
Subject	Summary of Stream Hydrology for Stream X	Project Name	EGP Tunnel Discharge Capacity Assessment
Attention	Darrin Marshall, FortisBC Energy Inc (FortisBC)		
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Status	Final		

1. Introduction and Project Description

The FortisBC Energy Inc. (FortisBC) Eagle Mountain - Woodfibre Gas Pipeline Project (EGP Project) involves the construction of an approximately 9 km tunnel (EGP Tunnel) from the BC Rail Properties Ltd. (BC Rail Site) to the proposed Woodfibre Liquefied Natural Gas Ltd. (WLNG) production facility (WLNG Site) in Squamish, BC. The ultimate purpose of the EGP Tunnel is to enclose a NPS 24 (610 mm O.D.) natural gas pipeline.

Tunnel construction activities will require the extraction of water as well as the disposal of treated water. Three potential locations for water discharge at the WLNG Site have been evaluated including the following:

- A non-fish bearing stream south of the Woodfibre Portal within the WLNG Site (Stream X or Stream N)
- Direct discharge onto Howe Sound
- A non-fish bearing stream south-east of the Woodfibre Portal within the WLNG Site (Stream Q)

Discharge directly onto Howe Sound was not considered as an option for the following reasons: anticipated concerns from First Nations and the public from discharging directly onto the marine environment; cost and schedule implications from requiring to conduct a year-long sampling program to determine background conditions of the receiving environment; and the need to develop a comprehensive mitigation and monitoring plan due to potential environmental impacts to marine ecosystems.

Jacobs and McMillen Jacobs Associates conducted a field visit to the WLNG Site on August 20, 2020 to evaluate Stream X and Stream Q. Stream Q was observed as a small creek with sections of bedrock control which increases the risk of lateral scour with increased flows (Figure 1). Based on this observation it was determined that Stream Q was not a suitable discharge location for the EGP Tunnel. As such, Stream X,

located immediately adjacent to the Woodfibre Portal, has been selected as the preferred discharge location. The condition of Reach B along Stream X as observed during the site visit is summarized in Section 5 of this memorandum.



Figure 1 Stream Q approximately 60 m upstream of Howe Sound, Photo taken looking downstream, August 20, 2020

In addition to the proposed treated water discharge from the EGP Tunnel, several new stormwater discharges to Stream X are currently proposed as part of the planned works within the WLNG Site (see Appendix A). These include the following:

- Runoff from the V2 Compressor Station during construction and operations (to Reach D);
- Runoff from the planned WLNG landfill closure (to Reach B);
- Runoff from the Custody Transfer Station (CTS) during construction and operations (to Reach B); and
- Runoff during construction from Woodfibre Portal (to Reach A).

Estimates of the proposed stormwater discharge volumes and the existing flows in Stream X at the proposed stormwater discharge locations have been estimated by others. However, to date none of the proposed studies have considered the impact on Stream X resulting from the combined flow from all discharges.

To support the EGP Tunnel Waste Discharge Authorization under the *Environmental Management Act*, a capacity assessment of Stream X downstream of the point of discharge (Reach A) is proposed. This memorandum provides a summary of the proposed stormwater discharges, upstream of the point of

discharge; these data are required as inputs to the hydraulic capacity assessment. It is proposed that for the EGP Tunnel water discharge, the hydraulic capacity of the stream be assessed for the 1 in 10-year runoff event, given that the discharge is associated with the short-term dewatering of the tunnel during construction.

This memorandum also documents the anticipated increases in flows to Stream X resulting from future development at the WLNG Site. This information will support permitting activities, and also informs the need for stream rehabilitation works downstream of the point of discharge.

2. Other Studies/Designs

The information presented herein was based on a review of available reports of work completed by others, on the following project components:

2.1 V2 Compressor Station and CTS Sites

A Flood Hazard Assessment and Site Hydrology Report was completed for the V2 Compressor Station and CTS Sites, both located upstream of the proposed tunnel water discharge location.

The Flood Hazard Assessment analyzed the potential for flooding at the proposed V2 Compressor Station and CTS as well as the erosion hazards along with proposed mitigation measures. The report details that runoff from the V2 Compressor Station is to be conveyed via drainage swales to nearby watercourses and water from the upgradient slopes is to be diverted via drainage ditches. The report states that the hydrological modelling of the catchment included runoff flows from the closed landfill, however, no details are provided on this within the report. Hydraulic modelling results suggests that sections of Stream X, downstream of the proposed V2 Compressor Station and CTS are subject to erosion and armoring of banks will be required. Additionally, it is reported that reaches of Stream X do not appear to have sufficient hydraulic capacity to convey the 1:200-year clear water flows and modification of the channel geometry is required.

2.2 Woodfibre Landfill Closure

The Woodfibre landfill is located downstream of the V2 Compressor Station, and upgradient of the CTS and EGP Tunnel water discharge location. The Woodfibre landfill is planned to be closed and an impervious geomembrane cap will be placed across the landfill site.

Surface water management for the landfill included analysis of precipitation and discharge to Stream X. The Woodfibre Landfill Closure Plan (Revision 2) Report (SHA, 2019) concluded that there is no downstream flooding risk as the discharging streams report to the ocean and that there is no significant change to the post-closure runoff volumes relative to the pre-development condition. This conclusion is not supported by other documents reviewed.

A pre-closure flow assessment and interim report was prepared by Keystone Environmental (2020) to calculate leachate storage requirements and to determine if a portion of stormwater collected onsite could be diverted to Reach C along Stream X post-closure.

2.3 Woodfibre Portal Laydown

The proposed Woodfibre Portal is located upstream of the proposed EGP Tunnel water discharge adjacent to Reach B. Following construction of the Woodfibre Portal, the construction laydown area will be repurposed for the construction of the CTS.

The Woodfibre Portal - Alternate Design with Increased Laydown memorandum was prepared by McMillen Jacobs Associates (2019) for FortisBC and presents four options to maximize the Construction Laydown Area. These options consider placing a portion of Reach C along Stream X in a culvert. The memorandum presents design details for the Woodfibre Portal culvert along Reach B. To support the sizing of the culverts, peak flow rates on Stream X (Reach C) are estimated.

2.4 Other Documents Referenced

2.4.1 Mill Creek Flood Study

An extract from this study was provided for review and provides the design precipitation events.

2.4.2 Woodfibre LNG Design Basis

An extract from this document was provided for review and provides the design precipitation events.

3. Hydrology Inputs

The hydrological inputs used in the estimate of Stream X flows and proposed stormwater discharge are not consistent between studies and reports. The hydrological input parameters used in the analysis and design of the project components discussed in Section 2 are presented in Table 1.

Table 1 Hydrological Design Parameters

Report Reference	Rainfall Intensity (mm/hour)	Precipitation Source	Duration	Return Period	Comment
AMEC Foster Wheeler 2015	11.5	Woodfibre 1960-2006 (ECCC ID 1048974)	24-hour	1:200 year	
Woodfibre LNG 2020	5.9	Unknown	24-hour	1:50 year	
Golder 2020	16.2	Squamish Airport 1982-1991 (ECCC ID 10476F0)	24-hour	1:200 year	Considers climate change and orographic effect
McMillen Jacobs Associates 2019	26.7	Squamish Airport 1982-1991 (ECCC ID 10476F0)	0.75-hour	1:200 year	

Report Reference	Rainfall Intensity (mm/hour)	Precipitation Source	Duration	Return Period	Comment
Keystone Environmental 2020	2.0	NA ^a	24-hour	~ 40% of the 2-year	
Sperling Hansen Associates Inc 2019	110	Squamish Central 1986 to 2005	5-minute	1:100 year	For sizing landfill infrastructure
^a Rainfall based on observed maximum rainfall and compared to ECCC Normals for "Squamish Upper" (ECCC ID 1048974) and 2018/2019 precipitation data from "Squamish Airport" (ECCC ID 1048974) ECCC – Environment and Climate Change Canada					

4. Flow Estimates

Existing Stream X flow estimates were calculated by others, for the studies listed in Section 2 and are presented in Table 2. As with the hydrological inputs, there is inconsistency with the flow estimate methodology and input data. While the Flood Hazard Assessment and Site Hydrology Report (Golder, 2020), notes that the stream flow estimates do include predicted runoff from the closed landfill, the other studies reviewed do not consider the additional flow in Stream X resulting from the proposed upstream discharges.

Table 2 Stream X Flow Estimates

Location of Stream X Flow Estimate	Flow Estimate	Return Period	Methodology	Reference
Downstream of V2 Compressor Station (Reach D)	3.4 m ³ /s	1:200 year	Soil Conservation Service (SCS) Method	Golder 2020
Within vicinity of V2 Compressor Station or CTS ^b	0.7 m ³ /s	Annual 10-year daily average historical flow ^c	Rational Method and runoff coefficient of 0.8	Golder 2020
Downstream of Landfill (between Reach D and C)	0.23 m ³ /s ^a	Approx. 40 percent of the 2-year	Rational Method	Keystone Environmental 2020
Upstream of Proposed Woodfibre Portal Culvert (between Reach C and B)	3.6 m ³ /s	1:200 year	Rational Method and runoff coefficient of 1.0	McMillen Jacobs Associates 2019
Downstream of CTS/Construction Laydown Area (between Reach B and A)	10.1 m ³ /s	1:200 year	Soil Conservation Service (SCS) Method	Golder 2020
^a Observed flow during storm event				

Location of Stream X Flow Estimate	Flow Estimate	Return Period	Methodology	Reference
^b Specific location of flow estimate not presented ^c Report does not state what rainfall intensity and duration was used for 10-year return period				

A summary of the proposed stormwater discharges to Stream X from future development at the WLNG Site, where available are presented in Table 3. Data presented includes the estimated discharge rate at the point of discharge and the return period for the design flow calculation methodology.

Table 3 Proposed Discharges to Stream X

Location of Proposed Discharge	Flow Estimate	Return Period	Methodology	Reference
V2 Compressor Station Stormwater (Reach A)	0.004 m ³ /s	Annual 10-year daily average historical flow ^c	Rational Method. Runoff Coefficient of 0.9	Golder 2020
Landfill Runoff (between Reach C and D)	0.0169 m ³ /s ^a	~ 40 percent of 1:2 year	Rational Method	Keystone Environmental 2020
Landfill Runoff (between Reach C and D)	1.108 m ³ /s	1:100 year	Unknown	Sperling Hansen Associates Inc 2020
CTS Stormwater (between Reach A and B)	0.004 m ³ /s	Annual 10-year daily average historical flow ^c	Rational Method. Runoff Coefficient of 0.9	Golder 2020
Woodfibre Portal and Construction Laydown Runoff (between Reach A and B)	Unknown	N/A	N/A	N/A
EGP Tunnel Water Discharge ^b (between Reach A and B)	0.017 m ³ /s (1,470 m ³ /day)	N/A	N/A	McMillen Jacobs Associates 2020
^a Predicted flow based on observed storm event ^b Tunnel water discharge during construction ^c Report does not state what rainfall intensity and duration was used for 10-year return period				

5. Stream X Existing Condition

The condition of Stream X along Reach B as observed during the site visit by Jacobs and McMillan Jacobs Associates on August 20, 2020, (Figure 2 and 3), and as documented by others, is summarized below:

- Debris, including scrap metal and garbage was observed within the channel;
- Stream banks were generally oversteepened with undercutting observed along both banks;
- The stream channel is approximately 1.5 to 3m deep and 2 to 3m wide;
- The stream substrate generally consists of cobbles and gravel;
- Several areas of active erosion and uncut banks observed along Reach B and upstream of the Woodfibre Portal/CTS(Golder 2020).

The current condition of Stream X along Reach B and downstream appears unsuitable to receive additional flows without causing additional erosion and potential bank failure.



Figure 2 Scouring and Erosion along Reach B Stream X, August 20, 2020



Figure 3 Stream X between Reach A and B, Looking Downstream, August 20, 2020

6. Discussion

6.1 Stream Flow and Capacity

Analysis and comparison of the proposed stormwater discharge estimates to Stream X is difficult given the inconsistency of hydrological parameters used such as rainfall intensity, storm duration and return period of the runoff estimates (Table 1), and in some cases, data is not reported (e.g. 10-year rainfall intensity for V2 Compressor Station and CTS).

The data reviewed confirms that the flow in Stream X will be significantly increased from background conditions with runoff from future development at the WLNG Site. The data also show that the largest discharge to Stream X is expected to be runoff from the landfill, post-closure, with a 100-year design stormwater discharges estimated to be approximately two orders of magnitude larger than the proposed EGP Tunnel water discharge.

The reported estimates of Stream X flow along Reach B, with a 200-year return period, differ considerably (3.6 m³/s and 10.1 m³/s, respectively [see Table 2]). While different methodologies were used to calculate peak discharge, and some differences in estimates of stream discharge is expected, this magnitude of this discrepancy suggests that Stream X flows at this location should be reviewed.

For assessing the hydraulic capacity of Stream X at the proposed discharge location, all proposed upstream stormwater discharges need to be added to the estimate of the baseline flows in Stream X. For the EGP Tunnel water discharge authorization a 1 in 10-year flow estimate of Stream X is required with the addition of the 1 in 10-year discharges from future development at the WLNG Site. This additional flow is available for the CTS and V2 Compressor Station but not the landfill closure. However, confirmation of the rainfall intensity used for the runoff estimate of CTS and V2 Compressor Station is also required.

The estimates of Stream X flow (Table 2) as presented in the Woodfibre Landfill Closure and the Woodfibre Portal Laydown reports do not appear to have considered the proposed upstream discharges to the stream; therefore, where the flows are used for design, the flow estimate may not be sufficiently conservative. As such, proposed culverts along Stream X may be undersized.

It should be noted that Keystone Environmental Pre-Closure Flow Assessment (2020) recommended a capacity assessment of Stream X from the landfill down to the Howe Sound discharge point (Reaches A, b and C). A similar capacity assessment is likely required for the V2 Compressor Station and CTS stormwater discharges as well as the proposed EGP Tunnel water discharge.

6.2 Stream X Bank Stability

The field inspection of Stream X identified areas of bank erosion along Reach B. This erosion is indicative of the upstream catchment having already been disturbed by site activities, and also indicates that additional flow, above baseline, from all proposed discharges will likely exacerbate erosion issues in the downstream reach of the creek.

The V2 Compressor Station and CTS Flood Hazard Assessment (Golder, 2020), notes a portion of Reach C channel along Stream X (upstream of the CTS/Construction Laydown Area) does not have capacity to contain the 1:200-year clear water flows. Mitigation would require constructing a new channel geometry with additional capacity and armoring (Golder 2020). This location coincides with the potential placement of a culvert recommended as Option 4 in the Potential Alternate Design with Increased Laydown Area memo (McMillen Jacobs Associates 2019).

It is recommended that the creek channel is stabilized, using riprap or similar, such that it has the capacity to withstand for the 200-year design flow including from all proposed discharges with consideration of climate change. Given this, it is anticipated that when the EGP Tunnel water discharge is initiated, the existing channel will have been significantly modified from its current condition.

7. Conclusion and Recommendations

7.1 Conclusions

- For the EGP Tunnel Waste Discharge Authorization, an estimate of Stream X flow during the 1 in 10-year event including all upstream proposed discharges is required. Currently, there is insufficient data available to estimate this flow. While there are some estimates of Stream X flow, not all appear to have considered the proposed upstream stormwater discharges, where applicable.
- The stormwater runoff from the Woodfibre Portal and Construction Laydown Area are currently unknown and are expected to contribute flow to Stream X at the proposed EGP Tunnel water discharge location.
- As the proposed EGP Tunnel water discharge is a relatively small percentage of the estimate of other proposed discharges to Stream X (for example the EGP Tunnel discharge is less than 1.5 percent of the estimated 1:100 year discharge from the landfill), creek stabilization works downstream of the proposed EGP Tunnel water discharge should likely be the responsibility of others.

- The capacity assessment for the EGP Tunnel Waste Discharge Authorization should be based on the condition of the creek at the time of discharge and; therefore, should include any proposed engineering modifications to Stream X such as creek stabilization designs and the Woodfibre Portal Culvert, completed either by FortisBC or by others.
- Stream bank stabilization downstream of the EGP Tunnel water discharge could be completed by FortisBC; however, these works would be designed for 1 in 10-year flow and; therefore, would not meet the design requirements (200-year flow) of the upstream dischargers.

7.2 Recommendations

- Discuss the timing of the proposed Stream X capacity assessment downstream of the landfill with WLNG (as recommended by Keystone Environmental [2020]) as this assessment may be sufficient for the EGP Tunnel Waste Discharge Authorization.
- Runoff from the Woodfibre Portal and Contactor Laydown Area should be calculated for the 1 in 10-year event, this flow estimate will be needed for the EGP Tunnel water discharge capacity assessment but will also likely inform the permitting requirements for the portal construction.
- A hydraulic stream capacity assessment in support of the EGP Tunnel Waste Discharge Authorization, if required before creek stabilization designs are completed, will be based on the current condition of Stream X. For this assessment it is recommended that all future discharges to Stream X are estimated for the 1 in 10-year runoff using consistent hydrology input parameters.

8. References

Golder Associates Ltd. 2020. Flood Hazard Assessment and Site Hydrology V2 Compressor Station and CTS Sites, Woodfibre, BC.

Keystone Environmental. 2020. Landfill Pre-Closure Flow Assessment – Interim Report. Prepared for Woodfibre LNG Limited.

McMillen Jacobs Associates. 2019. EGP Tunnel Project Woodfibre Portal – Potential Alternate Design with Increased Laydown Area. Prepared for FortisBC.

McMillen Jacobs Associates. 2020. Technical Memorandum on Temporary Waste Discharge Sept 2020 (draft).

Province of B.C. 2016. Water Sustainability Act - Water Sustainability Regulation B.C. Reg. 36/2016.

Sperling Hansen Associates Inc. 2019. Woodfibre Landfill Closure Plan (Revision 2) FINAL REPORT. Prepared for Woodfibre LNG.

Sperling Hansen Associates Inc. 2020. Personal Communication. April 23, 2020. FW: FT19-03780 Landfill Cover & Road Upgrade - Stream 2 Inquiries

Appendix A – Stream X Proposed Discharges Map

APPENDIX A

**STREAM X
PROPOSED DISCHARGES**

**EAGLE MOUNTAIN - WOODFIBRE
GAS PIPELINE PROJECT**

Project (EA Amendment)

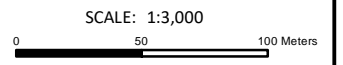
- Proposed Fortis NPS 24 Pipeline Route
- Proposed Lateral Pipeline
- Proposed Relocation Pipeline
- Proposed Custody Transfer Station
- Proposed V2 Compressor Station

Other

- Proposed Culvert
- Existing FortisBC Pipeline
- Surveyed Stream
- Resource Road
- Municipal Boundary
- Landfill Extent
- Portal
- Laydown Area
- Approximate extent of Stream X Hydraulic Capacity Assessment

Stream X Reach

- Stream X Reach



JACOBS

JACOBS Project Number CE777000

UTM Zone 10 North, NAD 1983.
 Proposed Pipeline Route: Universal Pegasus International (UPI) 03-27-2020
 (Route: 10230/4001); Proposed Lateral/Relocation Pipeline: Solaris 02-19-
 2020; Existing Pipeline: FortisBC 2012; CTS: FortisBC 2-25-2020;
 Compressor Station: KBR 2019-01-24; Landfill: Keystone Environmental
 2014; Roads: BC FLNRO Digital Road Atlas, 2010; Hydrography: BC
 MFLNRO 2008; Jacobs 2019; Municipal Boundaries: BC Ministry of
 Municipal Affairs and Housing, 2016; Proposed Culvert, Portal, Laydown
 area: Jacobs digitized (9-15-2020) based on drawing from McMillen Jacobs
 Associates 2019; Streams: Jacobs 2019; Hemmera 2020; Base Imagery -

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

Mapped By: SL

Checked By: ER

