DISTRICT OF SQUAMISH
PROJECT #: 18P-00095-00

SQUAMISH RIVER DIKE UPGRADE
UPPER JUDD (JIMMY-JIMMY) SLOUGH
SLOUGH INFLOW CULVERT OPERATING STRATEGY

JANUARY 21, 2020

QUALITY MANAGEMENT

ISSUE/REVISION	DRAFT	FINAL		
Date	9-Sep-2019	21-Jan-2020		
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File reference	18P-00095-00			

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1 BACKGROUND AND OBJECTIVES

1.1 PROJECT DESCRIPTION

Judd Slough (also referred to as Jimmy-Jimmy Slough) is located within the community of Brackendale in the District of Squamish (the District). The slough was formerly a sidechannel of the Squamish River which was isolated hydraulically when the dike was constructed. The District is interested in providing a culvert at the north end of Judd Slough to provide inflow for improvement of spawning habitat within the Slough. The culvert would be operated seasonally in the summer/early fall, introducing flow from the Squamish River into the Slough. Fish passage would continue to occur at the south end when the outlet gates are open.

There is an existing culvert which is reported to have been deactivated following the by collapsing the outlet. There are anectodal records of seepage observed on the landside of the culvert during a recent flooding event.

1.2 PURPOSE

A feasibility study has been completed by WSP[1]. The purpose of this document is to describe the operating strategy developed for the proposed culvert.

1.3 CONSIDERATIONS

Key considerations for the operating strategy include:

- Maintaining flood protection without compromise
- Achieving flow velocities required for scouring sediments and exposing gravels to encourage fish spawning
- Providing flow in the Slough during fish migration periods (attraction flows)
- Balancing capital costs with operational costs
- Emergency preparedness

[1] "Squamish River Dike Upgrade Upper Judd (Jimmy-Jimmy) Slough: Slough Inflow Culvert Feasibility Memorandum", WSP, July XX 2019.

2 FLOOD PROTECTION

The proposed inflow culvert can affect flood protection through three key mechanisms:

- Exceeding the flow capacity of the Slough if inflow coincides with heavy runoff from stormwater
- Exceeding the maximum allowable water level in the Slough if there is insufficient flow out of the Slough at the south end
- Reducing stormwater storage volumes in the Slough

The Slough is divided conceptually into four reaches. In Reaches #1 and 2, the water level is controlled by the channel hydraulics. The water level in Reaches #3 and 4 is governed by the backwater from the pond located downstream of the Slough. Additional detail is provided in the Feasibility Report[2].

Historically, flooding has only been documented during high river levels caused by storm events. During these events, discharge by gravity through the flood box is not possible. Flooding has occurred when the capacity of the Judd Slough Pump Stations is exceeded. Based on our observations during the flood event on August 2, 2019, river levels peaked approximately 12 hours after the peak rainfall.

2.1 INFLOW DURING STORM EVENTS

The design inflow for the proposed culvert is 3.3 m^3/s, as determined in the Feasibility Report. If the sluice gate is open during a storm event, then the combination of the inflow from the proposed culvert and from surface runoff could exceed the Slough's capacity. If the flow through the proposed culvert exceeds the Slough capacity, then the banks of the Slough could be breached, causing flooding.

Comment: Provided that the culvert is closed during storm events or high river levels, and that the design flowrate of 3.3 m^3/s is not exceeded, there is limited concern that the combined flows will exceed the Slough's capacity.

2.2 MAXIMUM WATER LEVEL AT OUTLET

If the water level builds up near the Slough outlet, it could cause damage to properties in Reaches 3 and 4. The maximum allowable operating level in the flood box is 9.23 m, based on the flood box record drawings[3]. Furthermore, furnishings were observed in properties at an elevation of approximately 8.7 m during WSP's site visit.

Comment: The capacity of the Slough outlet culverts at the flood box exceeds the capacity of the Slough. Provided that the inflow is below the specified 3.3 m^3/s maximum, the water level at the outlet will generally be less than 8.7 m.

The exception would be during very high river levels when the gates at the outlet culverts are closed, and the Judd Slough Pump Stations are running. The inlet culvert should be closed whenever the pond elevation is raised above its usual level of ~8.3 m due to backwater in the Squamish River. Based on our review of historical river levels and observations of the pond level downstream of the Slough, flow from the Slough into the Squamish River is achieved by gravity the overwhelming majority of the time. We estimate that pumping is required for approximately a two-year return period event.

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[2] "Squamish River Dike Upgrade Upper Judd (Jimmy-Jimmy) Slough: Slough Inflow Culvert Feasibility Memorandum", WSP, January 21 2020.

[3] Judd Slough Outlet Control Structure Record Drawings (Department of Lands, Forests and Water Resources, Water Resources Service, Water Investigations Branch, 1975)—Sheets 1-3 of 3.

2.3 REDUCTION IN STORAGE VOLUME

Inflow through the proposed culvert will increase the water level in the Slough, thereby reducing the Slough's storage capacity during a storm event.

Comment: The culvert should be closed and the Slough should be allowed to drain in advance of precipitation events, providing full storage capacity for flood protection.

3 CONTROL REQUIREMENTS

To provide inflow through the proposed culvert without compromising flood protection, the operating strategy includes the following provisions:

- The culvert shall be closed in advance of any heavy rainfall event.
- The culvert shall be closed when the water level in the pond downstream of the Slough exceeds the usual 8.3 m.
- The culvert shall be throttled, if required, to keep the flows below 3.3 m^3/s.

3.1 CLOSURE FOR RAINFALL

Weather forecasts should be checked daily by operations personnel.

The culvert shall be closed a minimum of 24 hours in advance of any rainfall event with more than 10 mm of precipitation forecast in a single day.

3.2 CLOSURE FOR POND LEVEL

A level alarm should be set for the pond level downstream of the Slough. An alarm would be activated if:

- The culvert is open to flow, AND
- The pond level exceeds the level setpoint.

Operators would close the culvert in response to the alarm.

3.3 FLOW CONTROL

Up to a headwater elevation of 11.3 m, the culvert can be kept fully open without exceeding the design flow of 3.3 m^3/s. If the culvert is operated for headwater elevations greater than 11.3 m, the following table is provided assuming a 2400 x 900 mm culvert and sluice gate based on a desired flow of 3.3 m^3/s.

Headwater Elevation (m)	Sluice gate opening (m)	% open
11.4	0.52	58%
11.6	0.47	52%
11.8	0.43	48%
12	0.40	44%
12.2	0.38	42%
12.4	0.36	40%
12.6	0.34	38%
12.8	0.33	37%
13	0.31	34%

4 OPERATING SEASON

The culvert is proposed to be closed the majority of the year, to be opened only on a seasonal basis. The choice of operating season depends on three major factors:

- River levels
- Frequency of storm events
- Fisheries requirements

WSP's considerations for river levels are based on the historical data at the Environment Canada Brackendale monitoring station between 2011 and 2017. The operating season may require adjustment as more data becomes available.

4.1 SCOURING

To achieve high flow velocities and optimize scouring, the culvert should be operated during relatively high levels in the Squamish River, subject to the operational criteria described earlier in this document. Based on records at the Brackendale Environment Canada monitoring station, average river levels are highest in July, reducing steadily until December, then increasing again starting in March.

From May to September, the historical average river levels have been high enough to achieve the design flowrate of 3.3 m^3/s.

From an operational standpoint, it would be advantageous to operate the culvert during the driest period possible to minimize the number of times that the culvert is closed and re-opened for storm events.

Recommendation: The culvert should be operated during July and August to achieve scouring velocities while minimizing operations during storm events.

4.2 ATTRACTION FLOWS

Attraction flows are desirable in October while salmonids are travelling upstream to lay eggs. Attraction flows would be perceived by fish in the Squamish River. The majority of the time[4], flow from Judd Slough is discharged into a channel south of the dike. The channel runs parallel to the dike, discharging to the east, picking up flow from both Judd Slough and Horse Creek before discharging into the Squamish River. At the discharge point, the channel is approximately 30 m wide.

In October, the average historical river level is 10.65 m, which would achieve a flowrate of 0.78 m^3/s through a 2400 x 900 mm box culvert at the slough inlet. At the outlet of the Slough discharge channel into the Squamish River, the channel is approximately 30 m wide. Assuming a Manning's roughness coefficient of n=0.04, and a channel slope of 0.1%, a velocity of 0.20 m/s is roughly estimated, with a flow depth of approximately 0.1 m. The actual flow depth would be deeper at the thalweg, and would likely not extend across the entire 30 m channel.

[4] The exception is during flooding events, when the Squamish River level is above the sand bank separating the Channel from the River.

5 CONTINGENCY

Two sluice gates are proposed in a chamber, located near the middle of the dike. The gates are accessible from the top of dike, so that the sluice gates can be closed during high river levels, if they have been left open due to equipment or operator error. Having two gates provides redundancy, allowing a second level of protection if one of the gates is unable to be closed fully.

Inability to close both gates is extremely unlikely. However, in this event, the contingency would involve blocking the culvert at the sluice gate chamber with the assistance of machinery.

6 LIMITATIONS AND ASSUMPTIONS

This operating strategy is based on calculated flows and historical data within a narrow timeframe (2011-2017). Actual water levels within the Slough should be monitored carefully during the first year of operation for the culvert.

The hydraulic calculations assume uniform flow and simplified channel cross sections. Although the calculations are considered suitable for purposes of this operating strategy, actual flow patterns are likely to differ significantly from the estimates in this report.

This operating strategy does not attempt to resolve the flood protection concerns during high river levels, due to the reported under-capacity of the Judd Slough Pump Stations. The pump stations should be assessed, and upgraded if required, as part of a separate project.

APPENDICES

BOUND SEPARATELY

Judd Slough Inflow Culvert
WSP Project #: 18P-00095-00
River Level Measurements

2019-Jan-07

UPSTREAM
Measured - 10.4
Env Canada - 2.36 (assume 10 a.m.)
Correction - 8.04

DOWNSTREAM
Measured - 8.0 (in pond)
Env Canada - 2.36 (assume 10 a.m.)

2019-Jun-11

UPSTREAM @ 11:30
Measured - 11.3 m
Env Canada – 3.349
Correction – 7.95

2019-Jul-03

UPSTREAM @ 08:26
Measured - 11.4 m
Env Canada – 3.731
Correction – 7.669

2019-Jul-19

UPSTREAM @ 07:56
Measured - ~12.0 @ 0756
Env Canada - 3.609
Correction - 8.39

DOWNSTREAM @ 0745
Measured - ~8.3 (in pond)
Env Canada - 3.604

2019-Aug-02 (~1 year storm event)

DOWNSTREAM @ 1400
Measured - ~8.3
Env Canada - 5.983

DOWNSTREAM @ 1900
Measured - ~8.4
Env Canada - 5.831

UPSTREAM @ 1930
Measured - 13.3
Env Canada - 5.803
Correction - 7.50

2019-Aug-15

DOWNSTREAM @ 0915
Measured – ~8.3
Env Canada – 3.338

UPSTREAM @ 1000
Measured – 11.4 (~ 1 m below top of headwall)
Env Canada – 3.308
Correction – 8.09