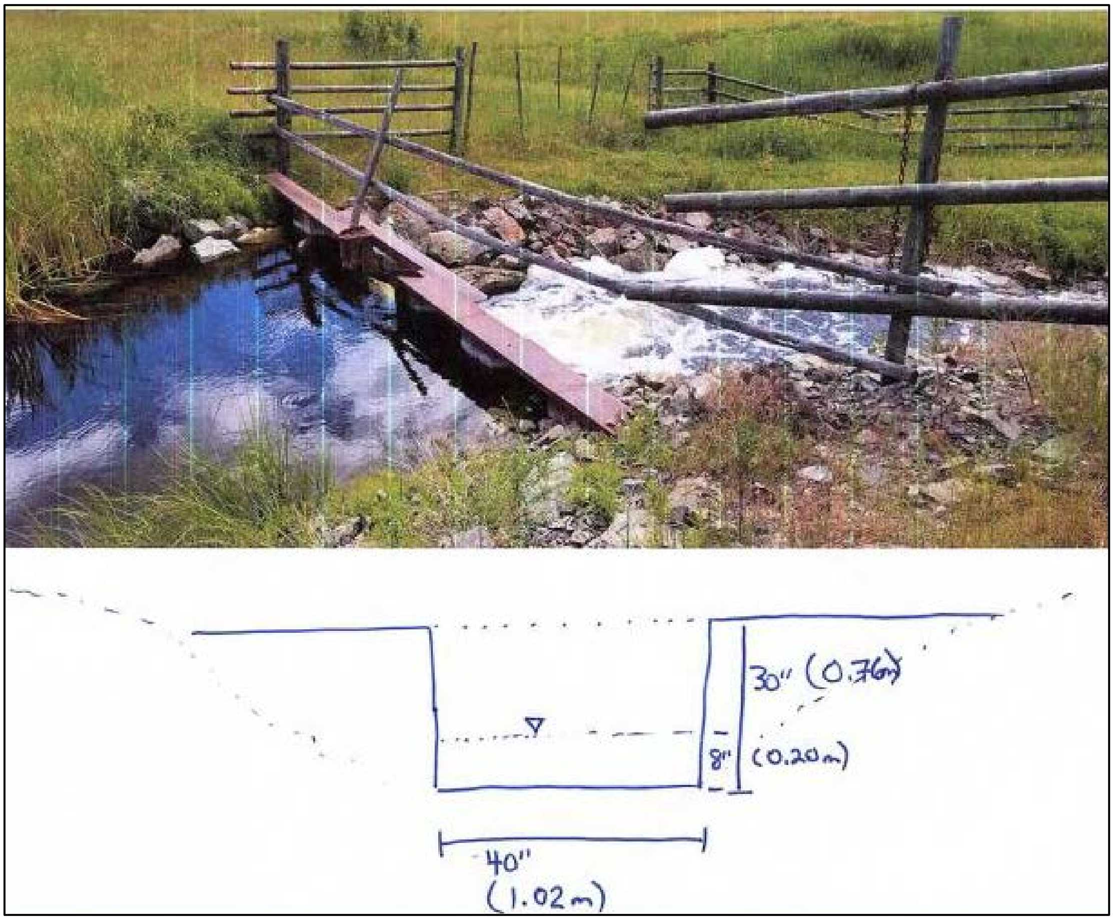


Figure 5-4: Guichon Dam Right Outlet Channel (Re-diversion to Moore Creek).

Table 5-1 below provides the capacity-depth relationship of each spillway and the total of the three.

Table 5-1: Guichon Dam Capacity-Depth Relationship for Spillways

Water Depth to invert of Left Lower Weir (m)	Left Outlet Lower Weir Flow (m^3/s)	Left Outlet Upper Weir Flow (m^3/s)	Right Outlet Weir Flow (m^3/s)	Total Guichon Ranch Pond Outflow (m^3/s)
0	0	0	0	0
0.42*	0.50	0	0	0.50
0.60	0.86	0	0.14	**1.00**
0.61**	0.88	0	0.15	1.03
0.77	1.24	0.29	0.37	**1.90**
0.94***	1.69	1.01	0.67	3.37
* invert of right spillway ** invert of left spillway *** top of left spillway				

The capacity of three spillways is 3.37 m^3/s and is reached when the water depth in the left outlet reaches the top of the upper weir. At this pond level, the flow through the right spillway is below the top of the weir (0.52 m depth of the 0.76 m weir height). The spillways can pass 1.0 m^3/s with a depth of 0.60 m on the left and 0.18 m on the right (the left outlet upper weir is dry). The spillways can pass 1.9 m^3/s with a depth of 0.77 m on the left and 0.35 m on the right.

5.2 Water Balance – Improved Outlet

The inflow hydrograph used for the improved outlet simulation was composed of the synthetic hydrographs for three years, the first two years preceding the design condition correspond to the 2018 and 2020 freshet periods; and the last year corresponds to the design condition defined by the 200-year freshet which starts on April 1 as described in the year 2021 hypothetical freshet scenario simulation. The water balance was run iteratively until the design criteria for peak lake level and outflow rate were achieved.

Water Balance Results

A single test with an improved outlet to achieve the above criteria was performed. This test used a hypothetical orifice outlet with the assumption that the outlet channel would be enlarged as required to deliver the flow to the control structure that would likely be located several hundred metres downstream of the lake.

An iterative process of adjusting the orifice diameter and invert elevation was performed until the 200-year peak lake water elevation equalled 743.5 m and the outflow was reasonable during the two preceding years (near 1 m^3/s average). The resulting outlet size was an 800 mm orifice at invert elevation 741.0 m. The peak outflow during the 200-year freshet with the orifice outlet was estimated at 1.9 m^3/s. This flow was used to check the downstream structure capacity in the preceding section.

Instead of an orifice located at a downstream control structure, a pipe of equivalent hydraulics could be constructed from the lake to the outlet channel where the invert elevation is approximately 739.5 m (assuming the pipe is placed following a 0.37 % slope). The pipe would be constructed along the outlet channel alignment and the backfill would be placed such that the high spot in the outlet channel would be 743.5 m and therefore channel flow would only happen with freshets that are greater than the 200-year return period.

This improved outlet would have resulted in the 2018 freshet reaching a peak water level of 741.6 m, a 2020 freshet of 742.4 m, and a 200-year freshet of 743.4 m. The peak outflow during the 200-year freshet with the improved pipe outlet was estimated at 1.2 m^3/s. During most years, the outflow rate would be lower than 1 m^3/s. Table 5-2 below provides the results of the estimated lake parameters for the design condition.

Table 5-2: Estimated Stump Lake Peak Parameters for the Improved Outlet Condition

Parameter	Maximum Inflow (m^3/s)	Maximum Outflow (m^3/s)	Maximum Water Elevation (m)	Time of Occurrence
Simulated	26.4	1.2	743.4	June 24

Figure 5-5 below shows the inflow and outflow hydrographs as well as the simulated lake water elevations for the improved outlet condition.

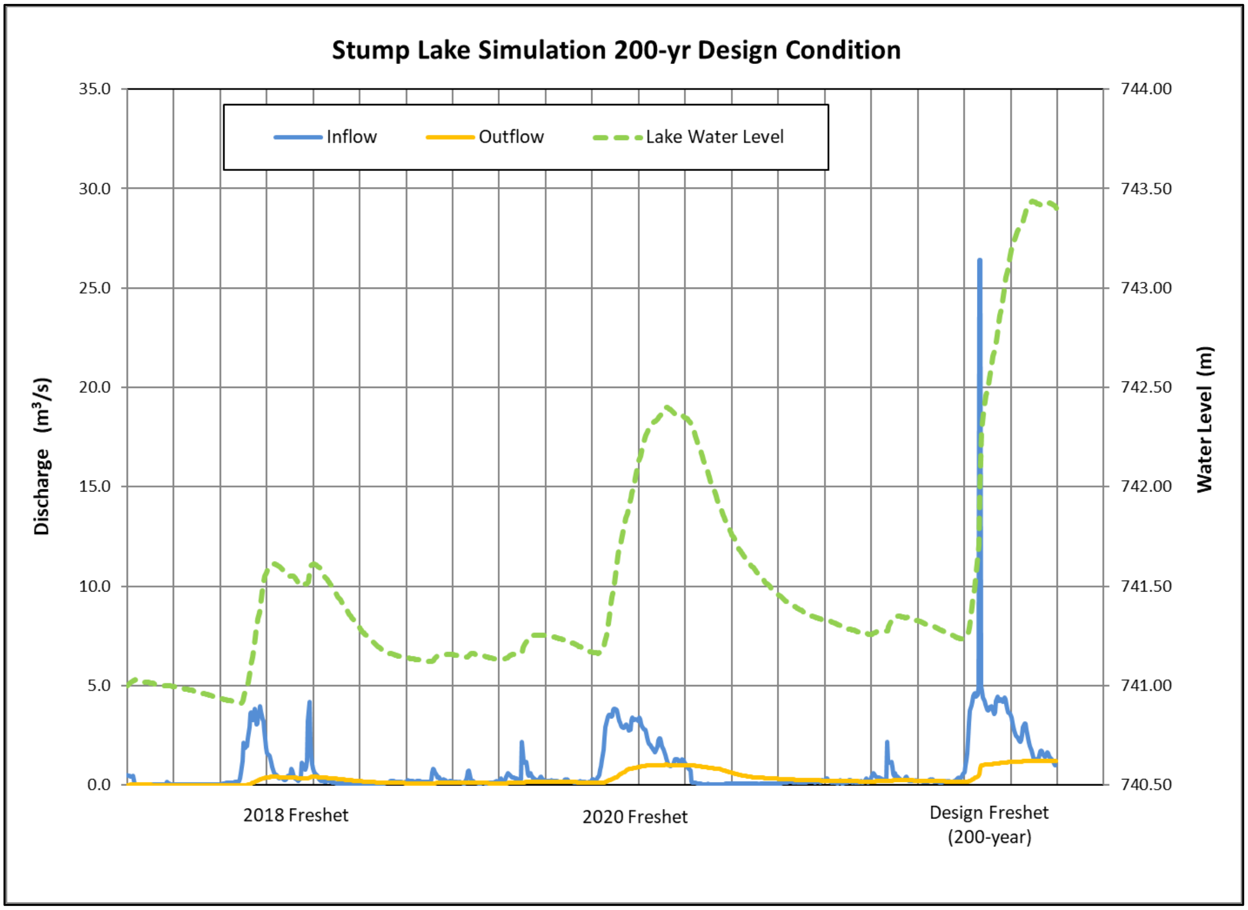


Figure 5-5: Stump Lake Water Balance for Improved Outlet

5.3 Interim Mitigation of 2021 Freshet

If water elevation predictions assessed in Section 4.2 are unacceptable for the freshet 2021, it will be necessary to proceed with a drawdown option in advance of the long term works being established. The short-term options were presented in the KWL technical memorandum (May 1, 2018).

6. Long-Term Solution

6.1 Improved Lake Outlet Design

Lowering the current lake water elevation is a potential solution to alleviate the flooding impacts around Stump Lake and therefore the outlet pipe proposed in Section 5.2 could be the long-term solution to achieve an overall decrease of the lake levels while safely releasing flow downstream.

Drawing C101 (Figure 6-1) shows the proposed pipe alignment and new outlet channel on plan view and longitudinal profile for the design condition.

Pipe Inlet

The proposed conceptual design consists of a 900 mm HDPE pipe with a concrete headwall, debris rack, and a gate valve at the inlet of the pipe. This diameter is the standard size above the minimum calculated as required in the design.

The inlet configuration also includes guardrails at the top of the headwall for safety purposes as well as an access road to Planet Road to facilitate regular maintenance operations and site inspections.

Pipe Outlet

At the downstream end of the pipe, a riprap channel lining may also be required to provide erosion protection and dissipate energy at this location.

Alignment and Overflow

It is recommended that the proposed pipe and new outlet channel follow the existing natural channel alignment as much as possible. The pipe will be placed and buried under the new channel; and therefore, all excavated material will be used to construct the new outlet channel (backfill to a maximum bottom elevation at 743.5 m). For the 900 mm HDPE (SDR 17) pipe, it is recommended to maintain a minimum radius bend of 23 m when welding the lengths together.

Air Release Vents

The installation of two air vents along the pipe is also proposed to allow the safe release of trapped air and reduce the potential for damage.

Rock Outcrops

It is unclear the exact locations of rock outcrops along the outlet channel that may need significant excavation and/or blasting to proceed with the proposed design. It is assumed that approximately 100 m of the pipe's length would require blasting of rock to create the pipe trench, however, further investigation is required to fully identify and verify these locations.

Fish Passage

At this time, a separate environmental assessment is currently being completed to determine the fish passage requirements. The design details will need to be determined to finalize the design.

PLAN

Scale 1:750

0 10 (1:750) 40m

PROFILE

Scale H 1:750: V 1:150

0 10 (1:750) 40m

KERR WOOD LEIDAL
consulting engineers

Info:

Seal:

Rev	Date	Des	Dwn	Chk	Description
A	2020-09-25	ASB	TMIN	DZ	FOR REVIEW
0	2020-10-05	ASB	TMIN	DZ	FINAL

THOMPSON-NICOLA REGIONAL DISTRICT
IMPROVED OUTLET DESIGN - CONCEPTUAL

STUMP LAKE WATER LEVEL CONTROL STRUCTURE

Project No.	Drawing No.	Rev.
2755.008	C-101	0

Group: CIVIL

6.2 Downstream Channel Improvements

Guichon Channel Development

In order to prevent the anticipating ongoing impacts to the Guichon property, the construction of a channel through the pasture containing water from Stumplake Creek and Peter Hope Creek would:

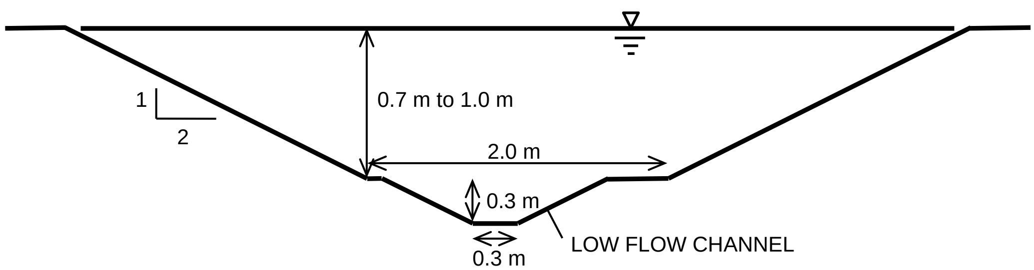
a) allow improved flood irrigation management;

b) control excess water from entering the fields, thereby allowing the fields to dry out for improved grass utilization; and

c) minimize the ongoing alkalinity changes to the soil chemistry.

A conceptual design includes:

- a 4.6 km long channel from approximately 500 m downstream of the Peter Hope Creek confluence to the upper DUC pond;
- a 2-year channel capacity of 3.3 m^3/s which includes the attenuated Stump Lake outflow of 0.3 m^3/s, plus the unattenuated flow from the catchment downstream of Stump Lake of 3.0 m^3/s). Refer to the sketch below;
- a trapezoidal cross section (2 m base width with 2H:1V side slopes, 0.7 m to 1.0 m deep depending on channel slope) with a meandering low-flow thalweg channel (0.3 m base width with 2H:1V side slopes, 0.3 m deep);
- a channel slope that matches the existing topography along the channel (approximately 1.5% for the upstream 2 km and 0.11% for the downstream 2.6 km); and
- riprap lining (D_{50} = 150 mm) in the steeper 2 km long upstream section and gravel lining (D_{50} = 19 mm) in the flatter 2.6 km long downstream section.



Typical Conceptual Guichon Channel Cross Section

It was beyond the scope of this study to determine the incremental costs caused by the altered timing and flow rates from the improved Stump Lake outflow through the Guichon channel versus the naturally occurring outflow from either lake.

Fish Habitat

Fish habitat was not contemplated in the conceptual channel design; however, depending on the results of the environmental assessment, habitat complexing may be required.

6.3 Costs

Class D costs were estimated for the design and construction of the Stump Lake improved outlet and for the improved Guichon channel. The Class D cost estimates are based on typical per unit length/area/ volume costs that do not account for site-specific information. The costs include allowances for:

- Mobilization and Demobilization (6%)
- Insurance and Bonding (2%)
- Engineering (20%); and
- Contingency (40%).

The Stump Lake Outlet includes: excavation, blasting, HDPE pipe, cast-in-place inlet headwall with grate, manual gate valve, precast outlet headwall, imported and native backfill, riprap, hydroseeding, and environmental protection. The total Class D estimated cost is $2.2 M.

The Guichon Channel includes: excavation, offsite disposal, riprap, gravel, and environmental protection. The total Class D estimated cost is $2.8 M.

7. Summary

KWL developed a series of water balance simulations for Stump Lake to obtain lake level estimates for different freshet events and outlet configurations. The water balance models were built based on simplified assumptions and limited available data for the site. The design values summarized in Table 7-1 provide results for an improved outlet that meets the proposed design criteria.

Table 7-1: Design Parameters

Parameter	Value
Stump Lake Improved Outlet	
Pipe	
Pipe Material	SDR17 HDPE
Diameter (mm)	900
200-Year Design Flow (m^3/s)	1.2
Pipe Inlet Invert Elevation (m)	741.00
Pipe Outlet Invert Elevation (m)	739.50
Total Length (m)	410
Slope (%)	0.37
Overflow Channel	
Channel Upstream Invert Elevation (m)	743.50
Channel Downstream Invert Elevation (m)	743.00
Channel Base Width (m)	1.0
Channel Depth (m)	0.5
Side Slopes	2H:1V
Riprap D_{50} (mm)	150
Guichon Channel	
Upstream 2 km Section	
Channel Slope	1.5%
Channel Base Width (m)	2.0
Channel Depth (m)	0.7
Low Flow Channel Base Width (m)	0.3
Low Flow Channel Depth (m)	0.3
Side Slopes	2H:1V
Riprap D_{50} (mm)	150

Parameter	Value
Downstream 2.6 km Section	
Channel Slope	0.11%
Channel Base Width (m)	2.0
Channel Depth (m)	1.0
Low Flow Channel Base Width (m)	0.3
Low Flow Channel Depth (m)	0.3
Side Slopes	2H:1V
Gravel D_{50} (mm)	19

Submission

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Statement of Limitations

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Revision History

Revision #	Date	Status	Revision Description	Author
0	October 5, 2020	Final	Issued as final for client copy.	ABS/DZ/DWM

OQM CERTIFIED