GREATPACIFIC
ENGINEERING & ENVIRONMENT

ENVIRONMENTAL IMPACT STUDY

District of Squamish – Squamish River Outfall

January 9, 2023

Prepared For:
District of Squamish
37955 2nd Ave
Squamish, BC, V8B0A2

202-2780 Veterans Memorial Parkway
Victoria, BC V9B 3S6
Phone: 778.433.2672
www.greatpacific.ca
gpinfo@greatpacific.ca

Disclaimer

GreatPacific Consulting Ltd. (GPC) has prepared this Report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professional current practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this Report. No other warranty and/or guarantee, whether expressed or implied is made, with respect to the Report, the Information, or any part thereof.

This Report has been prepared for the specific project and/or site, design objective, development and purposes described to GPC by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this Report and are not applicable to any other project or site location. GPC accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, marine, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

Except as agreed to in writing by GPC and our Client or as required by law; or to the extent used by governmental reviewing agencies for the purpose of obtaining permits or approvals, the Report and the Information may be used and relied upon only by the Client and no other party without the express written consent of GPC and payment of compensation for that consent.

Report Prepared By:

Peter Howland, EP B.Sc.
Aquatic Scientist

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA Dr. H. A. MIR # 33642
2023-01-10
CMO CONSULTANTS LTD.
PERMIT TO PRACTICE No. 1002971

Hammad Mir, P. Eng.
Coastal Modelling Specialist
CMO Consultants Ltd.

Reviewed By,

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. R. CLARKE # 39072
2023-01-13
GPC P2P#1000737

Jason Clarke, P.Eng.
Marine Pipelines and Aquatic Sciences

Executive Summary

The District of Squamish is proposing an extension of their river sanitary outfall that discharges treated effluent from the District's Mamquam Wastewater Treatment Plant to the Squamish River. The extension is required to address recent and anticipated future adverse river morphological changes posing risks to the adequate operation and functionality of the outfall. The recommended design (Option 1 from pre-design report) included an outfall that will extend approximately 20 m from the eastern riverbank, and terminate with a single discharge port (400 mm pipe diameter). Effluent would be released just above riverbed level in the downstream direction.

This environmental impact study was intended to supplement a 2014 environmental impact study prepared for the existing outfall and to confirm the proposed extension will comply with the Municipal Wastewater Regulation.

The proposed outfall will be designed to satisfy the outfall design requirements listed in the MWR. Specifically, the proposed point of discharge will be located to intercept the predominant current where the effluent can achieve maximum dilution in the river allowing for a suitable initial dilution zone (IDZ). The outfall will be designed to minimize damage from debris, air entrapment, and corrosion.

The proposed discharge will be to the lower reaches of the Squamish River. In the summer, river flows are dominated by snowmelt and glacial runoff with peak flows in the early summer (June and July), while minimum flows occur in the winter and early spring (January to April). The river also experiences large fluctuations in flow due to rainfall, with maximum flow events typically occurring in the fall coinciding with heavy rainfall events.

The lower reaches of the river and estuary are influenced by tides. A field study was completed in January 2022, during low flows, to measure variations in current speeds, elevations, salinity and water quality. During the investigation, water level at the proposed point of discharge was observed to be influenced by tides only when the water levels in Howe Sound exceeded an elevation of 0.4 m (geodetic). When tides dropped below an elevation of 0.4 m, the water elevation in the river was not observed to change, suggesting the river was not noticeably influenced by the sea level at lower tides.

Current and salinity profiles collected during this investigation confirmed that during high (flood) tide conditions the river flow slows as the water level rises; however, there was no indication of any flow reversal or saltwater migrating upstream to the point of discharge.

Water uses in the study area primarily include recreational and wildlife habitat. The proposed outfall location was not found to be in a unique or sensitive area. The location consists of swift water and coarse gravels that would not be suitable spawning habitat such as for eulachon or salmon.

A hydrodynamic model of the Squamish River was developed and calibrated against observed conditions. The model was used to simulate mixing and dispersion conditions of the effluent plume in the river. Both low and high flow conditions were modeled for varying tidal conditions. Results from the model runs suggested that minimum dilutions at the boundary of the regulated IDZ would be a

minimum during low flow conditions with a minimum dilution of 61:1 at the downstream edge of a 100 m long IDZ.

Based on the anticipated effluent quality and measured receiving environment quality, the discharge was predicted to satisfy applicable water quality guidelines at the boundary of the IDZ, with the exception of some metals that occur naturally in the receiving environment at concentrations in excess of water quality guidelines.

To confirm these predictions, and to comply with the MWR, a receiving environment monitoring program is recommended. The program should include the collection of water quality, sediment and benthic community samples.

Based on the analysis completed in this EIS, the proposed discharge will satisfy the requirements of the MWR, and no significant adverse affects were predicted for human health or the environment.

GreatPacific Engineering & Environment

Contents

Tables

Figures

Photos

Appendix

1 Introduction

GreatPacific Consulting Ltd. (GreatPacific) prepared this Environmental Impact Study (EIS) associated with the proposed extension of the river outfall connected to the District of Squamish's (District) Mamquam Wastewater Treatment Plant (WWTP).

The existing river outfall is required to be extended to address recent and anticipated future adverse river morphological changes posing risks to the adequate operation and functionality of the outfall.

This EIS is intended to supplement an Environmental Impact Study previously prepared for the existing outfall (Urban Systems, 2014).

2 Scope of Work

The scope of this Environmental Impact Study (EIS) was based on the *Environmental Impact Study Guideline* (Ministry of Environment, Lands and Parks, 2000), and the B.C. Ministry of Environment & Climate Change Strategy (ENV) standard Information Request Table (IRT) for *Municipal Wastewater Regulation* (MWR, British Columbia 2012) Registrations, with modifications to suit this specific project which involves an existing outfall in operation.

The EIS is intended to address the information required for MWR Registration. It is based on a combination of available desktop information and site-specific field investigations.

The scope of work for this EIS included the following components:

- Description of the study area
- Description of existing conditions
- Discharge characteristics
- Site characterization
- Dilution modelling and water quality predictions
- Effects assessment
- Receiving environment monitoring program recommendation

A field data collection campaign was carried out by GreatPacific on January 26 and 27, 2022 in the lower Squamish River, focused on the proposed new outfall terminus location. The program included measurements at various locations along the lower Squamish River as shown in Figure 2. The following items were measured during the field program:

- Flow transects
- Current speed and water level
- Profiles of selected water properties
- Bathymetry

The EIS was structured to address specific requirements of an IRT. IRT sections are cross referenced in each report section.

3 Background.

3.1 Existing Outfall and Discharge Permit

The District's sewage treatment plant is authorised under a permit (PE-01512) issued by the BC Ministry of Environment. The permit was first issued in 1972 and was last amended on October 6, 2017.

The permit authorizes the following:

- A maximum discharge rate of 17,850 m^3/d.
- An effluent 5-day biochemical oxygen demand (BOD5) concentration of ≤ 30 mg/L.
- An effluent total suspended solids (TSS) concentration of ≤ 40 mg/L.
- The effluent must pass a fish bioassay, which is defined as the LT50 96 hour rainbow trout bioassay.

The release from the sewage treatment plant is to the Squamish River, via an outfall with a point of discharge located at "foreshore and land covered by the water of the Squamish River located approximately 390 m north and 72 m west of the southernmost southeasterly cover of I.R. 18, Yekwaupsum NWD (Figure 1)

The outfall is described to extend approximately 5.8 metres (m) offshore from the east bank of the river and discharging to a depth of approximately 1.2 m below average low water level. The outfall is observable from the riverbank during low river flow conditions (Photo 1).

The existing outfall is partially isolated from the main flow of the river as a result of sediment aggradation. Figure 1 shows the current extent of the graavel bar as visible in the Squamish 2021 orthophoto (Squamish 2021a) compared with the approximate location of the gravel bar as visible in the 2013 orthophoto (Squamish 2021b). As shown, the gravel bar has been extending south towards the outfall which has impacted mixing conditions and triggered work to evaluate extending the outfall further south.

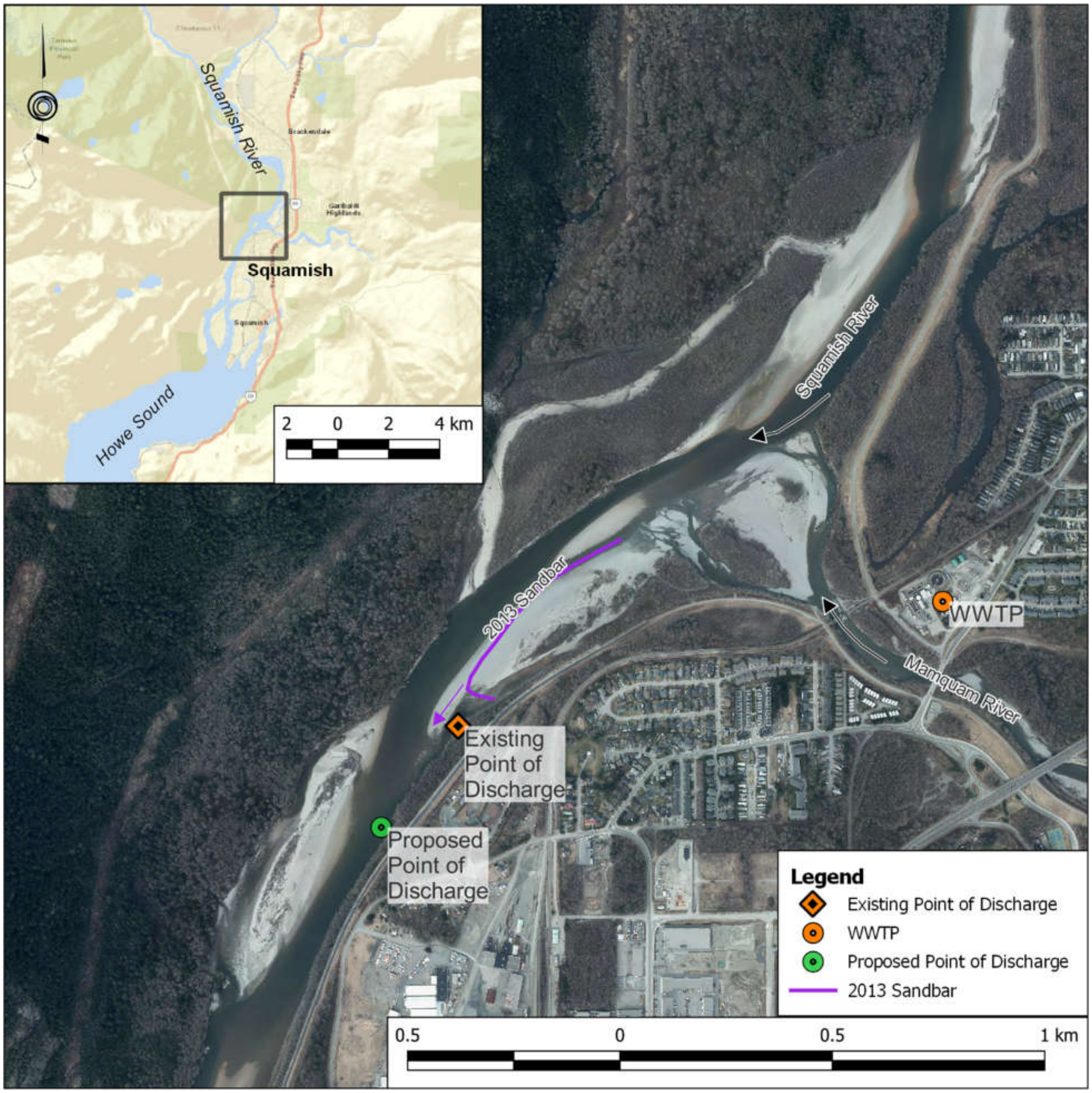


Figure 1 Existing Outfall and Sediment Aggradation

Image Source: Squamish 2021a

Photo 1 Existing Outfall

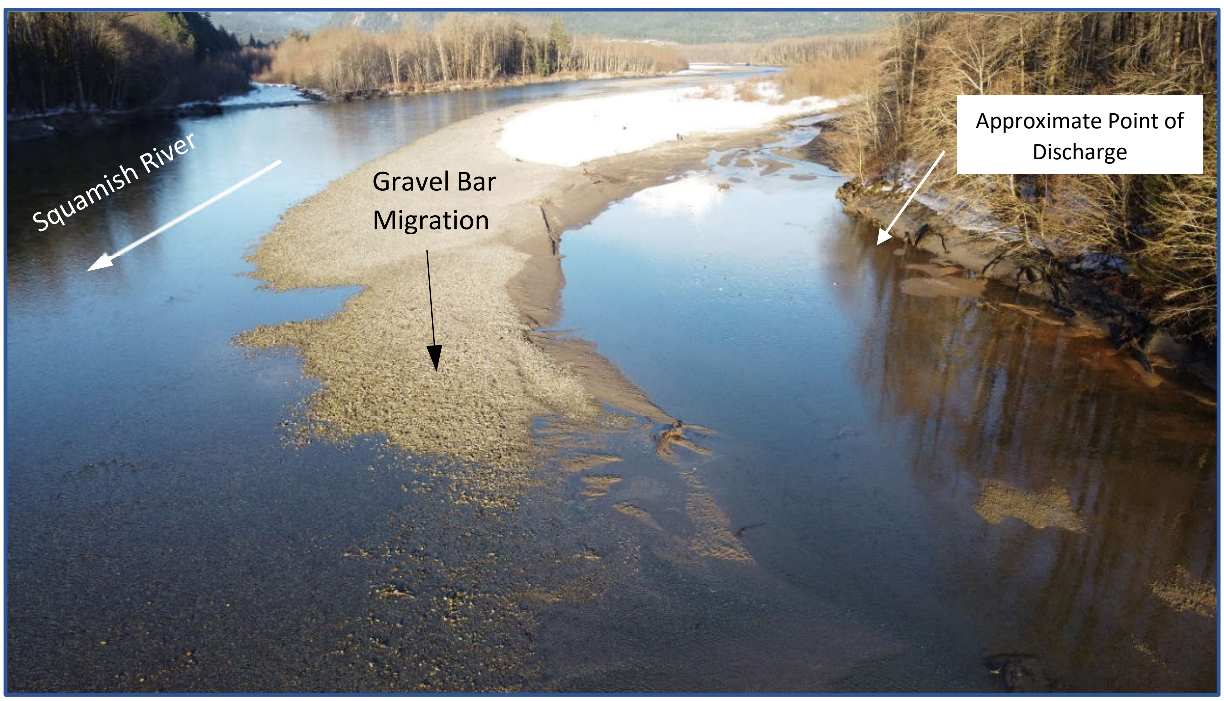


Photo 2 Existing Outfall Location

3.2 Liquid Waste Management Plan and WWTP Upgrades

In addition to the discharge permit, the District manages it's wastewater collection, treatment and disposal system under the guidance of a Liquid Waste Management Plan (LWMP), most recently updated in 2015 (Urban Systems 2015). The LWMP is intended to guide the District on the management of the system.

With respect to the Wastewater Treatment Plant, the LWMP recommended the following:

- *Design and construct an ultraviolet disinfection system to disinfect sewage effluent based on the results of the Environmental Impact Study on the Squamish River and based on feedback from the Ministry of Environment.*
- *Convert the older bio-reactor to Moving Bed Bioreactor (MBBR) to increase the capacity of the WWTP to achieve compliance with redundancy requirements of the Municipal Wastewater Regulation.*
- *Convert the newer bio-reactor to MBBR to increase the capacity of the WWTP to increase capacity and accommodate growth at lowest net-present value cost.*
- *Design and construct an anaerobic digester (or alternative technology that passes a District business case) to increase the capacity of the WWTP to reduce odours and to recover heat energy for use at the WWTP.*
- *Monitor and report on potential odour issues to define the issue for future improvements and to support communications to local residents.*
- *Implement odour control measures as needed based on monitoring program.*

It's understood that the ultraviolet disinfection system was completed in 2017, and the District is presently constructing a new secondary clarifier and concentric ring bioreactor to increase treatment capacity, provide system redundancy, increase seismic and flood resiliency, improve plant performance and effluent quality, decrease biosolids production and associated energy usage, and carbon emissions and handling costs.

The design flows for the system are capped below 21,000 m^3/d (WSP 2021).

Table 1 Design Flows (WSP 2021)

COMPONENT	YEAR 2020	YEAR 2030	YEAR 2040
Design Population	23,000	28,000	33,000
Per capita flow	0.336	0.33	0.32
Average Dry Weather Flow (ADWF), m^3/d	7,720	9,240	10,560
Average Annual Flow (1.14 x ADWF)	8,800	10,534	12,038
Max Month Flow (1.55 x ADWF)	12,000	14,322	16,368
Max Day Flow (capped below 21,000 m^3/d)	20,750	20,750	20,750

3.3 Environmental Impact Study 2014

An Environmental Impact Study was prepared on behalf of The District (Urban Systems, 2014) as part of the LWMP. The terms of reference for the EIS were developed based on the EIS guidelines (Ministry of Environment, Lands and Parks, 2000) and was intended to meet the requirements of the MWR.

The EIS provides details on the Treatment Plant, effluent quality, site characteristics, baseline water quality, and impact assessment.

3.4 Municipal Wastewater Regulation

The MWR provides specific siting and design requirements for outfalls and specific effluent quality criteria based on the receiving environment. The MWR also requires an EIS be conducted, receiving environment monitoring and routine inspections of the infrastructure.

The MWR allows discharges to surface water such as streams, rivers and lakes.

3.4.1 Discharge to Stream or River

For a discharge to a stream or river, a minimum dilution ration of 10:1 is required to comply with the regulation. The dilution ratio is the ratio of stream flow to effluent and calculated by *"dividing the 2-year return period 7-day low flow in the receiving stream by the maximum weekly (7-day) municipal effluent flow"*.

Where a minimum of 10:1 dilution ratio is achieved, the minimum effluent quality requirements with respect to the dilution ratio are outlined in Section 94. These include:

Dilution Ratio ≥ 100:1 and Flow Greater than 50^3/day The minimum effluent criteria are:

BOD5 & TSS	≤ 45 mg/L
pH	6-9
Total Phosphorous	≤ 1 mg/L
Orthophosphate	≤ 0.5 mg/L

Dilution Ratio <100:1 A qualified professional conducting an environmental impact study must determine if municipal effluent quality must be better than for dilutions ≥ 100:1.

Dilution Ratio <40:1 if the dilution ratio in respect of discharges to streams, rivers and estuaries used for recreational or domestic water extraction is less than 40:1, the following requirements must be met:
(a) the discharge meets advanced treatment requirements;
(b) no other discharge options are available;
(c) the discharge is authorized by a director.

Dilution Ratio <20:1 A director may approve the use of secondary treatment if there is a minimum dilution ratio of 20:1 and the streams or rivers are not used for recreational or domestic water extraction.

Dilution Ration < 10:1 Discharge is prohibited.

The dilution ratio of the proposed discharge is calculated in Section 9.3.

In addition to the minimum effluent requirements listed in the MWR, applicable water quality guidelines must be satisfied at the boundary of an Initial Dilution Zone (IDZ). The IDZ is an area within the receiving environment that allows for the mixing the effluent and receiving water. For parameters that may exceed applicable water quality guidelines within the undiluted effluent, mixing is allowed within the IDZ

In a river, an IDZ is defined as a three-dimensional area with a height the distance from the bed to the water surface; and the width, perpendicular to the path of the stream, is the lesser of 100 m and 25% of the width of the stream or estuary. The length, parallel to the path of the stream, is the distance between a point 100 m upstream and a point that is the lesser of 100 m downstream, and a distance downstream at which the width of the municipal effluent plume equals the width.

The IDZ and point of discharge must be located at least 300 m away from the following:

a) recreational areas;
b) aboriginal, commercial or recreational shellfish harvesting areas;
c) domestic or agricultural water intakes;
d) any sensitive area requiring protection identified in a notice given by a director.

The mixing of effluent within the IDZ and the prediction of potential effects of the discharge, including the need for disinfection are generally determined using computer models, baseline water quality data, and the knowledge of uses of the receiving environment with respect to associated water quality guidelines.

Additional design requirements for a discharge to a river are outlined in Section 3.4.2.

3.4.2 Outfall Design Criteria

The proposed outfall will be designed to achieve the minimum requirements of the MWR, specifically including those listed in section 99 and 101 of the MWR. The outfall design requirements listed in the MWR are cross referenced with the applicable section(s) of this EIS or applicable design elements in Table 2.

(1) A qualified professional must design an outfall such that
    (a) initial dilution zone requirements under this regulation are met,
    (b) air entrapment is prevented,
    (c) adequate weighting is provided to prevent movement from currents, ice or possible entrainment of air, and
    (d) the outfall is protected from corrosion.
(2) A qualified professional must ensure that outfall diffusers are
    (a) located at a sufficient depth to maximize the frequency that municipal effluent is trapped below the surface of the water,

(b) located to intercept the predominant current and avoid small currents that tend to move toward the shore,

(c) designed to ensure that

(i) each diffuser section will provide at least 10:1 dilution within the initial dilution zone, and

(ii) outside the initial dilution zone, discharge does not cause water quality parameters to fail to meet water quality guidelines, and

(d) designed to achieve maximum dilution in a river, stream or estuary located in the channel in which most of the water flows.

(3) A qualified professional must ensure that outfalls are located

(a) such that they are protected from wave, boat and marine activity, and

(b) at a depth of at least

i. 40 m below mean low water in the Okanagan Basin, and

ii. subject to subparagraph (i), 10 m below mean low water in estuaries, lakes or marine waters with a surface area greater than 100 ha.

(4) A discharger must ensure that all outfalls are marked on shore with a sign that meets the following requirements:

(a) the sign must indicate, with wording acceptable to a director, the length and depth of the outfall;

(b) the sign must be at least 1 m^2;

(c) the colours of the lettering and the background of the sign must contrast sufficiently with each other, and the sign must be located, such that the wording is clearly visible from both land and water.

3.4.3 Environmental Impact Study

The MWR stipulates a requirement to complete an Environmental Impact Study (EIS), for the proposed discharge.

4 Discharge Characteristics (IRT 1.7.4)

The proposed discharge was based on the preferred Option 1 from GreatPacific's outfall preliminary design report (GreatPacific 2021). The proposed location of the new outfall is shown in Figure 2, at the following UTM coordinates: 488226m E, 5508368 m N, 10N

The outfall will extend approximately 20 m into the river from the eastern riverbank and terminate with a single discharge port (400 mm pipe diameter). Effluent would be released just above riverbed level in the downstream direction.

The proposed outfall location was selected with input from a river geomorphologist as being an area where the river channel has a lower likelihood of shifting laterally or becoming infilled with sediments.

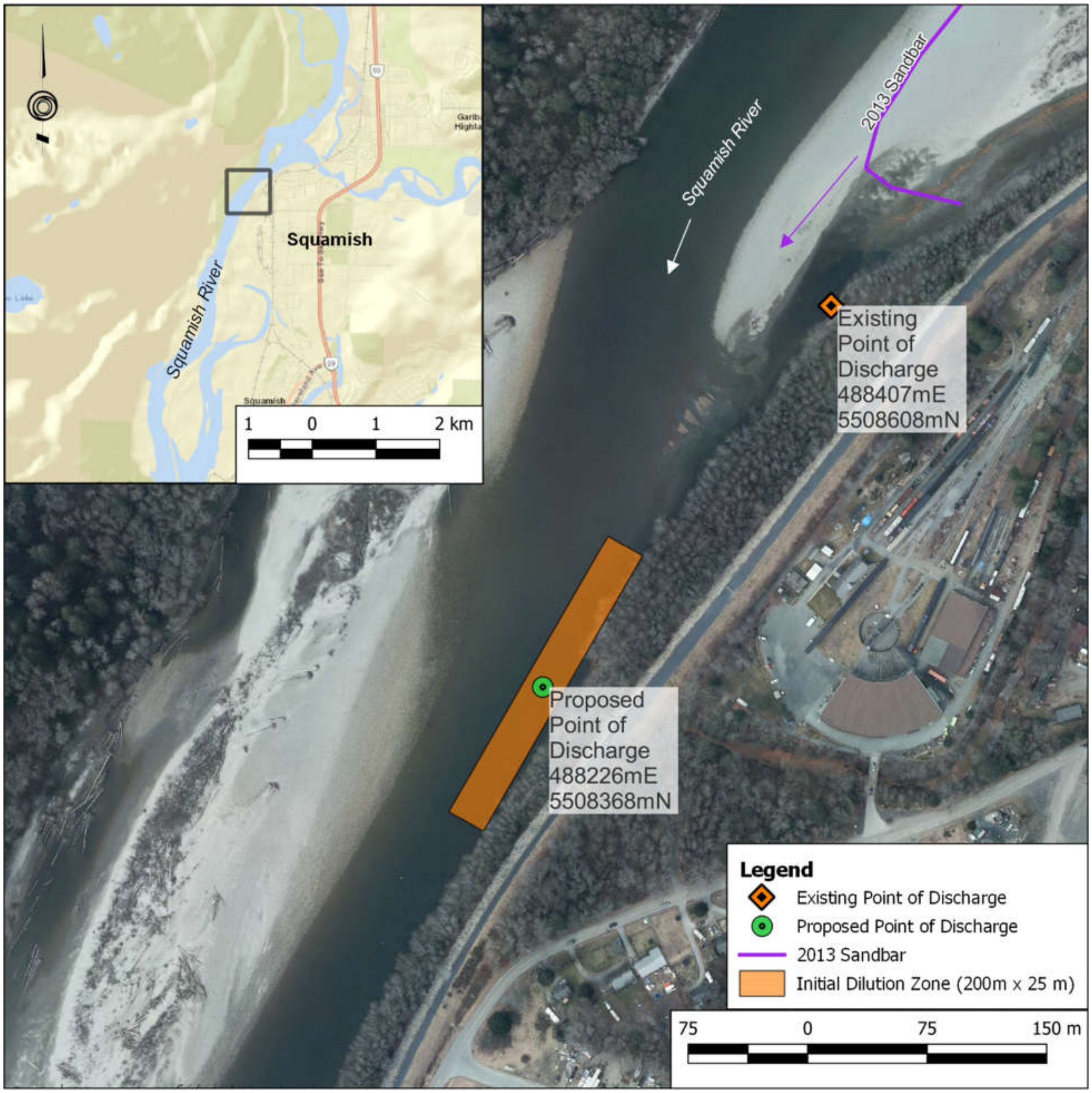


Figure 2 Proposed outfall alignment, initial dilution zone, and depth contours

Image Source: Squamish 2021a

The outfall will be designed to achieve the requirements of the MWR, including those listed in section 99 and 101 of the MWR. The outfall design requirements listed in the MWR were cross referenced with the applicable section of this EIS or applicable design elements in Table 2.

Table 2 WMR Design Requirement

MWR Design Requirement	EIS Section
A qualified professional must design an outfall such that	
(a) initial dilution zone requirements under this regulation are met,	See section
(b) air entrapment is prevented,	The outfall alignment ensures a continuous down grade, with no localized high points. Air relief will be incorporated into the design.
(c) adequate weighting is provided to prevent movement from currents, ice or possible entrainment of air, and	The outfall will be buried below the rive bed to prevent moment.
(d) the outfall is protected from corrosion.	The outfall will primarily be designed with corrosion
(2) A qualified professional must ensure that outfall diffusers are	
(a) located at a sufficient depth to maximize the frequency that municipal effluent is trapped below the surface of the water,	Trapping of the effluent is not feasible in a shallow and well mixed river.
(b) located to intercept the predominant current and avoid small currents that tend to move toward the shore,	See section 9.3
(c) designed to ensure that	
(i) each diffuser section will provide at least 10:1 dilution within the initial dilution zone, and	See section 9.3
(ii) outside the initial dilution zone, discharge does not cause water quality parameters to fail to meet water quality guidelines, and	See section 9.3and 10
(d) designed to achieve maximum dilution in a river, stream or estuary located in the channel in which most of the water flows.	See section See section 9.3
(3) A qualified professional must ensure that outfalls are located	
(a) such that they are protected from wave, boat and marine activity, and	The outfall will be buried, a Transport Canada and MWR compliant sign will be erected and the outfall will be shown on marine charts.
(b) at a depth of at least	
(i) 40 m below mean low water in the Okanagan Basin, and	n/a
(ii) subject to subparagraph (i), 10 m below mean low water in estuaries, lakes or marine waters with a surface area greater than 100 ha.	n/a

5 Site Characteristics - Discharge to Water (IRT 1.7)

5.1 Study Area / Site Plan (IRT 1.7.1)

The proposed outfall is located in the lower reaches of the Squamish River, approximately 1 km downstream of the confluence of the Mamquam and Squamish Rivers.

This EIS is focused on the assessment of potential effects from the discharge of treated municipal effluent to the Squamish River. Onshore components of the wastewater facility (e.g. collection system and wastewater treatment facility) were excluded from this EIS.

Specific areas referred to in this EIS are described below and identified in Figure 3.

Initial Dilution Zone:	Effects from the continuous discharge of the treated effluent have the potential to occur within an initial dilution zone (IDZ). All applicable water quality guidelines are to be achieved at the boundary of the IDZ.
400 m Offset:	Section 91 (2) of the MWR requires the edge of the IDZ must be located at least 300 m away from; recreational areas, or any sensitive area requiring protection.
Study Area	The study area considered under this EIS includes the Squamish River within approximately 2 km of the point of discharge.

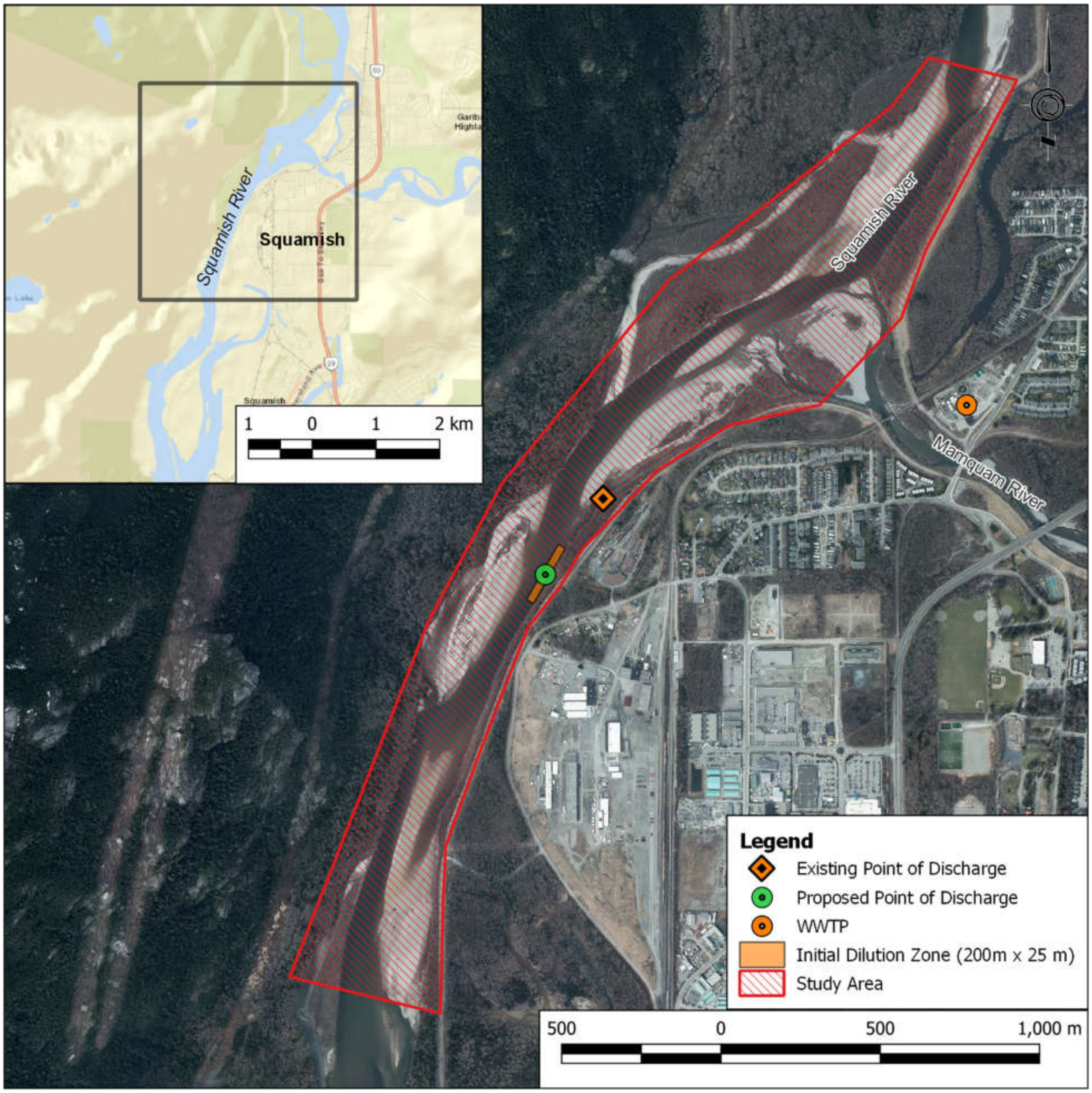


Figure 3 Study Area

Image Source: Squamish 2021a

5.2 Dilution Ratio (IRT 1.7.2)

The dilution ratio, as defined in MWR, was calculated using the 2-year return 7-day (7Q2) low flow of 53.5 m^3/s, established in the 2014 EIS, and the maximum municipal effluent flow of 20,750 m^3/d (0.24 m^3/s). The dilution ratio was calculated to be 220:1, which satisfies the MWR dilution ratio criteria as described in Section 3.4 of this EIS.

5.3 Initial Dilution Zone (IRT 1.7.3)

The IDZ for the proposed discharge will be a three-dimensional area with the following dimensions:

Height: riverbed to the water surface;

Width: 25 m (25% of the width of the stream; approximately100 m total width at mean low water)

Length: 200 m (100 m upstream and a point that is the lesser of 100 m downstream, and a distance downstream at which the width of the municipal effluent plume equals the width of the IDZ).

The initial dilution zone is discussed further in Section 9.3.

5.4 Critical Flow Calculation (IRT 1.7.5)

The critical flow calculation (Section 100) does not apply to a discharge to rivers.

5.5 Advanced Treatment (IRT 1.7.6)

Advanced treatment requirements as defined in Section 97 of the MWR do not apply to the Squamish River.

5.6 Enhanced EIS (IRT 1.7.7)

An "Enhanced EIS" as described in Section 98 of the MWR does not apply to the proposed discharge.

6 Environmental Impact Studies

6.1 Construction (IRT 2.1)

Construction activities in relation to the outfall will involve excavation, material placement, and backfill within the Squamish River. The key potential effects during construction will be related to leaks/spills and sedimentation/erosion. These potential effects will be mitigated by implementing a Construction Environmental Management Plan that details mitigation measures consistent with environmental best practices (e.g. fisheries timing windows, spill control and response, sedimentation and erosion control) for the project.

6.2 Overflow (IRT 2.2)

Potential overflow scenarios from the wastewater treatment plant were not identified for the discharge.

7 Site Characteristics (IRT 2.4.1)

7.1 Spatial Boundaries for Effects Predictions (2.4.1.1)

The proposed discharge will be to the Squamish River, with the outfall terminating approximately at the coordinates shown in Figure 2. Effects from the discharge of the treated effluent are allowed to occur within an initial dilution zone as described in section 5.3, Figure 3.

Additional setbacks are required between the point of discharge and sensitive areas (if present) as described in Section 5.3.

7.2 Hydrological Conditions (IRT 2.4.1.2)

The hydrological conditions including site bathymetry, tidal influences, river flows and hydro geomorphology are described in the following sections.

7.2.1 Bathymetry

Prior bathymetric surveys in the vicinity of the study area by BC Ministry of Environment (1976), BCHydro (2007), and Polar (2015) were gathered for review. Changes to riverine cross-sectional geometry were noticeable between the surveys, indicating the dynamic nature of the riverbed. Prior surveyed cross sections did not necessarily coincide with the new outfall terminal locations of interest.

Additional site-specific bathymetry was also acquired in January 2022. The bathymetry is shown in Figure 2.

7.2.2 River Flows

The Squamish River drains three main watersheds including the Squamish, Cheakamus, and Mamquam Rivers. Environment Canada operates gauges on all three rivers, the mean, minimum, maximum flow for all three rivers are shown in Figure 4 to Figure 6. The measured flow in 2020 is also provided for reference.

The proposed location for the outfall is located downstream of the confluence of all three rivers. The flows experienced at the outfall will be a combination of the three river flows.

River flows are mixed with summer flows dominated by the snowmelt and glacial runoff. Mean flow rates for all three rivers peak in the early summer (June and July) with minimum (mean) flow rates in the winter and early spring (January to April).

The rivers also experience large fluctuations in flow due to rainfall. Maximum flow rates typically occur in the fall.

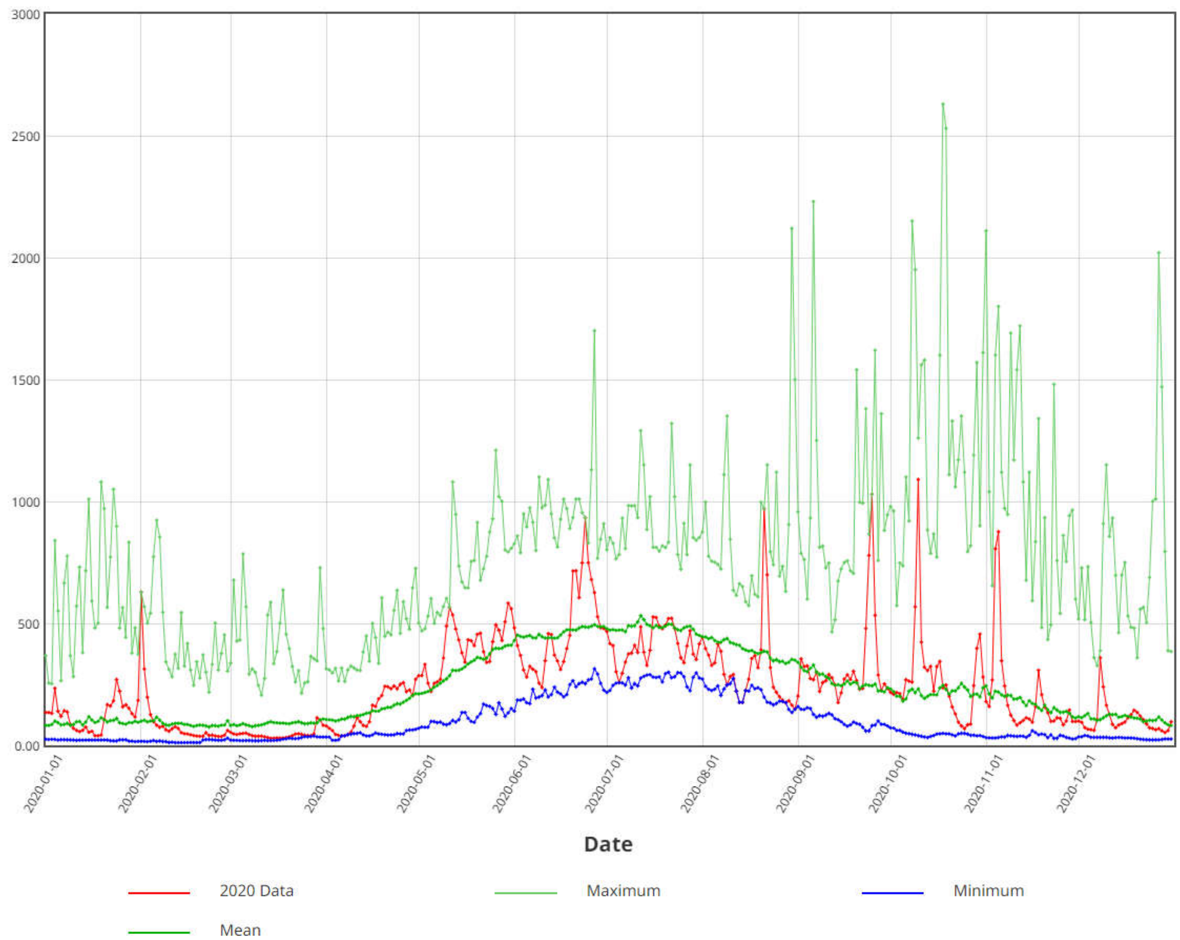


Figure 4 Daily Discharge Graph for SQUAMISH RIVER NEAR BRACKENDALE (08GA022) [BC]

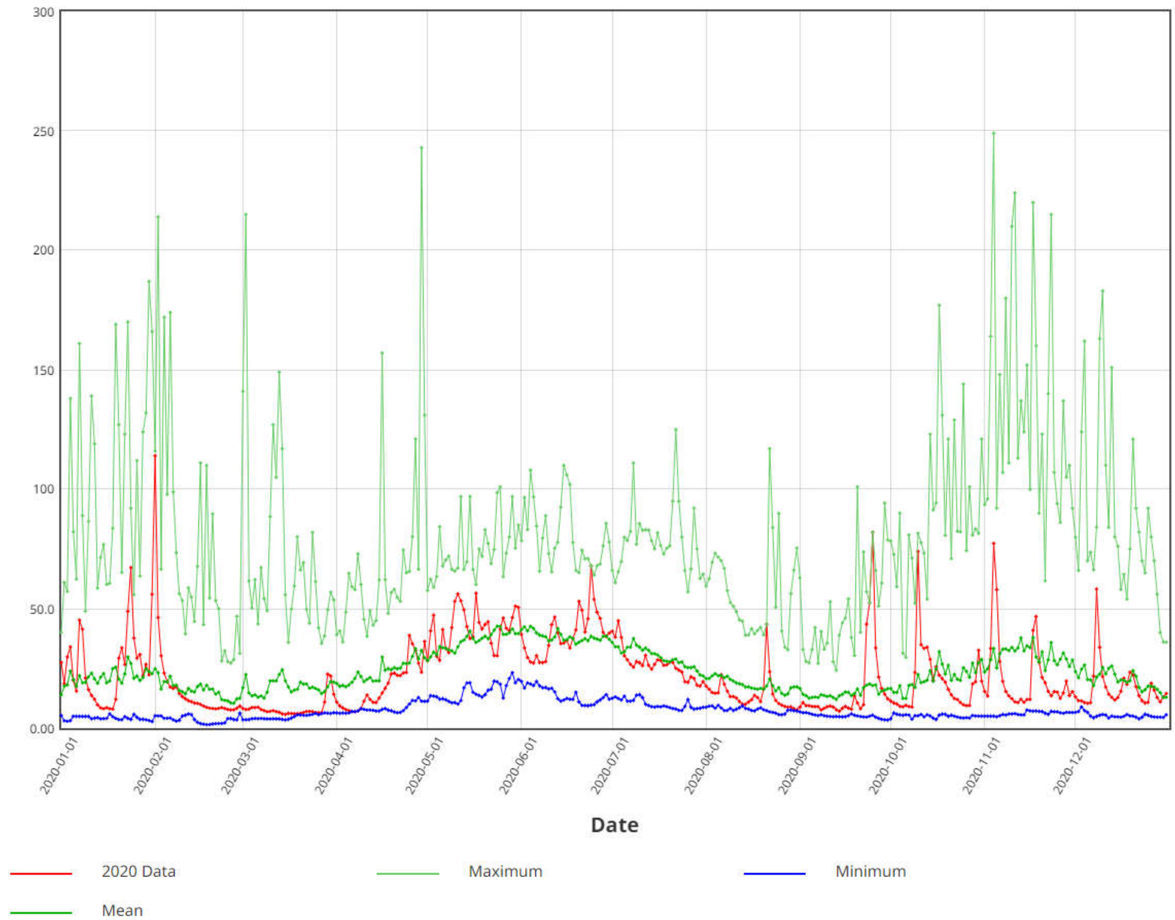


Figure 5 Daily Discharge Graph for MAMQUAM RIVER ABOVE RING CREEK (08GA075) [BC]

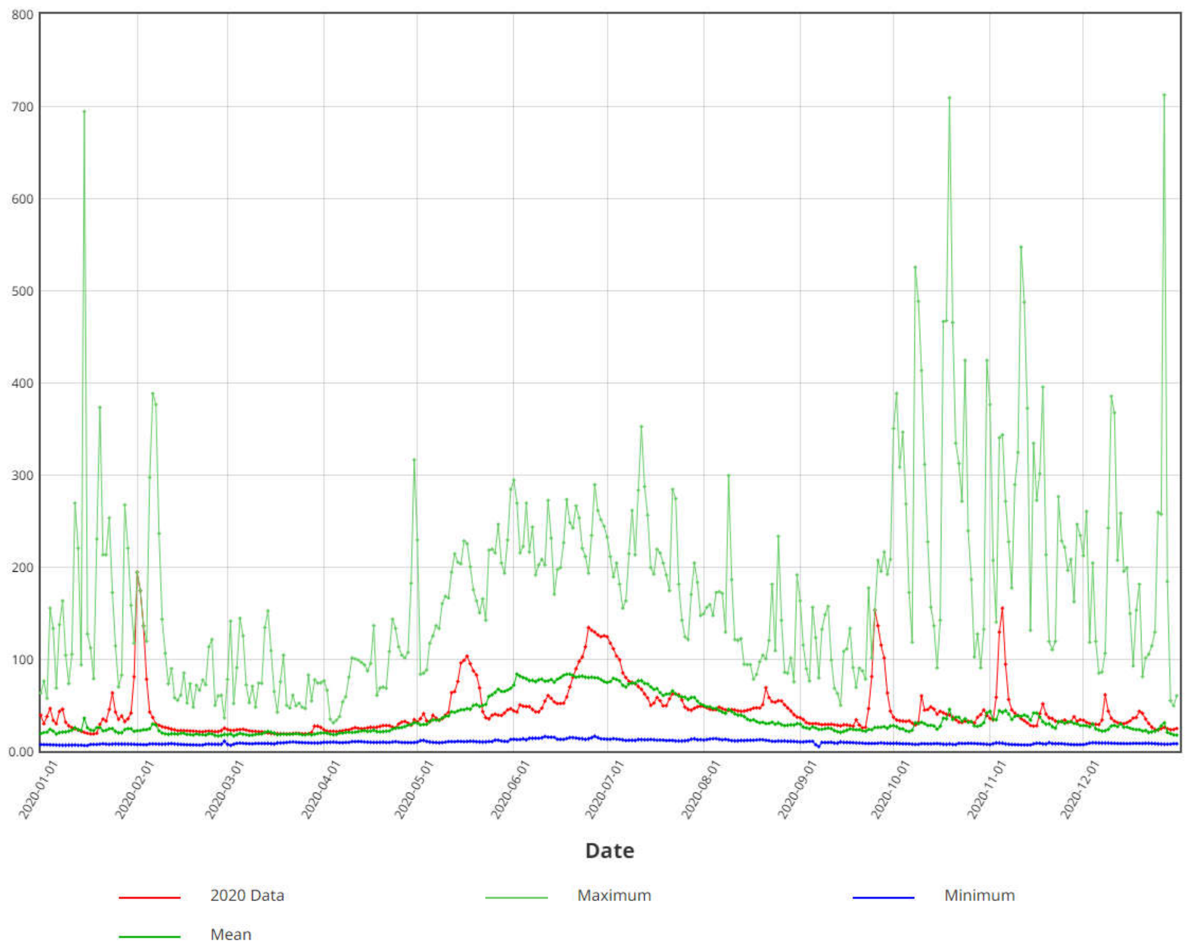


Figure 6 Daily Discharge Graph for CHEAKAMUS RIVER NEAR BRACKENDALE (08GA043) [BC]

In 2010, Kerr Wood Leidal (KWL) reported return-period based flows for the Squamish, Cheakamus, and Mamquam rivers which are provided in the table below (KWL 2010). The 1 in 200 year instantaneous flows were updated and future projected to address climate change trends as part of the District's 2017 Integrated Flood Hazard Management Plan (IFHMP; KWL 2017) which are also provided in the table below.

Table 3 Modelled Instantaneous River Flows

Flood Frequency Return Period	**Squamish River** Instantaneous Discharge (m^3/s)*	**Cheakamus River** Instantaneous Discharge (m^3/s)*	**Mamquam River** Instantaneous Discharge (m^3/s)*
2 Year	1270	317	
5 Year	1720	506	
10 Year	2083	650	
20 Year	2483	803	
50 Year	3090	1023	
100 Year	3620	1207	1050
200 Year	4213	1407	1200
200 Year (Year 2100 climate; updated 2017)	4480	1760	1000

*Average flow calculated from KWL report based on multiple modelled distributions. Reader is directed to Squamish River Instantaneous Flood Frequency Results, KWL 2010 and the 2017 IFHMP for further details.

7.2.3 Hydro Geomorphology

The Squamish River is a hydro geomorphologically active environment, which demonstrates substantial changes from year to year and season to season. Processes of aggradation and avulsion frequently change the geometry of the river, which has which has posed challenges for the existing outfall.

In 2020, Polar Geoscience (Polar) completed an assessment of the river at the existing outfall location to provide recommendations to mitigate the issues of channel shifting and sediment aggradation (Polar 2020). Based on the Polar recommendations, the District's preferred option was the relocation of the outfall terminus approximately 300-450 m downstream of its current location, to an area where sediment aggradation and river shifting was less likely to adversely affect an outfall. This general area (300 m to 450 m downstream of the existing outfall location) is hereafter referred to as the outfall area.

The outfall area was selected in part due to the understanding that the river flows against the armoured, eastern bank in this area, and aggrades against the west bank. Consequently, this region was promising for mitigating the issues with sedimentation near the outfall. As provided in the Polar report, an outfall in this area may be expected to have a design life of at least 20 years before the river geomorphology necessitates a retrofit. The life expectancy is difficult to predict with certainty as it depends on a variety of factors such as the variability in sediment supply within the watershed (including tributaries), and the future climate and associated flood characteristics.

7.2.4 Tidal Range

The outfall area of the Squamish River is tidally influenced, which could potentially generate backwater effects, as well as ingress of a saltwater wedge up the river during flooding high tide events.

The tide ranges published for the Squamish tidal station (DFO 2021) are presented below:

Table 4 Tide Levels – Squamish (CHS #7811)

Quality	Elevation m Chart Datum	Elevation m Geodetic Datum
Extreme High Tide*	5.6	2.5
Higher High Water (Large Tide)	5.1	2.0
Higher High Water (Mean Tide)	4.6	1.5
Mean Tide	3.1	0
Lower Low Water (Mean Tide)	1.2	-1.9
Lower Low Water (Large Tide)	0.1	-3.0
Extreme Low Water*	-0.4	-3.5

*Point Atkinson Measurement

Water elevations at the proposed point of discharge were measured as part of the January 2022 field investigations. The measured water elevation at the point of discharge as compared to the observed tides at Darrell Bay are provided in the following figure.

For the river flow conditions observed (Combined flow of 94 to 83 m^3/s), the water level at the proposed point of discharge was observed to be influenced by tides only when the water levels in Howe Sound exceeded an elevation of 0.4 m (geodetic). When tides dropped below an elevation of 0.4 m, the water elevation in the river was not observed to change suggesting the river was not noticeably influenced by the sea level at lower tides.

Water levels at the point of discharge are discussed further in Section 9, as part of the numerical modelling. During low river flow conditions, the water level at the point of discharge may vary by up 1.5 m during large tidal exchange conditions. During high river flow conditions, the water level at the point of discharge is not anticipated to vary significantly (<0.25 m).

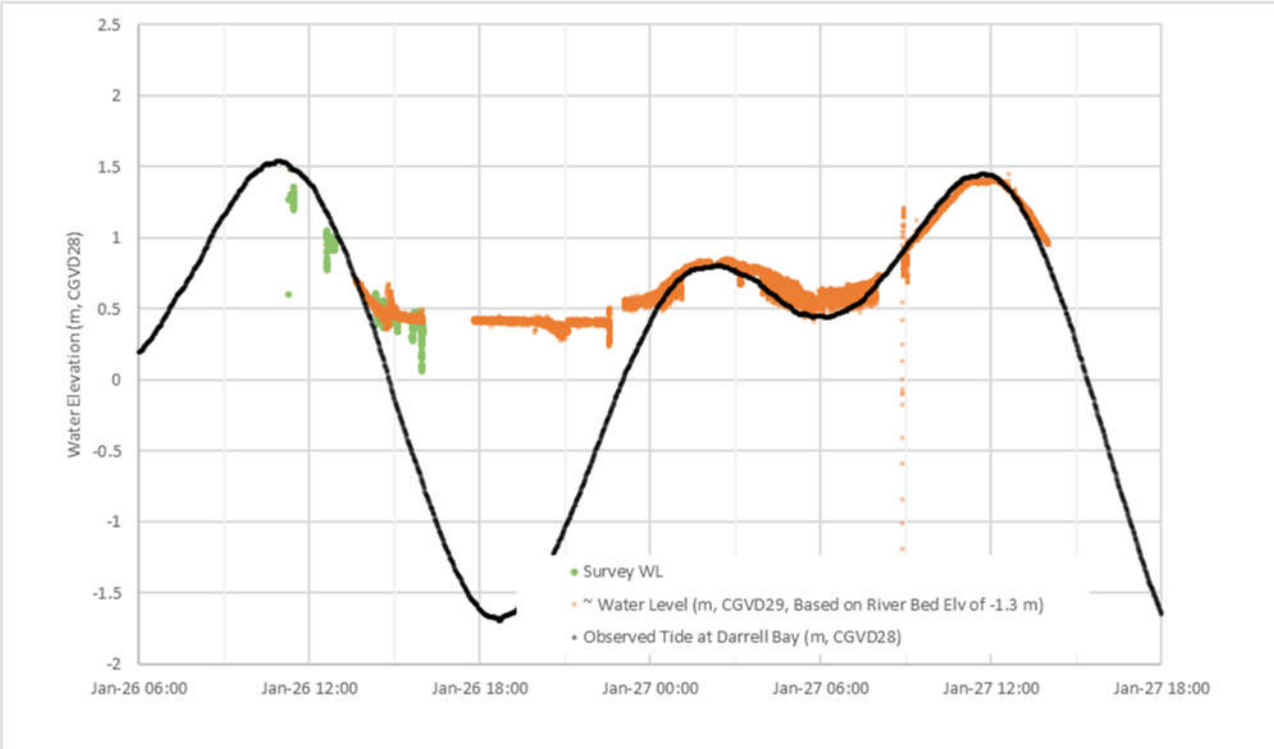


Figure 7 Measured Water Elevation at Acoustic Doppler Current Profiler (ADCP) vs. Tide at Darrell Bay

7.2.5 Substrate

As described in the 2020 Polar report, the bed texture in the Subject Area was characterized as primarily gravel, transitioning downstream to a sand-bed texture.

During a site visit in July 2021, b-axis dimensions of gravel were measured along a 30 m transect along the offshore side of the gravel bar opposite the existing outfall. The gravels in this location appeared to be representative of current-swept gravels in the broader river channel area. The measurements provided a D_{50} estimate of 3.6 cm.

7.3 Climate (IRT 2.4.1.2)

Climate normals (temperature and precipitation) provided by Environment Canada (2022) at Squamish Sewage Treatment Plant (STP) are provided in Table 5. Squamish has a climate that is typical of coastal British Columbia with average temperatures above freezing year-round. Maximum precipitation occurs in November and January

Table 5 Canadian Climate Normals 1981-2010 – Squamish STP

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Average (°C)	2.7	4.6	6.7	9.9	12.9	15.5	17.8	17.8	15	10.3	5.5	2.5
Rainfall (mm)	300.2	179.7	198.4	152.5	115.7	82.6	59.3	66.2	82.6	255.5	382.2	268.4
Snowfall (cm)	25.9	13.1	8.1	0.1	0	0	0	0	0	0	9.2	30.6
Precipitation (mm)	326.1	192.8	206.5	152.6	115.7	82.6	59.3	66.2	82.6	255.5	391.3	299

Winds are not expected to significantly influence the effluent plume.

7.4 General Usage (IRT 2.4.1.4)

River uses are detailed in the 2014 EIS (Urban Systems 2014), and are summarised below.

7.4.1 Water Licences

There are no known water licences within the study area, and particularly downstream of the outfall within the influence of the effluent plume (Urban Systems 2014 and British Columbia 2022)

7.4.2 Existing Discharges

No other permitted discharges were identified in the study area (Urban Systems 2014).

7.4.3 Industrial Uses

Industrial uses in the lower Squamish River are defined in the 2014 EIS. There were no industrial activities anticipated to result in combined effects from the discharge.

7.4.4 Recreational Use

Recreational use of the Squamish River was identified in the 2014 EIS and observed during site visits. The main activities observed included boating (fishing, canoeing, rafting, etc..), fishing and walking. The east bank of the river downstream of the proposed point of discharge is not conducive to recreational access. The gravel bar upstream (approx. 500 m) of the proposed discharge is a popular location that may include swimming, and should be assumed to be a primary contact recreational area.

7.4.5 Wildlife Resources.

Wildlife resources are detailed in the 2014 EIS. The Squamish Estuary is described as a highly productive ecosystem providing habitat for waterfowl, shore birds and raptors (BC Ministry of Environment, 2007). The Brackendale Eagles Provincial Park is a tourist attraction for eagle viewing, and is located on the west side of the Squamish River, with the southern tip of the park being in the vicinity of the outfall. The estuary also provides good habitat for several species of mammals. Wildlife, including bear, deer and many birds, can utilize the areas adjacent to and downstream of the outfall on the Squamish River.

Given that the effluent release is to water, the primary consideration for wildlife resources relate to fisheries values. The Squamish Estuary in general is a feeding, spawning and rearing ground for a variety of fish species, including eulachon, steelhead and salmon (BC Ministry of Environment, 2007).

The proposed location of the IDZ is within habitats of the identified wildlife resources. The proposed outfall location was not found to be unique or sensitive. The location consists of swift water and coarse gravels that would not be suitable spawning habitat such as for eulachon or salmon.

8 Pre-Discharge Environmental Conditions (IRT 2.4.2)

Pre-discharge environmental baseline data were available from a combination of historical studies, data collected as part for the 2014 EIS along with water quality samples collected as part of the 2022 field studies.

The available data included water quality data and flow velocities. No sediment quality or benthic community data was found.

8.1 Water Quality Data (IRT 2.4.2)

British Columbia Environmental Monitoring System (EMS) data collected at Squamish River approximately 10 km upstream of the study area (49.7994N, 123.2061W) (British Columbia 2022) ,is presented in Table 6. The data was collected between January to October 1991.

Table 6 Squamish River (~10 km Upstream of Study Area 1991)

Row Labels	# Samples	Min	Average	Max
Specific Conductance (uS/cm)	55	30.0	61	11
Turbidity (NTU)	54	34.0	160	1.5
pH (pH units)	45	7.1	7.9	6.7
Fecal Coliform (CFU/100mL)	46	7.9	166	1
Enterococci (CFU/100mL)	32	7.7	35	1
Ammonia Dissolved (mg/L)	55	0.007	0.04	0.005
Nitrate + Nitrite Diss. (mg/L)	60	0.037	0.146	0.017
Nitrogen - Nitrite Diss. (mg/L)	34	0.0037	0.008	0.001
Ortho-Phosphate Dissolved (mg/L)	54	0.0028	0.021	0.001
Biomass (mg)	16	374	1400	51
BiomsFix (mg)	16	332	1300	36

Water quality data was collected by Urban Systems in August and September 2013, samples were collected upstream and downstream of the existing outfall. The samples were collected near the riverbank, and not necessarily within the direct path of the effluent plume.

Samples were analysed for a range of parameters including physical, nutrients, and microbiological indicators, and metals. The full results are included and discussed in detail in the 2014 EIS including comparisons to applicable water quality guidelines. During the sampling period water flow rates ranged from 277 m^3/s (August 23, 2013) to 877 m^3/s (August 30, 2013) (Canada 2022) which is within the anticipated range of river flows for the season. The water quality data is the therefore expected to represent typical August and September conditions with higher water flows.

Water quality samples were also collected during the January 2022 (low river flow conditions) field study. River flow rates during the investigation were 94 to 83 m^3/s (Canada 2022). Samples were in the Squamish River upstream of the confluence with the Mamquam River, approximately 50 m downstream of the existing outfall, and in the location of the proposed discharge. The sampling locations are shown in Figure 8, and coordinates are provided in Table 7.

Table 7 Water Quality Monitoring Stations

Station	Latitude	Longitude
1	49.7380	-123.1480
2	49.7359	-123.1492
3	49.7296	-123.1615
4	49.7279	-123.1632

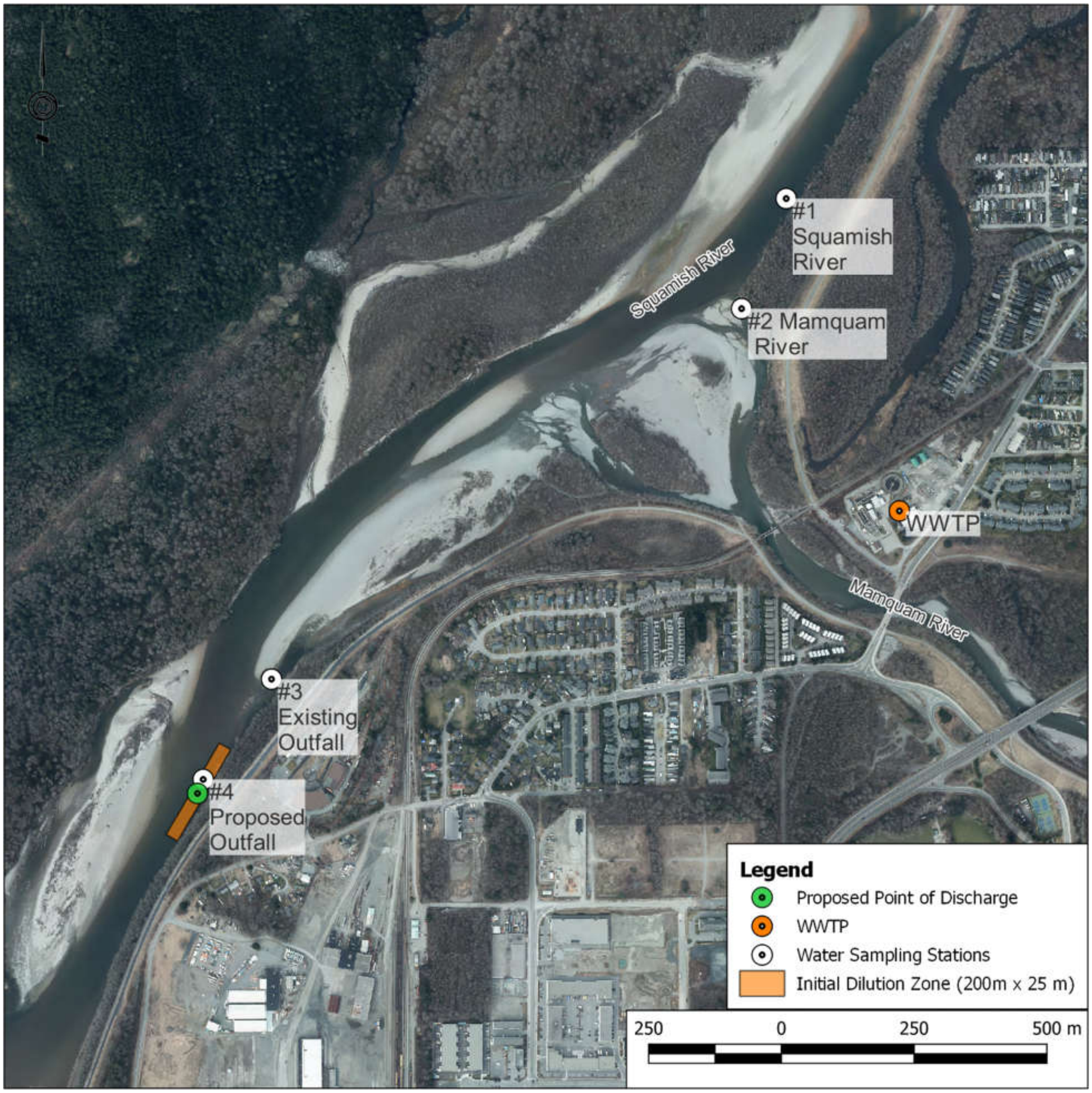


Figure 8 Water Quality Samples (January 2022)

Image Source: Squamish 2021a

The samples were collected at the water surface either from shore (Stations 2 & 3) or from the survey vessel (Stations 1 & 4). Samples were kept cool and delivered to the analytical laboratory within appropriate hold times. Each sample was analysed for a range of anions and nutrients (nitrogen and phosphorus), microbiological indicators, physical properties, polycyclic aromatic hydrocarbons, and total metals.

The results of the analysis are tabulated and included as Appendix 1. Applicable water quality guidelines are provided for reference, and any exceedances were highlighted.

Ammonia, nitrate and nitrite concentrations were within applicable guidelines at the stations beyond the influence of the existing outfall.

Microbiological indicator concentrations were low (non detect or <10 CFU/100 mL) at stations beyond the influence of the existing outfall.

PAH concentrations were below applicable guidelines at all stations at the time of sampling, and the majority of metals were measured within applicable guidelines. At the two upstream stations (1 and 2), guidelines for aluminum, copper and iron were exceeded, and at station 3 downstream of the existing outfall, a guideline for total copper was exceeded. The results suggested that background concentrations of some metals may naturally exceed guidelines.

Results of the monitoring are intended to provide refence data for any future receiving environment monitoring used in the impact assessment (Section 11).

8.2 River Velocities (IRT 2.4.2.4)

River velocities were measured using downward looking Teledyne StreamPro type Acoustic Doppler Current Profiler (ADCP) during the January 2022 field investigation. The ADCP was anchored at a location (latitude 49.72798^o, longitude -123.16321^o) near the proposed outfall discharge point.

The location of the ADCP deployment is shown in Figure 9. The measured current shows that the maximum current speeds were observed from 13:00 to 22:00 on January 26, when the water elevation was minimum during low water ebb tide conditions. In the later phase of the tide cycle, the current speeds were reduced during the rising water levels that accompany the flood tide.

A number of ADCP transects across the river were also collected. The transects were located near the new outfall site and upstream of the confluence of the Mamquam River. The current speeds near the outfall varied from 0.4 m/s near the banks to 1.3 m/s at the channel center. The flow estimated using the transects varied between 82 m^3/s and 89 m^3/s at the survey time. Measured currents were used for model calibration and are discussed in Section 9.

The measured current speeds are expected to be representative of low flow conditions. Anticipated speeds during high flow conditions were modeled and presented in Section 9.

Figure 9 Current Meter Location

Image Source: Squamish 2021a

8.3 Water Column Profiles (IRT 2.4.2.5)

In situ water column properties (temperature, salinity/conductivity, pH, dissolved oxygen and turbidity) were measured during January 26, 2022. The data applies to both the application of water quality guidelines and was used in hydrodynamic modelling.

Specific to the proposed discharge, water column profiles were collected to identify whether salt water from Howe Sound intrudes upriver to the point of discharge during high tides. This process is typically referred to as a “salt wedge”, where dense salt water is pushed upstream with the rising tide and the lower density outflowing fresh river water continues to flow downstream. The presence of a salt wedge in the location of the discharge would significantly affect the dilution potential, and the dynamics of the effluent plume.

Water profiles were collected at eight locations as shown in Figure 10. The coordinates of the profiles are provided in Table 8.

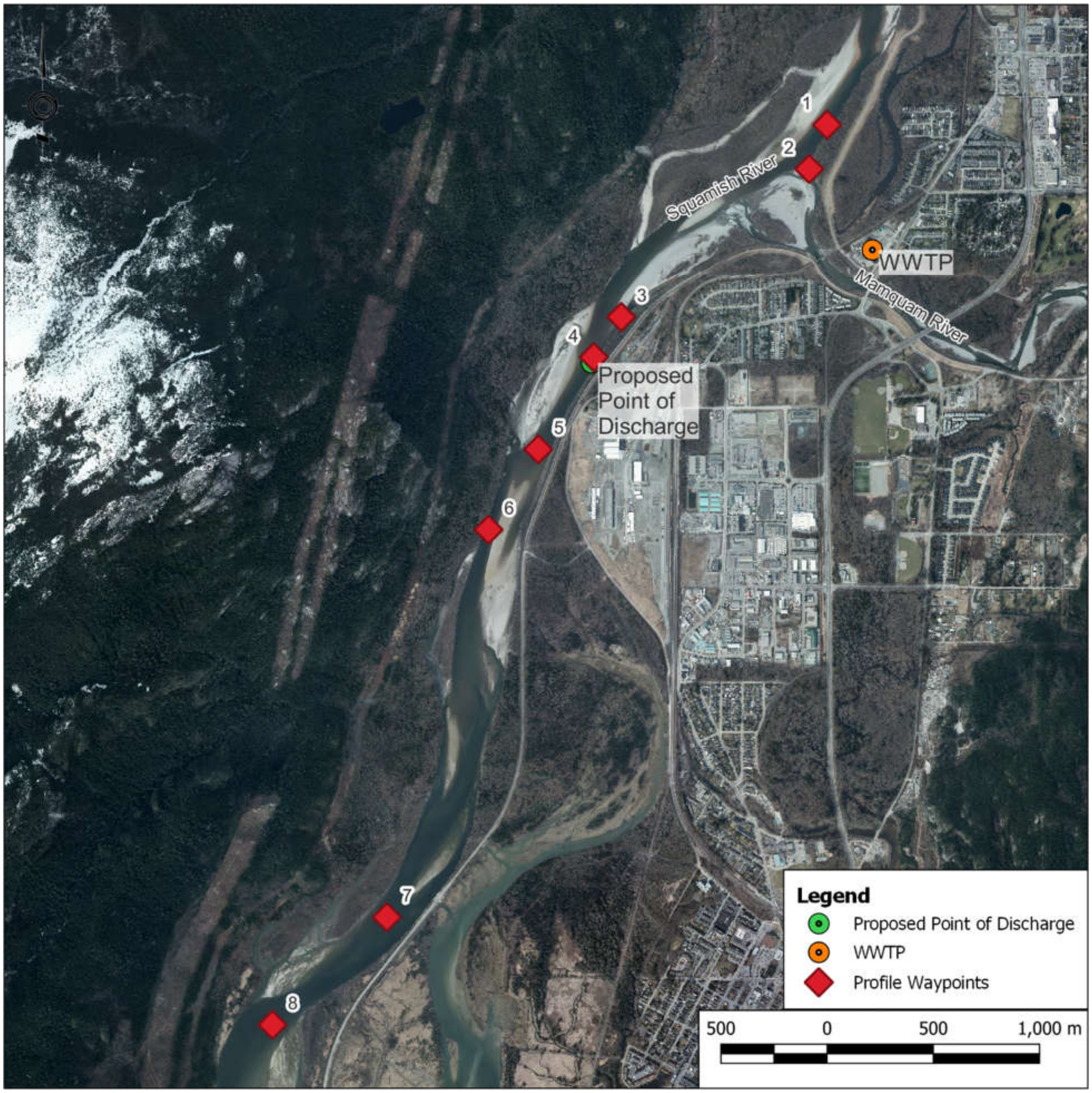


Figure 10 Water Column Profile Locations

Image Source: Squamish 2021a

Table 8 Profile Waypoints Stations (January 26, 2022)

Station	Latitude	Longitude
1	49.738	-123.1480
2	49.7359	-123.1492
3	49.7296	-123.1615
4	49.7279	-123.1632
5	49.7240	-123.1668
6	49.7206	-123.1700
7	49.7042	-123.1767
8	49.6996	-123.1841

Results of the measurements, for various depths, are provided in Table 9. Measured salinities at all sample locations were negligible and indicated no intrusion of seawater in the outfall area. Salt intrusion was observed at stations 7 and 8, four kilometers downstream of the proposed point of discharge. Salt intrusion at the proposed outfall location was determined to be negligible.

Vertical distributions of temperature and salinity show that the river remained well mixed even during the low flow period.

Table 9 Profile Data (January 26,2022)

Station	Latitude	Longitude	Depth (m)	Temp °C	Sal psu	ODO mg/L	NTU	pH
1	49.7359	-123.1492	0.5	2.80	0.03	13.18	1.74	6.89
			1.5	2.80	0.03	13.18	2.54	6.90
2	49.7378	-123.1480	0.0	3.00	0.03	13.67	49.47	7.21
3	49.7296	-123.1614	0.0	3.65	0.05	12.59	3.14	7.13
4	49.7279	-123.1632	0.0	2.70	0.03	13.35	1.46	6.60
			1.0	2.70	0.03	13.34	1.41	6.62
			1.5	2.70	0.03	13.35	1.45	6.66
			2.0	2.70	0.03	13.35	1.75	6.70
5	49.7240	-123.1668	0	2.90	0.03	13.18	1.77	6.88
			1	2.90	0.03	13.17	13.17	6.90
			1.5	2.90	0.03	13.17	13.17	6.90
6	49.7240	-123.1669	0.0	3.10	0.03	13.40	7.48	6.96
			1.0	3.00	0.03	13.28	1.71	6.94
			1.5	3.00	0.03	13.23	1.75	6.93
			2.5	3.00	0.03	13.20	1.70	6.92
			3.0	3.00	0.03	13.17	1.81	6.93
			4.0	3.00	0.03	13.16	1.82	6.93
			4.5	3.00	0.03	13.15	1.86	6.93
7	49.7042	-123.1767	0.5	3.10	1.33	13.07	1.83	6.76

Station	Latitude	Longitude	Depth (m)	Temp °C	Sal psu	ODO mg/L	NTU	pH
			1.0	3.10	1.59	13.05	1.82	6.73
			1.5	3.74	7.66	12.61	1.79	6.56
8	49.6996	-123.18411	0	3.20	1.55	13.11	3.11	6.88
			1	4.03	9.11	12.26	1.52	6.81
			1.5	6.20	20.77	10.97	1.44	7.25
			2	6.68	24.24	10.01	1.22	7.46

9 Hydrodynamic Modelling (2.4.2.6)

The proposed discharge location will be subject to modified flow hydraulics, under the influences of river discharge and tide. As such, an assessment of the minimum dilution properties for the proposed discharge location was completed. A plume advection-dispersion model was developed employing a two-dimensional hydrodynamic model.

The input data requirements, methodology, and results are presented in the following sections.

9.1 Model Scenarios

9.1.1 Ambient Conditions

The WWTP effluent plume released into the Lower Squamish River will begin to disperse in the downstream direction. The key ambient conditions that affect the amount of near-field mixing are:

- Ambient current: The greater the ambient current, the larger the amount of near-field mixing.
- Ambient water depth: The local elevation of the riverbed at the discharge point is approximately 1.5 m CD.
- Ambient temperature and salinity: A fully mixed condition is assumed for the river based on the field data. The river water is considered fresh, and temperature is considered constant.

To examine the extreme conditions, two river flow conditions corresponding to different weather conditions were selected for the simulations. The condition of low river flow was defined based on the BC MWR (2018). The selected flow conditions were as follows:

- Low River Flow - 7-day low flow of 2-year return period corresponding to a dry period (February)
- High River Flow - high flow of 2-year return period corresponding to a post storm condition (October)

A two-week spring-neap tidal cycle was considered for the study for including the oceanographic influence within the estuary.

9.2 Discharge Conditions

The following discharge conditions are used for the plume dispersion assessment:

- Design Flow: maximum discharge of 20,750 m^3/d (0.240 m^3/s) (WSP, 2021)
- Average Dry Weather Flow (ADWF): 0.139 m^3/s

The outlet for the outfall was set above riverbed level, and the simulated effluent released through a 400 mm diameter port in the downstream direction. The discharge was considered constant and continuous for the entire simulation period.

9.3 Hydrodynamic Model

9.3.1 Modelling Tools and Approach

The lower Squamish River is characterized by mostly shallow water depth and moderate to high currents which develop a vertically near homogeneous condition. Hence, a depth-averaged 2D modelling suite, MIKE21 FM, developed by DHI Water and Environment, was used to simulate mixing and dispersion conditions in the far-field region.

The HD Module (MIKE21 FMHD) is the basic module in the MIKE21 FM package, and an additional advection-dispersion (AD) scheme was used for the simulation of effluent dispersion and environmental hydraulics. The HD module provides the hydrodynamic inputs for the computation of effluent dispersion by the AD module. The hydrodynamic model which can simulate the water level variations and flows in response to a variety of forcing functions in lakes, estuaries, and coastal areas. The model resolves dynamics of water levels, flows and effluent transport using model inputs such as bathymetry, bed resistance coefficient, hydrographic boundary conditions and dispersion coefficient.

The system solves the full time-dependent non-linear equations of continuity and conservation of momentum. The solution is obtained using a so-called Alternating Direction Implicit (ADI) finite difference scheme of second-order accuracy to integrate the equations for mass and momentum conservation in the space-time domain. The effects and facilities incorporated within the model include:

- Convective and cross momentum
- Bottom shear stress
- Wind shear stress at the surface
- Barometric pressure gradients
- Coriolis forces
- Momentum dispersion (e.g. through the Smagorinsky formulation)
- Wave-induced currents
- Sources and sinks (mass and momentum)
- Flooding and drying

An advection-dispersion (AD) scheme was used for the simulation of the far-field effluent dynamics in the river. The AD scheme simulates the spreading of dissolved substances subject to advection and dispersion processes by taking other water parameters such as salinity, temperature, heat etc. into account.

Linear decay and/or heat dissipation to the atmosphere can optionally be included within the model when atmospheric and oceanographic influences are important.

The MIKE 21 FMHD uses flexible grids for the schematization of bathymetry within the model domain. The flexible grid model is less restrictive in terms of temporal and spatial resolution criteria and, therefore, a wide range of grid sizes can be used to resolve the local shoreline details, thus reducing the computation time, and increasing stability.

9.3.2 Model Setup

Bathymetry and Topography

The model was set up by covering the lower Squamish River and Howe Sound. The model bathymetry at the project site was created using water depth and topography data collected from the following sources

- Site-specific sounding surveys carried out in January 2022
- Canadian Hydrographic Service (CHS) Non-Navigational (NONNa) Bathymetric data
- Natural Resources Canada (NRC) High Resolution Digital Elevation Model (HRDEM) data defining the above water banks, as well as shoals and other shallow areas that would otherwise be data gaps
- CHS Chart 3534 (CHS 2015) .

For areas within the Squamish River channel with data gaps, the nearest survey data were interpolated or extrapolated, using imagery as a guide for the river’s path. Visually identified shallow areas with data gaps were filled with the nearest HRDEM values and survey data.

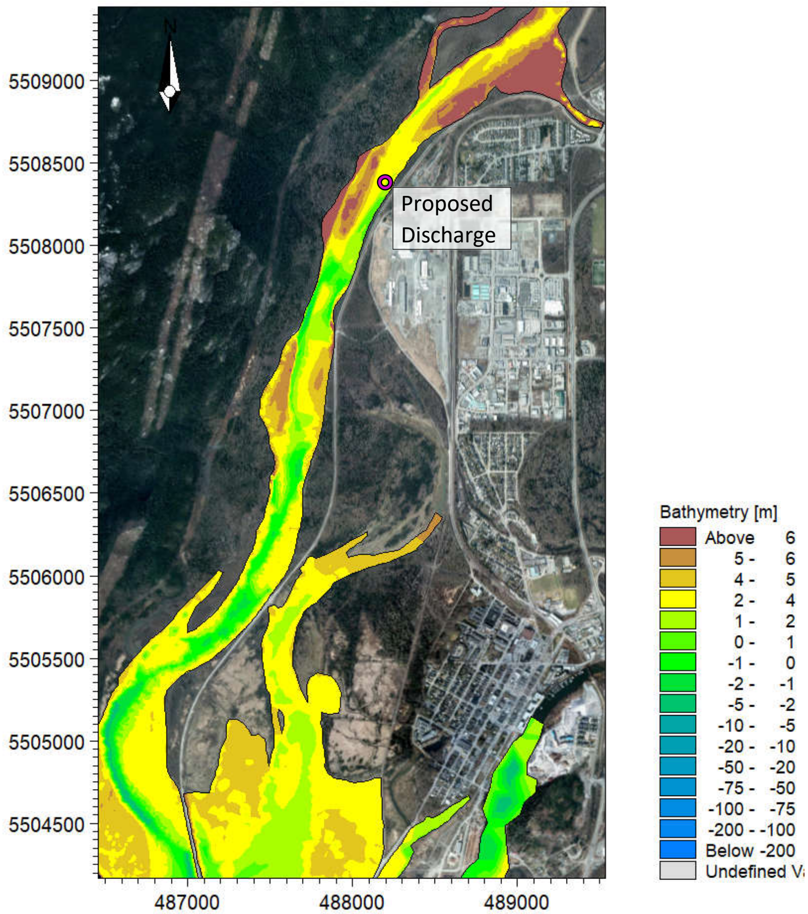


Figure 11 Bathymetry of the Lower Squamish River

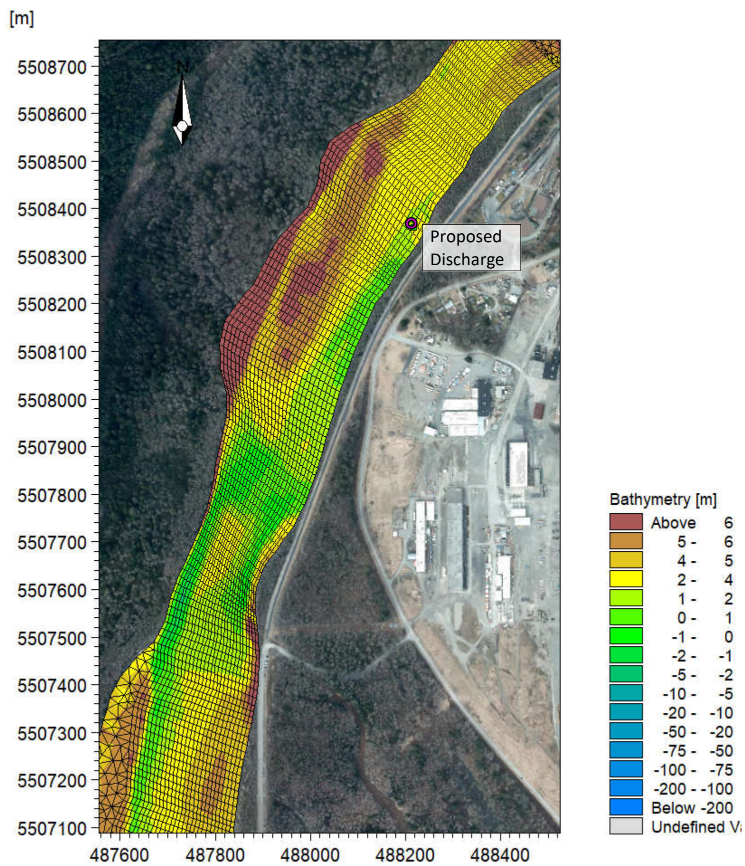


Figure 12 Model grids around the proposed outfall location

Model Boundary

A regional model covering the southern BC coast including the Strait of Georgia was used to generate the boundary condition for the Howe Sound Local model.

River discharges were introduced at the upstream of Lower Squamish River. Although a 2D model was used for the study, depth average salinity inputs were included in the model to incorporate the effect of horizontal density gradients. For Howe Sound including the sea boundary, salinity of 30 Practical Salinity Unit (PSU) was used. River flows were considered freshwater.

9.3.3 Model Calibration

As a first step, the hydrodynamic model was calibrated against the measured water level and current speed near the proposed outfall discharge location on January 25 and 26, 2022. Recorded discharges at the WSC hydrometric stations covering the calibration period were introduced at Squamish, Cheakamus, and Mamquam Rivers. The cross-section profiles defining the shoals downstream of the outfall are manually adjusted at a number of locations to match with the recent images provided by Google Earth.

The channel bed resistance was adjusted by setting the model Manning parameter M=60 $m^{1/3}/s$ which corresponds to Manning number 0.017.

The Smagorinsky formulation (DHI 2017) with a coefficient of 0.28 m was used to describe the dispersion in horizontal directions.

Results of the model calibration are shown in Figure 13 and Figure 14. In Figure 13, the plot illustrates the comparison of simulated and measured water levels in the outfall area. The recorded water level at Darrell Bay was also included in the plot. The simulated water level agrees very well with the measurement.

Comparison of simulated and measured currents at different depths is shown in Figure 14. The simulated depth-averaged current also agrees well with the measurements considering that the simulated current is depth-averaged.

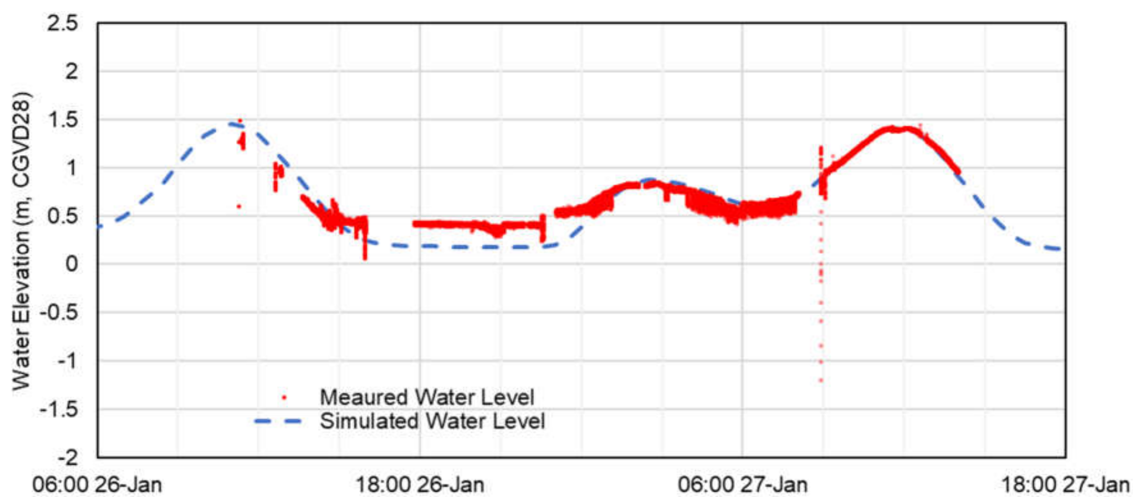
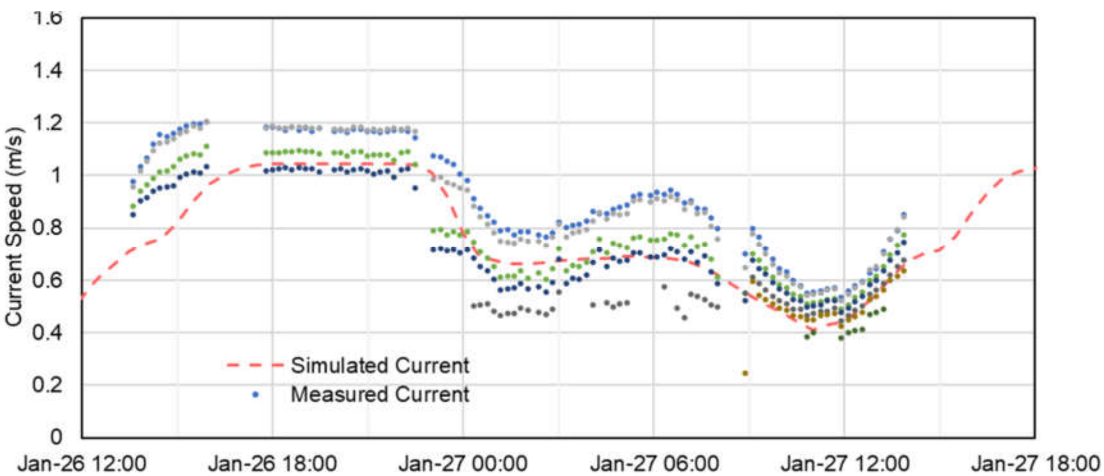


Figure 13 Comparison of measured and simulated water levels at the proposed outfall location.



the study

Figure 14 Comparison of measured and simulated depth-averaged current speed at the ADCP deployment location downstream of the proposed outfall terminus.

9.3.4 Scenario Simulation

After the model calibration, the model was applied to perform the scenario simulations involving different tide and river flow conditions as discussed in Section 9.1 for the purpose of characterizing the critical conditions when the plume dilution would be minimal.

Four different scenarios which were selected for modelling are provided in Table 10.

Table 10 Outfall Dispersion Simulation Scenarios

Scenario	River Flow	Outfall Flow	Date & Time
LF1	Low River Flow	Design Flow, 0.240 m^3/s	Neap tide in February
LF2	Low River Flow	ADWF, 0.139 m^3/s	Neap tide in February
HF1	High River Flow	Design Flow, 0.240 m^3/s	Neap tide in October
HF2	High River Flow	ADWF, 0.139 m3/s	Neap tide in October

9.3.5 Results of Scenario Simulation

Hydrodynamics

Model simulated time series of water level and currents at the outfall terminus location for the low and high river flow conditions are shown in Figure 15. The results show the hydrodynamic response of the river at this location under varying tidal action. The current attains peak speed as the water level dips below a threshold elevation but starts to subside as the water level rises with the flood tide until the current reduces to the lowest value of 0.2 m/s. As the water level rises to the peak, the current speed increases again.

The interaction of the downstream shoals and shallow areas with estuarine flow does not allow the water level to subside below 2.8 m (Chart Datum) at the outfall terminus location.

The current was predicted to reach nearly similar peak values of 1.4 m/s during each episode of low tide for the entire spring-neap tidal cycle. The lowest currents occur during the spring tide when the tidal range is maximum with the largest volume of tidal prism. The current speed reaches its lowest value as the water level rises during flood tide.

For the high flow event, tidal oscillation was found to be only up to 0.15 m during the spring tide. The maximum current was predicted to consistently remain above 2.8 m/s for most of each tidal episode, but reduced slightly by 0.1 – 0.2 m/s as the water lever reached the peak.

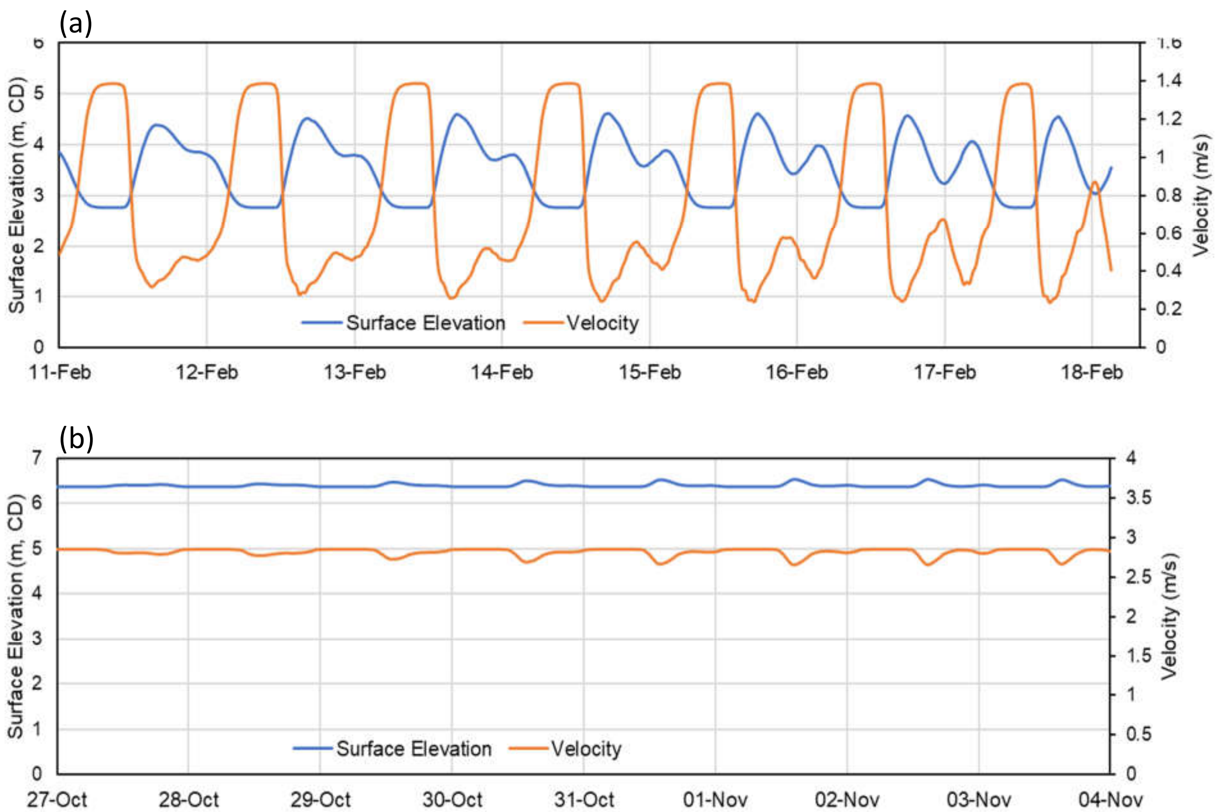


Figure 15 Simulated water level and current speed at the proposed outfall terminus location for (a) 2-year low flow and (b) 2-year high flow.

Simulated distribution currents in the outfall area for the 2-year low 7-day average river discharge at flood tide and low tide conditions are shown in Figure 16 and Figure 17 respectively. The current speed reduced to below 0.2 m/s in the areas downstream of the proposed outfall during flood tide.

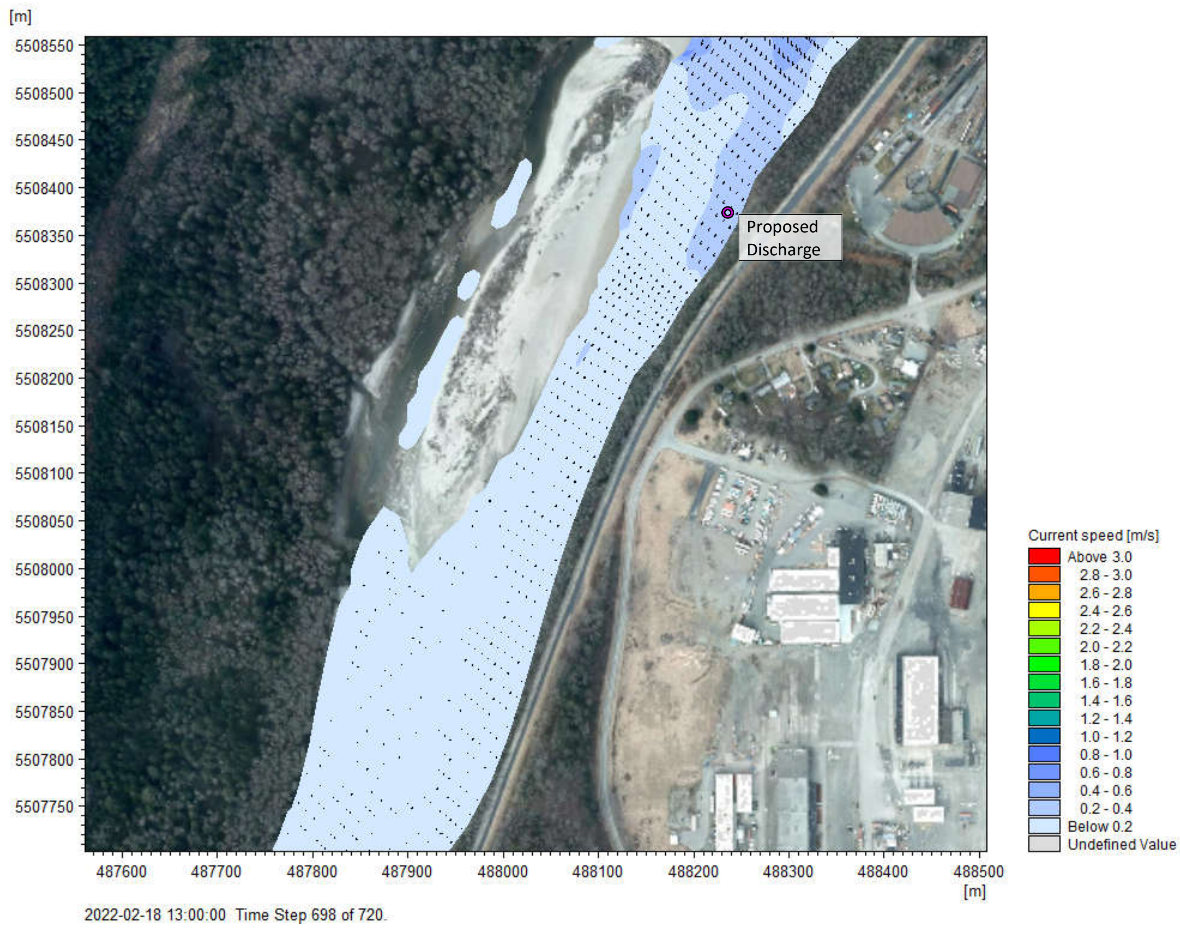


Figure 16 Distribution of simulated current velocity for 2-year low 7-day average river discharge at flood tide (13:00 18 Feb).

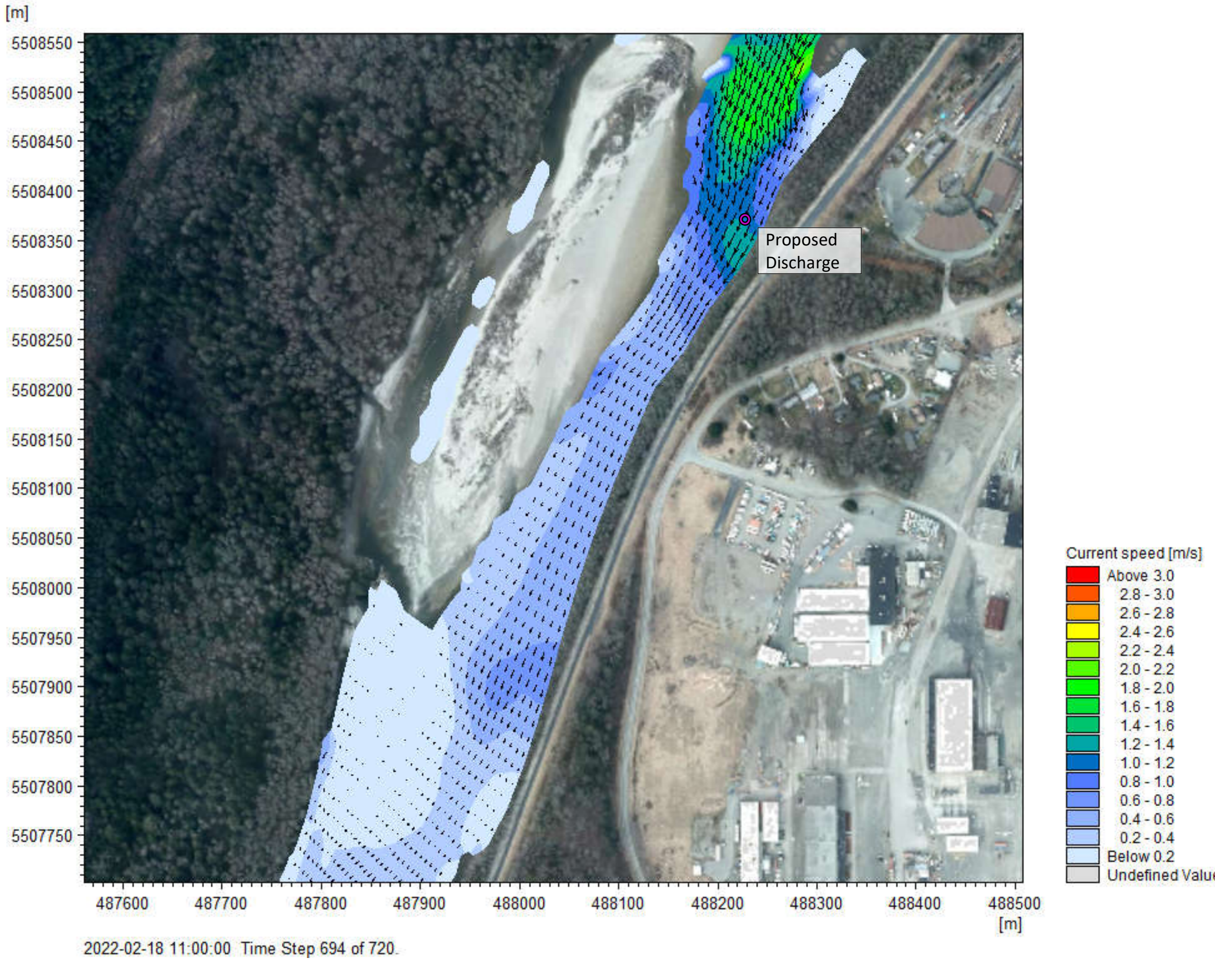


Figure 17 Distribution of simulated current velocity for 2-year low 7-day average river discharge at low tide (11:00 18 Feb).

The simulated distribution currents in the study area for the 2-year high river discharge at flood tide and low tide conditions are shown in Figure 18 and Figure 19 respectively. A current speed up to 3 m/s are predicted in the area of the proposed discharge.

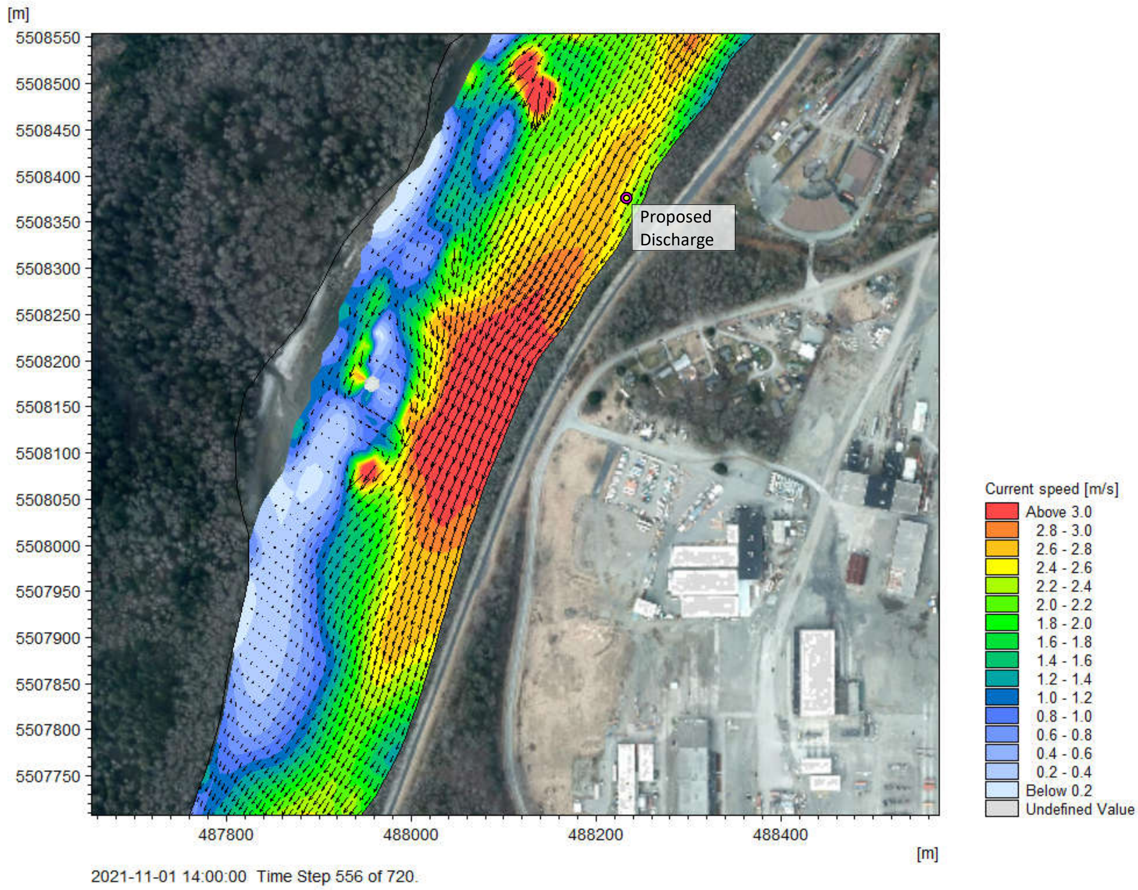


Figure 18 Distribution of simulated current velocity for 2-year high river discharge at high tide when the current speed reaches the daily low at the new outfall (14:00 11 Nov).

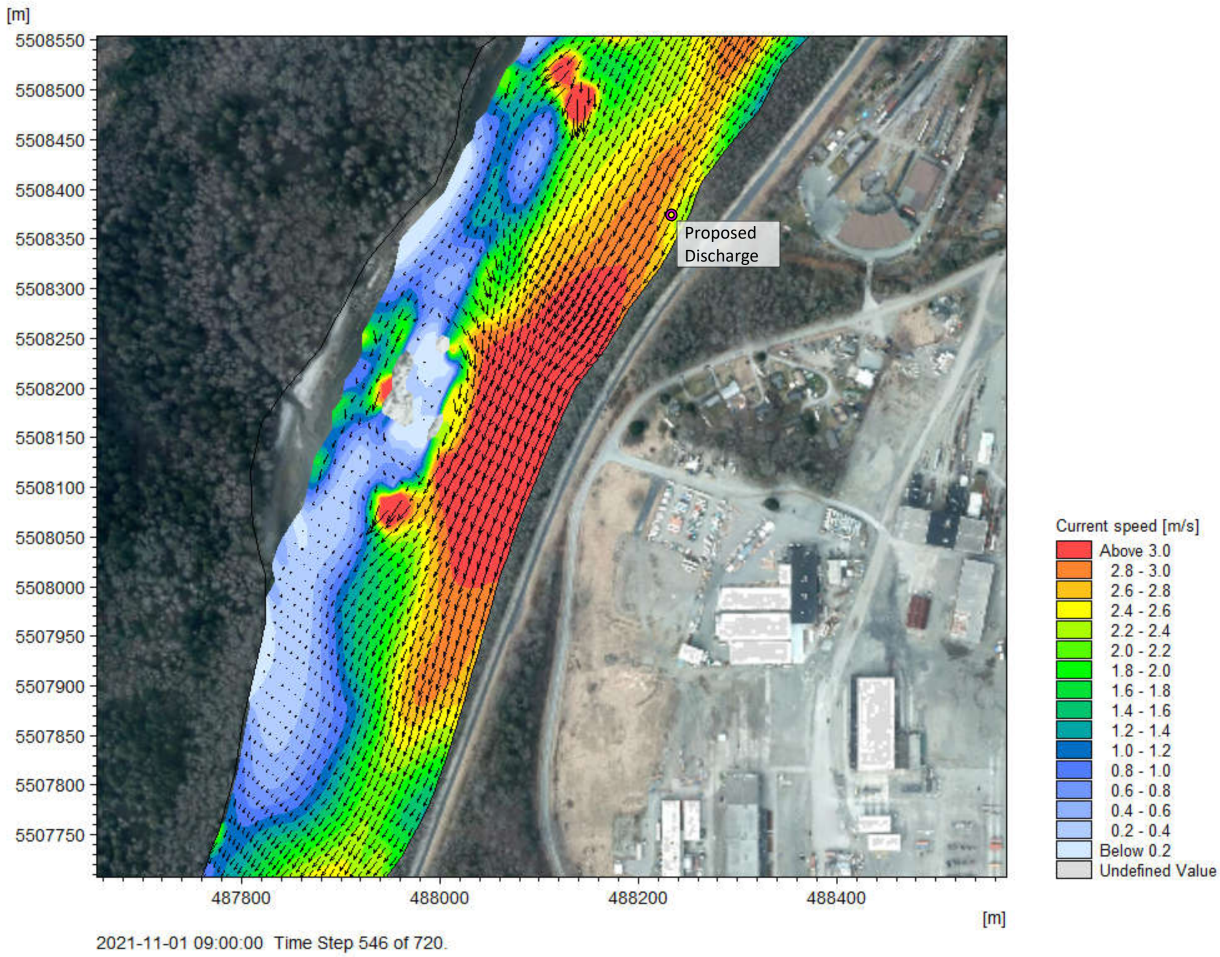


Figure 19 Distribution of simulated current velocity for 2-year high river discharge at high tide when the current speed reaches the daily peak at the new outfall (14:00 11 Nov)

In general, the hydrodynamics of an effluent continuously discharging into a receiving water body can be conceptualized as a mixing process occurring in two separate regions (Doneke and Jirka 2007). In the first region, which is known as near-field, the jet trajectory and mixing is governed by the shape, momentum, and buoyancy of the initial release. The 2D model computes the dilution at the discharging cell based on the mixing of the effluent and flow flux through this cell. Thereby the results of the discharging cell give a spatially averaged dilution. As the turbulent plume travels further away from the source, the plume mixing is governed by the ambient hydrodynamics and this region is known as far-field.

The lowest dilution maps for the design outfall flow and ADWF for the 2-year low 7-day average river discharge are shown in Figure 20 and Figure 21. The released plume was predicted to maintain a low dilution along its axis but as it moves downstream, the plume disperses laterally towards achieving a fully mixed condition across the river width.

Based on results of the model the proposed initial dilution zone as described in Section 4.3 are defined to be:

- a width of 25 m, which corresponds to 25 % of the width of the river ~100 m at mean low water at the point of discharge.
- a length of 100 m parallel to the path of the stream. This corresponds to the maximum allowable distance downstream of the IDZ.

For the purpose of defining the length of the IDZ, the edge of the effluent plume was defined as the point where the predicted dilution is greater than the "dilution ratio" of 220:1 in model scenario LF1 (Low River Discharge and Design Outfall Flow). The plume attains a width of 25 m, 284 m downstream, and therefore the proposed IDZ will be extended to the maximum allowable length of 100 m.

The simulated time varying effluent dilution at 10 m, 50 m, and 100 m downstream are shown in Figure 22 for the 2-year low 7-day average river discharge scenario when the outfall releases design flows and ADWF flows. For the design effluent flow, low dilutions occur during flood tide and the dilution reached the lowest number during the spring tides. The simulated lowest dilution over the period of a spring neap tidal cycle was 61:1 at the maximum downstream length of the IDZ (Table 11).

Table 11 Lowest dilution at different downstream distances

Scenario	Minimum Dilution		
	10 m	50 m	IDZ (100 m)
Low River Discharge and Design Outfall Flow	31:1	50:1	61:1
Low River Discharge and ADWF	51:1	84:1	102:1
High River Discharge and Design Outfall Flow	686:1	1062:1	1260:1
High River Discharge and ADWF	1184:1	1833:1	2174:1

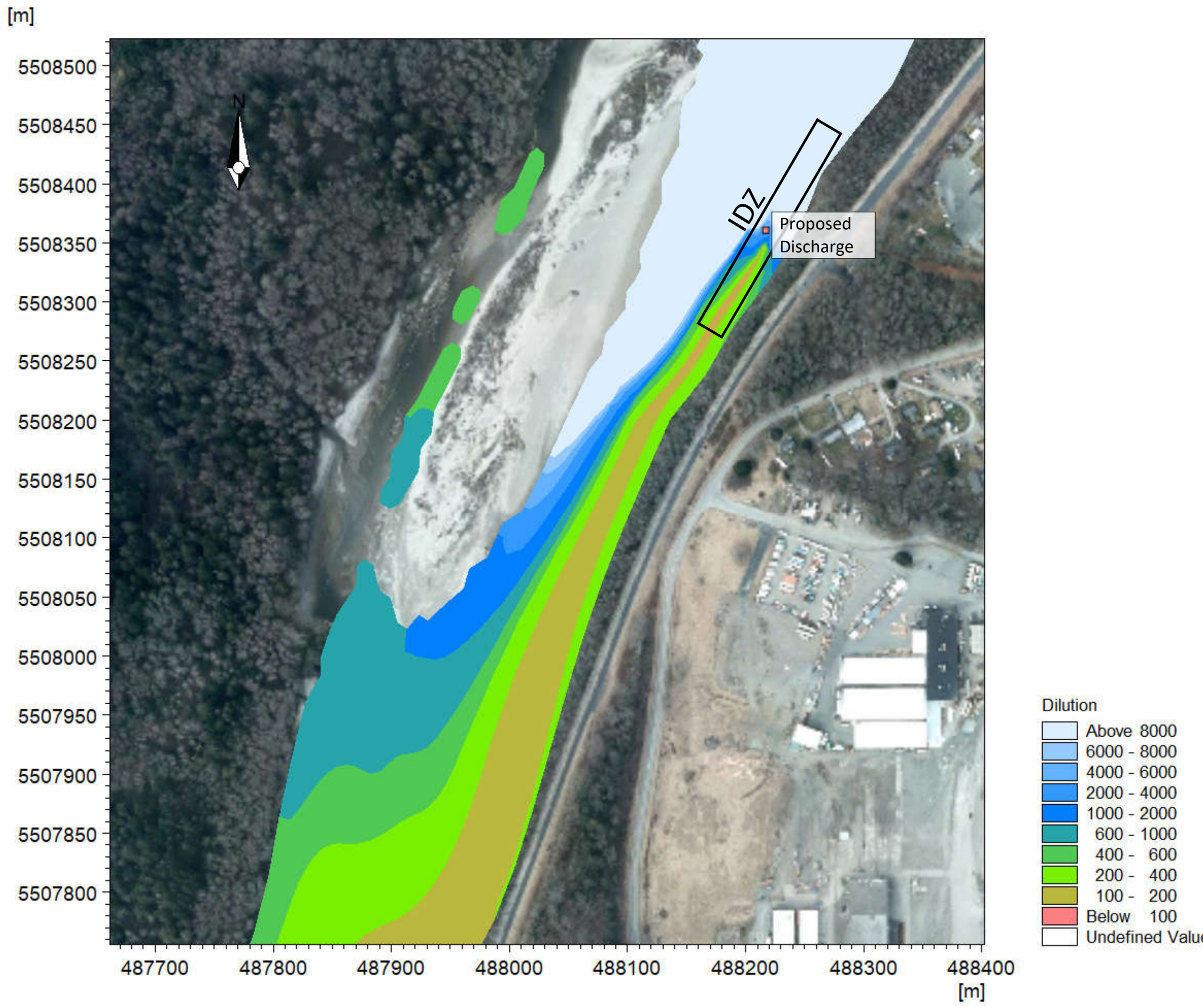


Figure 20 2-Year Low 7-Day Average River Discharge Scenario - Design Outfall Flow

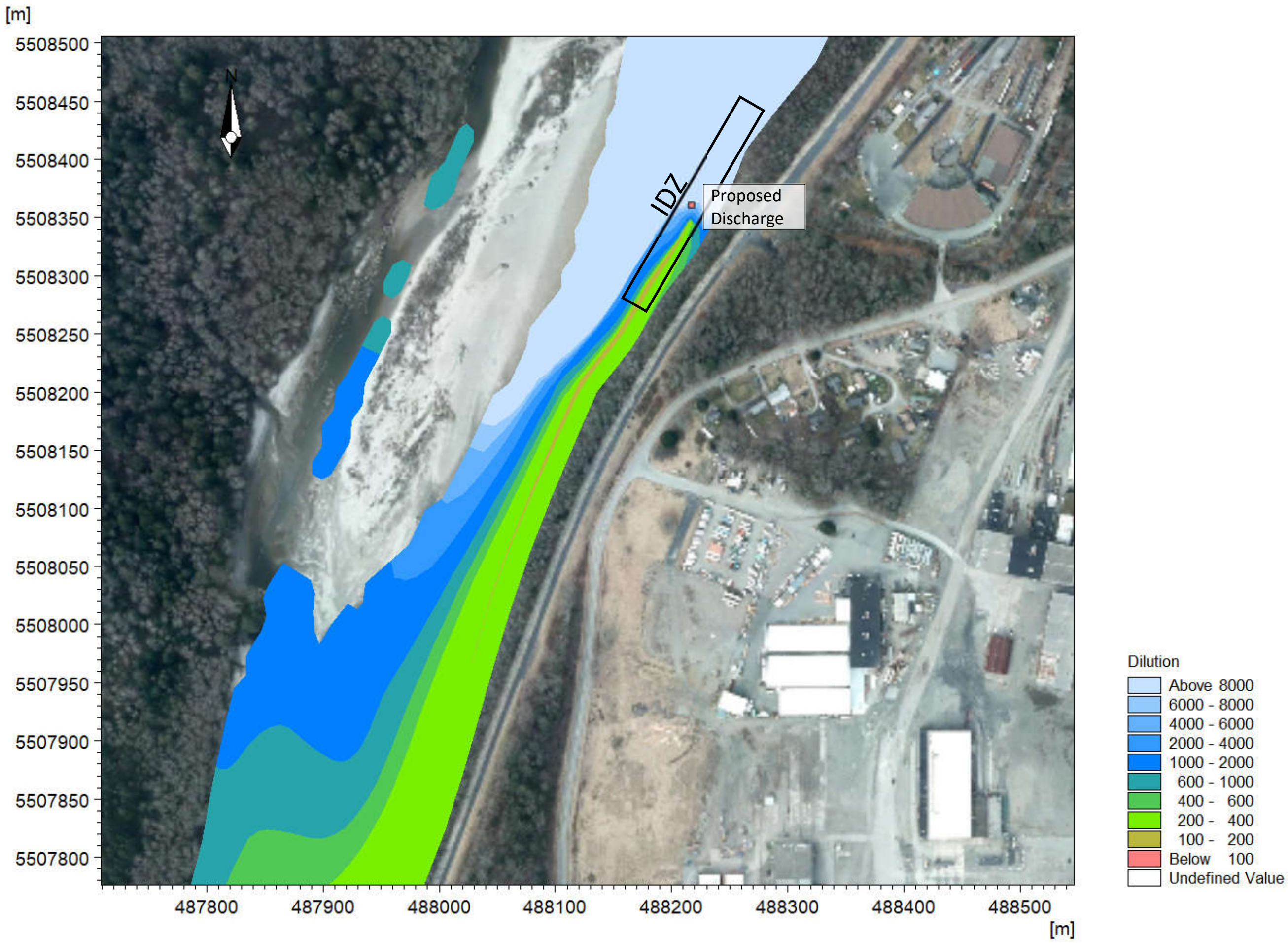
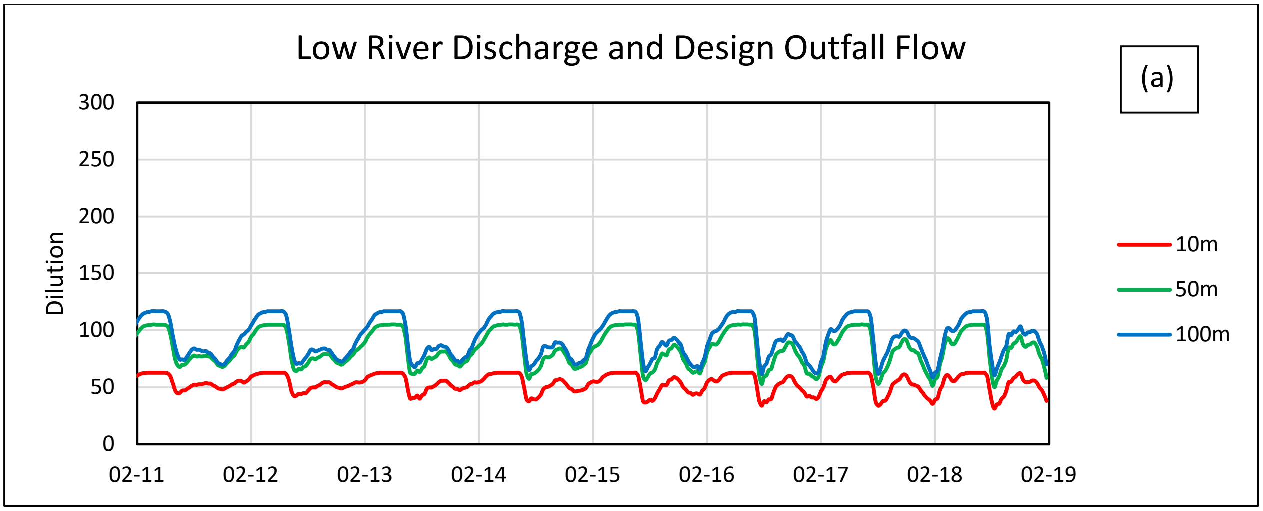
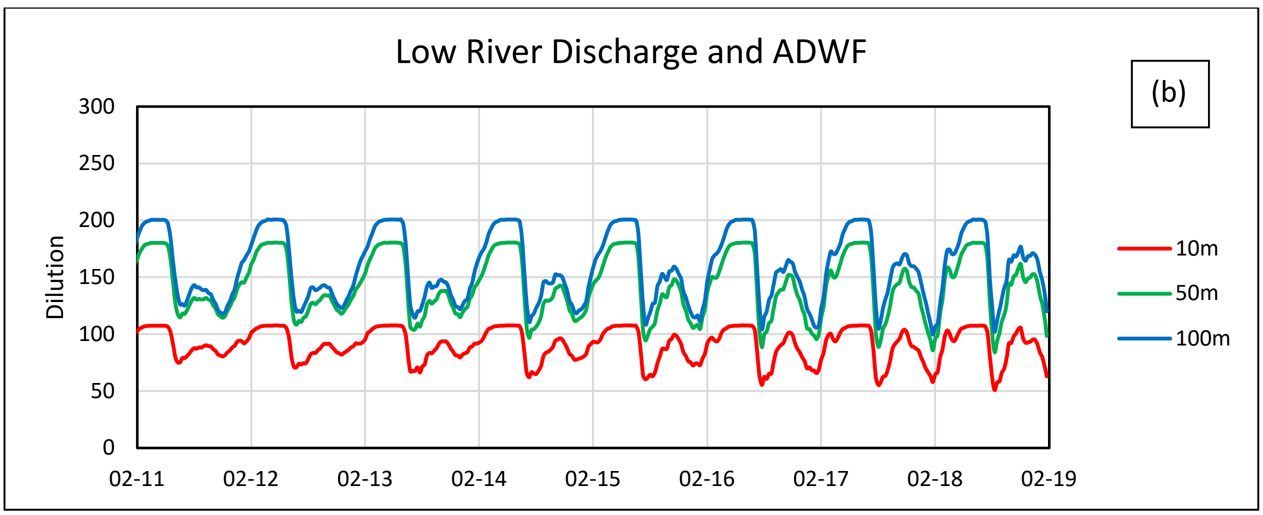


Figure 21 2-Year Low 7-Day Average River Discharge Scenario – ADWF



(a)



(b)

Figure 22 Low River Discharge Scenario (a) Design Outfall Flow (b) ADWF

The lowest dilution maps for the design outfall flow and ADWF for the 2-year high river discharge are shown in Figure 23 and Figure 24. The plume achieves dilutions greater than 1000:1 beyond 20 m downstream that will continue to disperse as it moves toward the river mouth. For a fully laterally mixed condition, a dilution of 10,000 and 6,000 are available for the design outfall flow and ADWF respectively. However, the plume reaches the river mouth before achieving a fully laterally mixed condition.

For the high river discharge scenario, time varying effluent dilutions at 10 m, 50 m, and 100 m downstream are shown in Figure 25. The large river flow significantly dilutes the effluent, and the tide does not cause significant fluctuation of dilution. The dilutions at 10 m are 686:1 and 1184:1 for the design outfall flow and ADWF respectively. At 100 m downstream, the dilutions exceed 1200:1 and 2100:1 for the design outfall flow and AWDF respectively.

The maximum dilution available for the low river flow and design outfall flow is 223:1, which is estimated by dividing the river discharge with the effluent flow rate. The fully laterally mixed condition is achieved approximately 1.8 km downstream from the outfall terminus when the current speed was minimum. For the case of ADWF and low river discharge, the maximum dilution available is 385:1 and it is achieved 1.7 km downstream.

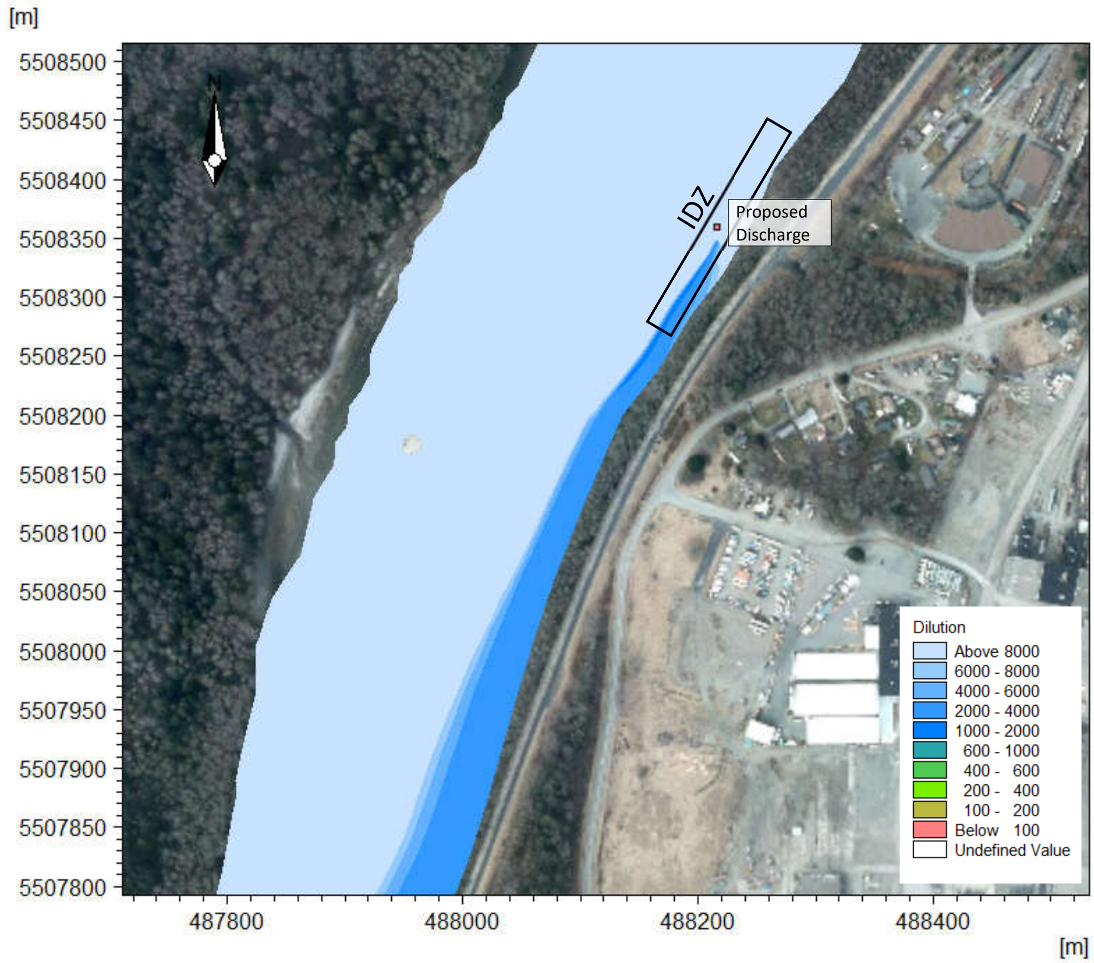


Figure 23 High River Discharge Scenario - Design Outfall Flow

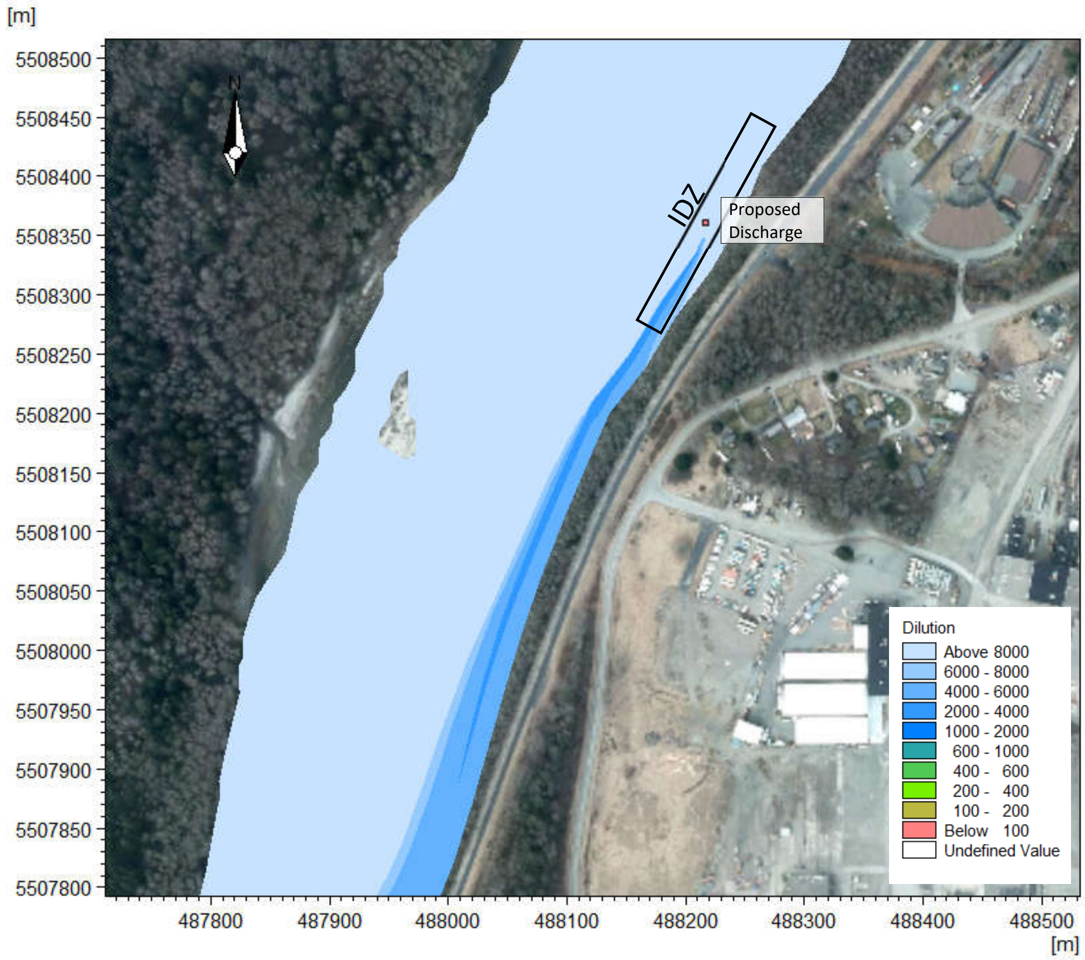
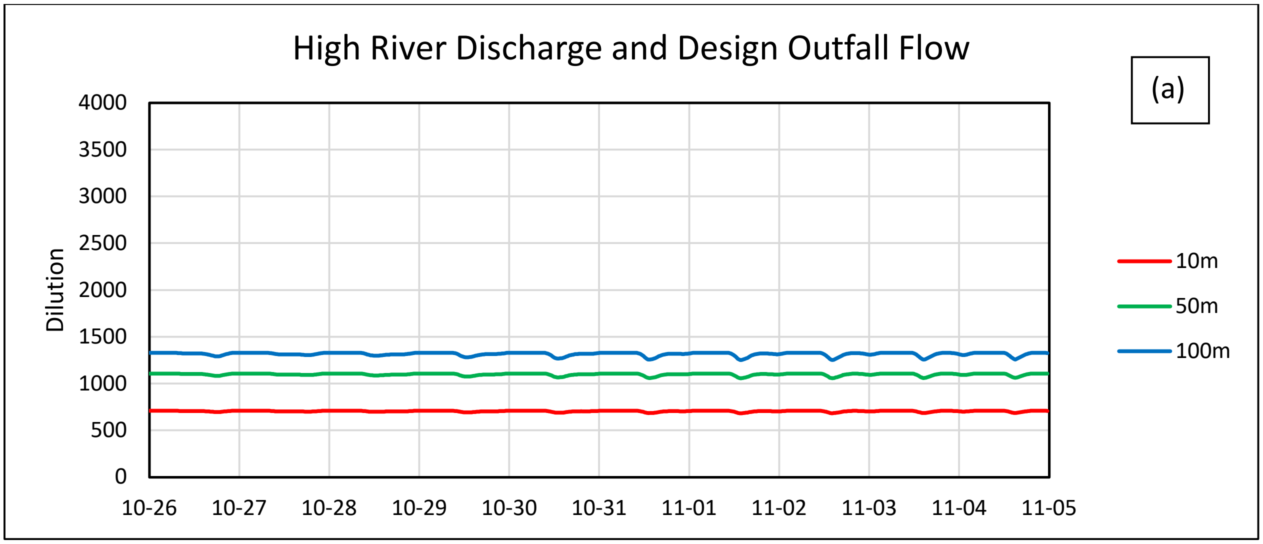


Figure 24 High River Discharge Scenario - ADWF



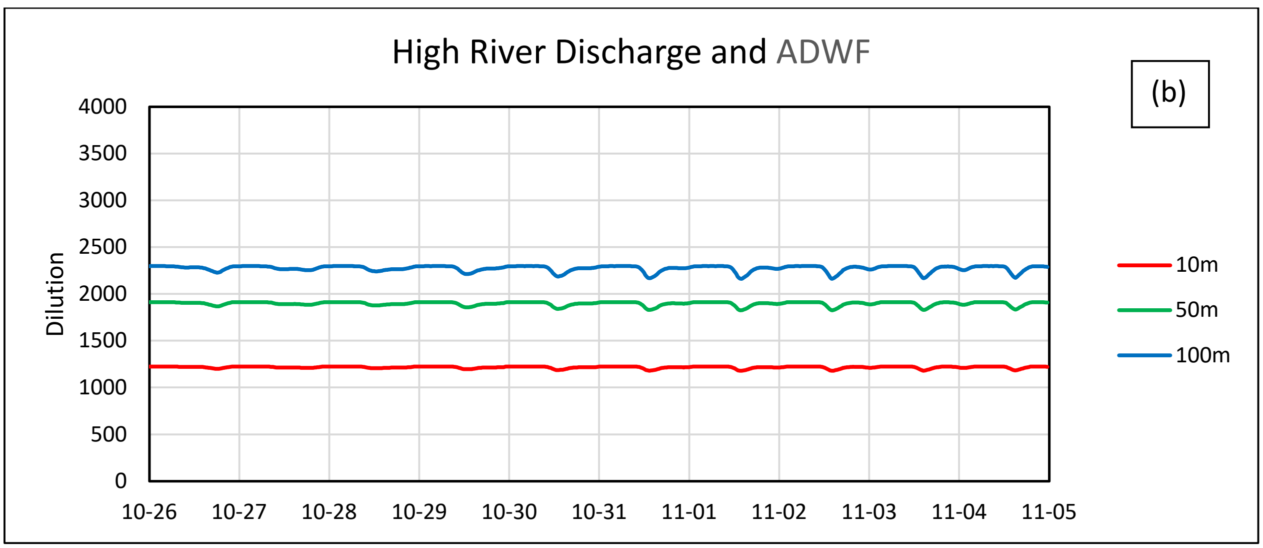


Figure 25 Low River Discharge Scenario (a) Design Outfall Flow (b) ADWF

9.3.6 Sensitivity Test

In addition to the scenario simulations, the model was used to test plume dilution sensitivity to the water level changes due to storm surge or sea level rise. Two simulations were performed for elevated sea level boundary by 0.5 m and 1.0 m respectively with low river discharge and design outfall flow.

Results of sensitivity simulations are provided in Table 12. The high sea level condition in Howe Sound reduced the river current and resulted in noticeable lowering of dilution. However, it should be noted that the probability of a combined occurrence of a major storm surge and a design discharge event during low river discharge is very low.

Table 12 Change of dilution as a result of water level (WL) rise in Howe Sound

Howe Sound Water Level Rise	Minimum Dilution		
	10 m	50 m	100 m
0 m	31:1	50:1	61:1
0.5 m	19:1	40:1	59:1
1.0 m	12:1	41:1	59:1

9.4 Ammonia (IRT 2.4.2.8)

The maximum allowable ammonia concentration was back calculated from the predicted dilution of the effluent plume at the boundary of the IDZ as per section 95 (6) of the MWR.

The water quality guideline for total ammonia is based on the anticipated temperature and pH of the receiving environment. Based on maximum ambient temperature of 15°C and pH of 7.8 (Urban Systems 2014) conservative water quality guidelines used for the calculation are:

- Average 5 to 30 Day Ammonia Guideline: 1.53 mg/L
- Maximum Ammonia Guideline (mg/L): 7.95 m/L

Based on a minimum (worst case) dilution of 61:1, and ambient concentration <0.1 mg/L, the theoretical maximum allowable effluent concentrations would be:

- Average 5 to 30 Day Ammonia Guideline: 92 mg/L
- Maximum Ammonia Guideline (mg/L): 477 m/L

These theoretical allowable concentrations greatly exceed ammonia concentrations in the effluent (< 6 mg/L, Urban Systems 2014) and would also be considered deleterious under the *Fisheries Act*.

10 Impact Assessment

The 2014 EIS evaluated the potential changes to the water quality of Squamish River at both the edge of the initial dilution zone (for the existing outfall) and based on the bulk dilution ratios (river vs. effluent for various season). The predicted water quality at the edge of the IDZ was based on a predicted worst-case dilution of 30:1 and 60:1, for the 2-year 7-day average low river discharge conditions at high tide and low tide respectively. Measured effluent and ambient water quality parameters were used to predict water quality during these scenarios.

Based on the analysis, the 2014 EIS concluded:

- The potential for a change in the dissolved oxygen concentration in the Squamish River is unlikely, as is the potential for any change in the dissolved oxygen concentration to result in a detrimental effects to the fisheries uses for this part of the Squamish River.
- Of the effluent parameters that could be assessed with respect to water quality guidelines TSS, ammonia, nitrate, total metals were predicted to be within applicable water quality guidelines at the boundary of the IDZ.
- The treatment for phosphorous was not recommended; and,
- Disinfection of the effluent below 5,500 CFU/100mL was recommended to achieve recreational water quality guidelines.

The proposed new outfall location is predicted to achieve a "worst case" dilution of 61:1 at the edge of the IDZ, slightly higher than the worst-case dilutions (30:1) predicted for the existing outfall in the 2014 EIS. The greater dilution should provide an improvement in water quality over the existing discharge configuration.

The "worst-case" predicted concentration of effluent parameters was calculated, based on the predicted dilution of the effluent plume at the IDZ and "worst-case" measured ambient concentrations. These predictions should be considered conservative as they are for a scenario that combines the lowest dilution, with anticipated maximum concentration in effluent and ambient receiving waters. The results of the calculations are included as Appendix 2. Water quality guidelines at the boundary of the IDZ were predicted to be satisfied for the parameters, with the exception of some metals that occur in the receiving environment at concentrations in excess of water quality guidelines.

A factor of safety was calculated to help assess the risk of any given parameter that exceeds applicable guidelines in undiluted effluent. Based on the worst case values presented, the factor of safety for TSS and temperature is less than 10, and there are several metals with no factors of safety, based on the high ambient concentrations.

11 Effluent and Receiving Environment Monitoring

Receiving environment monitoring is a requirement under the MWR. The recommendations for a post-discharge effluent and receiving environment monitoring program are described below.

In general, a receiving environment monitoring (REM) program is designed to understand effects and track changes in these effects from outfall discharges to the receiving environment, thus providing information for management of the outfall and treatment operations. There are typically two primary components of the program: receiving water quality monitoring, and sediment/benthic environment monitoring.

Receiving water quality monitoring will verify the predictions of this EIS, *i.e.*, to confirm that receiving environment water quality parameters are not being exceeded outside the IDZ.

Benthic monitoring is intended to assess potential effects of the discharge to the benthic environment (typically those that may occur over the longer term). Substances originating from the discharge may have potential to deposit on the surrounding riverbed with potential to alter the sediment chemistry and benthic community which are part of the food web.

The following recommended REM program should be reviewed periodically and updated as necessary to maintain relevancy with monitoring methods and scientific knowledge.

Monitoring is to be carried out using methodology consistent with BC field sampling protocols (BC 2013).

11.1 Risk Classification

A modified risk classification process similar to that outlined in the ENV's marine monitoring guidance document (LGL & BC MECCS 2019), was developed to help inform the design of the receiving environment monitoring program. The proposed risk rating scheme was based on GreatPacific's outfall monitoring experience and judgement in assessing the risk to the receiving environment and the need to monitor specific parameters.

A risk classification scheme and points rating system are presented in Table 13, which were based on the effluent volume outlined in section 103 (Table 12) of the MWR, effluent quality, and marine receiving environment types defined in MWR section 94 (Tables 9, 10, & 11). The risk rating also includes a dilution factor of safety, calculated from the predicted pollutant concentration within the effluent plume at the IDZ and/or the location of sensitive receptors and applicable water quality guidelines.

With respect to this proposed wastewater system, the maximum design daily flow is 20,750 m^3/day (40 points), the effluent quality is BOD ≤ 45 mg/L, TSS ≤ 45 mg/L (20 points), and discharge is to river waters. The factor of safety is > 2 for all substances identified (i.e., nutrients, metals, and organics), assuming the recommended and designed minimum treatment performance is being achieved (20 points).

Based on the combined risk factors, the overall risk of the discharge scored as "medium".

Table 13 Risk Classification

Category	Subcategory		Score	Project Rating (FCPCC)
Effluent	Effluent Flow (Maximum Daily, m^3/day)	<10 *	0	**40**
		10 - 500	10	
		500 - 5,000	20	
		5,000 - 50,000	40	
		50,000 - 200,000	60	
		> 200,000	80	
	Effluent Quality	BOD ≤10 mg/L, TSS ≤10 mg/L And Dilution ratio ≥100:1	5	**20**
		BOD ≤45 mg/L, TSS ≤45 mg/L* And Dilution ratio ≥100:1	20	
		Dilution ratio <100:1	(Based on results of EIS)	
Stream, River and Estuary	Factor of Safety on Dilution Performance at IDZ	>10	5	**20**
		2-10	20	
		<2	30	
Overall Rating		**Low**	**≤60**	**80**
		Medium	**60-90**	
		High	**>90**	

* For lagoon systems, TSS ≤60 mg/L

11.2 Water Quality Monitoring

11.2.1 Objective

Potential effects to aquatic life is an important aspect of the proposed discharge. For this reason, the proposed receiving environment monitoring program was focused primarily on water quality parameters.

11.2.2 Pre-Discharge Conditions

Give the presence of the existing outfall, pre-discharge monitoring is not possible.

11.2.3 Post-Discharge Monitoring

Post-discharge monitoring should include those analytes that are listed in Table 14. These parameters are to be measured either in-situ or by an appropriate analytical laboratory. Analytes that are associated with applicable BC water quality guidelines or criteria are indicated, as well as those that have applicable Canadian Council of the Ministers of Environment (CCME) guidelines. It is recommended that the parameters to be measured in the receiving environment should also be measured in the effluent at the time of sampling, including effluent monitoring for standard parameters (Flow, BOD_5, and TSS). This will help provide a better understanding of the correlation between effluent and receiving water quality.

Based on the effects assessment, receiving environment monitoring should include TSS and temperature due to the low factor of safety. Metal concentrations should also be monitored due to naturally high levels measured in the river. Dissolved Organic Carbon and Hardness are required to assess water quality guidelines for various metals.

Additional effluent parameters such as fecal coliforms, ammonia nitrogen and total metals are also recommended as compliance with applicable water quality guidelines requires dilution.

Table 14 Proposed Water Quality Monitoring Parameters

Group	Analyte	Applicable Guideline or Criteria	Sampling Location
In-Situ	• Flow	MWR	Effluent
	• pH [1]	BC	Effluent, Receiving Environment
	• Temperature [1]	BC	Receiving Environment
	• Turbidity	BC	Receiving Environment
	• Dissolved Oxygen	BC	Receiving Environment
Laboratory Analysis	• BOD_5	MWR	Effluent
	• TSS	MWR, BC	Effluent, Receiving Environment
	• Fecal Coliform	MWR,BC	Effluent, Receiving Environment
	• Total Ammonia Nitrogen	BC	Effluent, Receiving Environment
	• Nitrate & Nitrite	BC	Effluent, Receiving Environment
	• Total Metals	BC / CCME	Effluent, Receiving Environment
	• Dissolved Metals	BC / CCME	Effluent, Receiving Environment
	• Dissolved Organic Carbon	BC	Receiving Environment
	• Hardness	BC	Receiving Environment
	• Toxicity	MWR	Effluent

[1] Ambient temperature, salinity, and pH are required to determine the appropriate ammonia guideline for the protection of aquatic life.

Timing and Frequency

Samples should be collected as per the MWR and to provide statistically significant numbers of samples to appropriately compare to applicable water quality guidelines.

Minimum dilutions were predicted during the winter; therefore, sampling should be carried out during the winter low flows (January to April). A minimum of 5 samples within a 30-day period (5 in 30) should be collected for the parameters. This is required for the calculation of average, geometric means and 90th percentile concentrations.

Station Locations and Specific Analytes
Water quality samples should be collected at the wastewater treatment plant (effluent), the boundary of the IDZ, at one reference sampling location outside the influence of the effluent plume, and one station downstream of the IDZ.

The proposed sampling stations are provided in Figure 26. The exact coordinates of the stations should be determined following construction of the outfall.

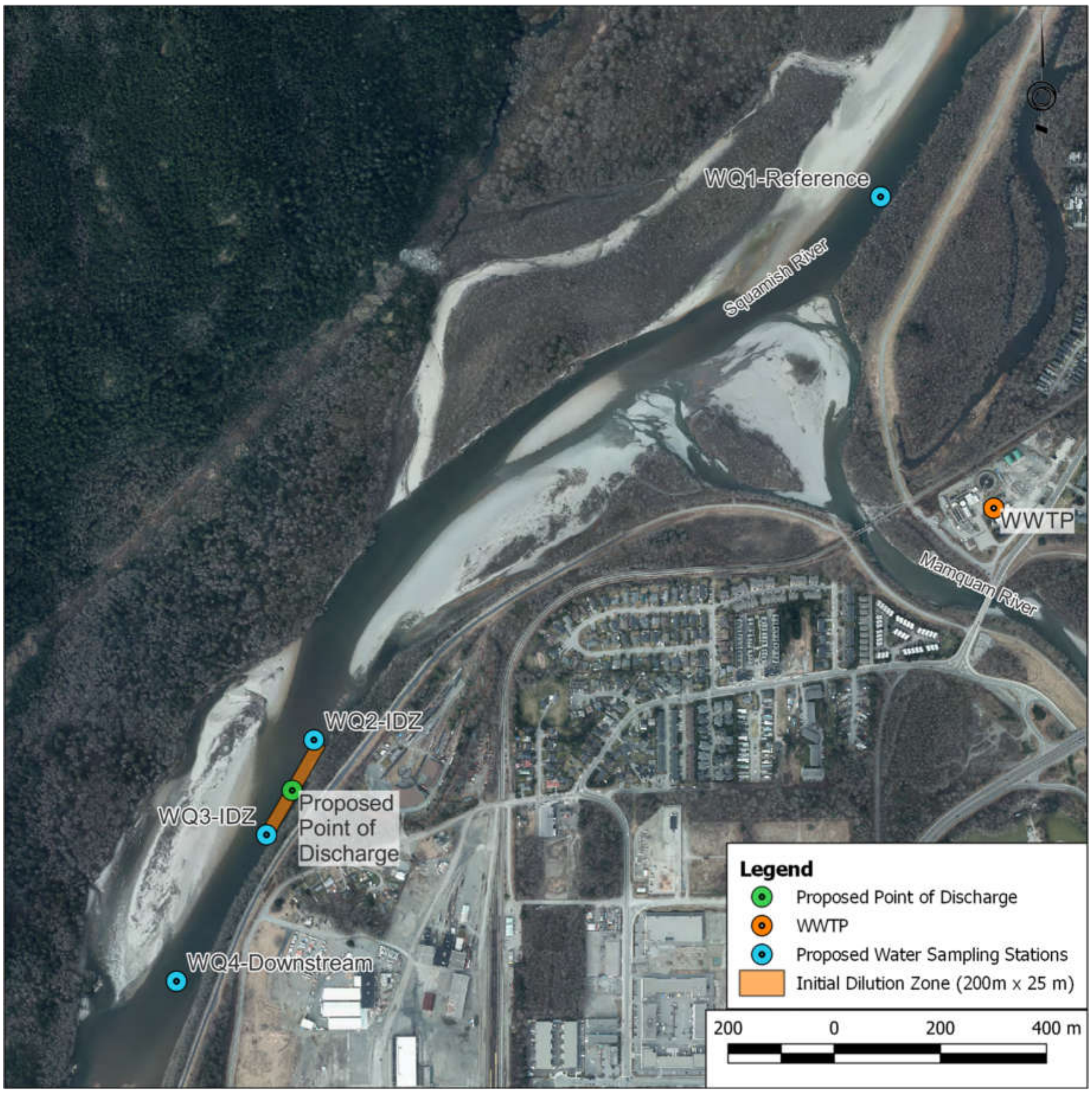


Figure 26 Proposed Receiving Environment Water Quality Monitoring Stations

.

11.3 Sediment Sampling

11.3.1 Objective

The medium risk level for the discharge (based on a combination of treatment level, dilution level and receiving environment characteristics) suggests that sediment monitoring should be undertaken to help assess whether any long-term deposition of pollutants has/is occurring.

11.3.2 Study Design

The proposed study is designed as a “multiple gradient design”, with sediment samples to be collected along stations aligned with the predominant current directions.

Sediment samples should be collected at the following preliminary locations:

- Upstream location in a depositional area of the Squamish River
- Upstream location in a deposition area downstream of the confluence of the Squamish River and Mamquam River
- Downstream edge of the IDZ in a depositional area on the riverbank
- Downstream of the outfall (far field) in a depositional area.

The proposed monitoring areas are shown in Figure 27.

Figure 27 Proposed Sediment Quality REM Stations

11.3.3 Analytical Parameters & Frequency

Sediment monitoring should include at a minimum those analytes that are listed in Table 15. These parameters are to be analysed by a Canadian Association of Laboratory Accreditation (CALA) accredited analytical laboratory.

Table 15 Proposed Sediment Monitoring Parameters

Group	Analyte	Purpose
Physical	• Granulometry / Grain Size	Indicator of sedimentary properties
	• Redox Potential (Eh)	Indicator of oxygen conditions in sediment
	• Sulfides	To calculate metal toxicity
Metals	• Total Metals	BC and CCME Sediment quality guidelines
	• Simultaneously Extracted Metals	To determine bioavailability and toxicity of metals
Nutrients	• Total Organic Carbon	Indicator of organic enrichment
Organics	• PAHs	BC and CCME Sediment quality guidelines, may be present in municipal effluent
	• PBDEs	BC and CCME Sediment quality guidelines, may be present in municipal effluent

11.3.4 Timing and Frequency

A single sampling event for sediment chemistry, during low flow condition, is proposed at this time, sampling parameters and locations are to be reviewed following the initial sampling program. For ongoing monitoring of wastewater discharges characterized as “medium risk”, the BC MECCS suggested the collection of sediment samples once every five years.

11.4 Biological Monitoring

11.4.1 Objective

The medium risk level for the discharge suggests that biological monitoring should be undertaken to help assess potential effects to the biological communities.

11.4.2 Study Design

The proposed sampling program will include the collection of benthic infauna community data using methods consistent with the BC Field Sampling Manual (ENV 2013). The benthic community data should be collected in conjunction with the proposed sediment sampling program.

Samples should be collected from four stations (same as sediment program). Collected benthic infauna should be preserved and delivered to a qualified taxonomic laboratory for analysis.

11.4.3 Timing and Frequency

A single sampling event for benthic community, during low flow condition, is recommended as a baseline archive. For ongoing monitoring of wastewater discharges characterized as “medium risk”, the BC MECCS suggests the collection of benthic community samples once every five years.

11.5 Toxicity Monitoring

Effluent toxicity monitoring described in Section 58 of the MWR does not apply for any of the following circumstances:

a. the discharge quality does not exceed a maximum BOD5 and TSS of 10 mg/L each;
b. the discharge does not exceed a maximum daily flow of 50 m^3/d;
c. the discharge is diluted such that, at the outside boundary of the initial dilution zone, the dilution ratio exceeds 100:1;
d. a director waives the requirement on the basis that the discharge does not adversely affect the receiving environment.

The target effluent quality will have concentrations of BOD_5 and TSS that exceed 10 mg/L (each) and the predicted dilution of the effluent plume at the IDZ is less than 100:1 therefore toxicity monitoring will be required (Section 58 of MWR).

11.6 Monitoring Program Review

Water samples should be collected for a minimum of two years of operation. Based on the results, the water sampling component should be reviewed and adjusted accordingly to focus on parameters of significance for the subsequent annual monitoring.

11.7 Outfall Inspection

Following installation, the outfall should be inspected by a Qualified Professional at a minimum of once every 5 years. The inspection must include examination of the outfall pipe and diffuser for leaks, breaks or blockages to verify the condition and performance of the outfall as intended in the design.

12 Summary

The District of Squamish is proposing an extension/relocation of their river sanitary outfall that discharges treated effluent from the District's Mamquam Wastewater Treatment Plant to the Squamish River. The extension is required to address recent and anticipated future adverse river morphological changes posing risks to the adequate operation and functionality of the outfall. The recommended design included an outfall that will extend approximately 20 m from the eastern riverbank, and terminate with a single discharge port (400 mm pipe diameter). Effluent would be released just above riverbed level in the downstream direction.

This EIS was intended to supplement a 2014 environmental impact study prepared for the existing outfall and to confirm the proposed extension will comply with the Municipal Wastewater Regulation.

The proposed outfall will be to the lower reaches of the Squamish River and designed to satisfy the outfall design requirements listed in the MWR. Specifically, the proposed point of discharge will be located to intercept the predominant current where the effluent can achieve maximum dilution in a river of the riverbank allowing for a suitable initial dilution zone. The outfall will be designed to minimize damage, air entrapment, and corrosion.

Based on the analysis completed in this EIS, the proposed discharge will satisfy the requirements of the MWR, and no significant adverse affects were predicted for human health or the environment.

13 References

British Columbia Ministry of Environment, 2007. Skwelwil'em Squamish Estuary Wildlife Management Area. Management Plan 2007. Prepared by Lower Mainland Region Environmental Stewardship Division

British Columbia (BC). 2012. Municipal Wastewater Regulation. BC Reg. 87/2012. Queens Printer.

British Columbia (BC). 2013. B.C. Field Sampling Manual.

British Columbia 2022. Environmental Monitoring System. SQUAMISH RIVER IN TAILRACE. Available online at Environmental Monitoring System - Province of British Columbia (gov.bc.ca).

British Columbia. 2022. Water Licence Points of Diversion - Drinking Water Sources. Accessed online via ImapBC. https://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc

Canada.2022. Real-Time Hydrometric Data Graph for SQUAMISH RIVER NEAR BRACKENDALE (08GA022) [BC]. Available online at wateroffice.ec.gc.ca

Canada 2022a. Canadian Climate Normals 1981-2010 Station Data. SQUAMISH STP CENTRAL. Available online at https://climate.weather.gc.ca/climate_normals/index_e.html

Canada. 2022b. Canadian Hydrographic Service Non-Navigational (NONNA) Bathymetric Data. Accessed July 2022. https://open.canada.ca

CHS (Canadian Hydrographic Service). 2015. Plans Howe Sound. Nautical. Chart No. 3534. Squamish Harbour. 1:10,000.

DHI (2017) MIKE 21 FM HD User's Manual. DHI Water and Environment.

Doneke, R.L. and Jirka, G. H. 2007. CORMIX User Manual - A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters, U.S. Environmental Protection Agency.

Fisheries and Oceans Canada (DFO). 2021. Canadian Tide and Current Tables – 2021 – Volume 5. Canadian Hydrographic Service. Cat No. Fs73-5/2021-PDF.

GreatPacific Consulting ltd. 2021. Pre-Design Memo – District of Squamish WWTP Outfall Extension. Draft Memo to District of Squamish. August 27, 2021

KWL (Kerr Wood Leidal) 2010. Squamish River and Mamquam River Survey and Flood Assessment. Report to District of Squamish.

KWL (Kerr Wood Leidal) 2017. Integrated Flood Hazard Management Plan – Background Report. Prepared for the District of Squamish.

LGL Ltd. and Ministry of Environment & Climate Change Strategy (MECCS). 2019. Marine Monitoring Guidance. 43 pp + app.

Ministry of Environment, Land and Parks (MELP). 2000. Environment Impact Study Guideline – A Companion Document to the Municipal Sewage Regulation. Issued: December 2000.

Polar Geoscience Ltd. 2020. Hydrogeomorphic Assessment of Squamish River Near the Wastewater Treatment Plant Outfall. Prepared for the District of Squamish.

Squamish. 2021a. Aerial 2021(10cm). Squamish 2021 10cm Orthophoto flown March 13, 2021. Available online at https://data.squamish.ca/

Squamish. 2021b. Aerial Photo 2013. Squamish 2013 Orthophoto. Available online at https://data.squamish.ca/

Urban Systems. 2014. Environmental Impact Study Effluent Discharge to the Squamish River, Report prepared for District of Squamish, February 2014.

Urban Systems. 2015. Liquid Waster Management Plan Stage 2-3 Report. Report to the District of Squamish.

WSP. 2021. Squamish WWTP Upgrade (2021) Seismic Structural Risk Assessment, Long-Term Build Out Review and Biological Upgrade Option Review for 2021 Upgrade. Memo Prepared for the District of Squamish.

GREATPACIFIC
ENGINEERING & ENVIRONMENT

Appendix 1 Water Quality Data

GREATPACIFIC ENGINEERING & ENVIRONMENT

			Guidelines											
			British Columbia Approved and Working Water Quality Guidelines (FEB, 2021)			Canada CCME Canadian Environmental Quality Guidelines (SEP, 2021)		Canada Guidelines for Canadian Recreational Water Quality (APR, 2012)						
			Freshwater Aquatic Life			Freshwater Aquatic Life								
			Long-Term Chronic	Phototoxic	Short-Term Acute	Long Term	Short Term							
Sample														
Name									#1 Squamish River - Upsteam	# 2 Mamquam River	#4 Proposed Outfall (Surface)	#3 Existing Outfall (50 m Downstream)	Duplicate (#2)	#6 Blank
Sampling Date									27-01-2022	27-01-2022	27-01-2022	27-01-2022	27-01-2022	27-01-2022
Test	**Unit**	**LOR**												
Anions and Nutrients														
ammonia, total (as N)	mg/L	0.005	<=1.99 T 3.0C, pH 7.2		<=19 T=3C, pH=7.2				0.0204	0.0085	0.0150	4.12	<0.0050	<0.0050
ammonia, un-ionized (as N), 15C (WSER)	mg/L	0							0.00008	0.00006	0.00008	0.0199	<0	<0
Kjeldahl nitrogen, total [TKN]	mg/L	0.05							0.099	<0.050	<0.050	4.40	0.103	<0.050
nitrate (as N)	mg/L	0.005	<=3		<=32.8	<=3			0.0612	0.0497	0.0564	0.103	0.0502	<0.0050
nitrite (as N)	mg/L	0.001	<=0.02		<=0.06	<=0.06			<0.0010	<0.0010	<0.0010	0.0325	<0.0010	<0.0010
nitrogen, total inorganic	mg/L	0.025							0.082	0.058	0.071	4.26	0.050	<0.025
nitrogen, total	mg/L	0.03							0.105	0.105	0.105	4.26	0.097	<0.030
nitrogen, total organic	mg/L	0.629							<0.050	<0.050	<0.050	<0.629	<0.050	<0.050
phosphate, ortho-, dissolved (as P)	mg/L	0.001							0.0040	0.0052	0.0054	0.0424	0.0056	<0.0010
phosphorus, total	mg/L	0.002							0.0115	0.0122	0.0104	0.106	0.0098	<0.0020
														Microbiological Tests
coliforms, Escherichia coli [E. coli]	CFU/100mL	1						<=200	<1	7	<1	168	3	<1
coliforms, thermotolerant [fecal]	CFU/100mL	1							<1	7	<1	168	3	<1
Enterococcus	CFU/100mL	1						<=35	<1	3	2	116	<1	<1
														Physical Tests
hardness (as CaCO3), from total Ca/Mg	mg/L	0.6							19.6	21.9	19.5	27.9	22.1	<0.60
pH @ 15°C (WSER)	pH units								7.19	7.39	7.28	7.25	7.44	5.70
solids, total suspended [TSS]	mg/L	3							<3.0	<3.0	3.4	<3.0	<3.0	<3.0
														Polycyclic Aromatic Hydrocarbons
acenaphthene	µg/L	0.01	<=6			<=5.8			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
acenaphthylene	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
acridine	µg/L	0.01	<=3	<=0.05		<=4.4			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
anthracene	µg/L	0.01	<=4	<=0.1		<=0.012			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benz(a)anthracene	µg/L	0.01	<=0.1	<=0.1		<=0.018			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benzo(a)pyrene	µg/L	0.005	<=0.01			<=0.015			<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
benzo(b+j)fluoranthene	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benzo(b+j+k)fluoranthene	µg/L	0.015							<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
benzo(g,h,i)perylene	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
benzo(k)fluoranthene	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
chrysene	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
dibenz(a,h)anthracene	µg/L	0.005							<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
fluoranthene	µg/L	0.01	<=4	<=0.2		<=0.04			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
fluorene	µg/L	0.01	<=12			<=3			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
indeno(1,2,3-c,d)pyrene	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 1-	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
methylnaphthalene, 2-	µg/L	0.01							<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
naphthalene	µg/L	0.05	<=1		<=1	<=1.1			<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
phenanthrene	µg/L	0.02	<=0.3			<=0.4			<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
pyrene	µg/L	0.01		<=0.02		<=0.025			<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
quinoline	µg/L	0.05	<=3.4			<=3.4			<0.050	<0.050	<0.050	<0.050	<0.050	<0.050

GREATPACIFIC
ENGINEERING & ENVIRONMENT

			Guidelines											
			British Columbia Approved and Working Water Quality Guidelines (FEB, 2021)			Canada CCME Canadian Environmental Quality Guidelines (SEP, 2021)		Canada Guidelines for Canadian Recreational Water Quality (APR, 2012)						
			Freshwater Aquatic Life			Freshwater Aquatic Life								
			Long-Term Chronic	Phototoxic	Short-Term Acute	Long Term	Short Term							
Sample														
Name									#1 Squamish River - Upsteam	# 2 Mamquam River	#4 Proposed Outfall (Surface)	#3 Existing Outfall (50 m Downstream)	Duplicate (#2)	#6 Blank
Sampling Date									27-01-2022	27-01-2022	27-01-2022	27-01-2022	27-01-2022	27-01-2022
Total Metals														
aluminum, total	mg/L	0.003	<=0.05 Dissolved pH> 6.5)		<=0.1 Dissolved pH> 6.5	<=0.1 pH >=6.5			0.0579	0.122	0.0475	0.0242	0.0343	<0.0030
antimony, total	mg/L	0.0001	<=0.009						<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
arsenic, total	mg/L	0.0001	<=0.005			<=0.005			0.00026	0.00025	0.00022	0.00026	0.00022	<0.00010
barium, total	mg/L	0.0001	<=1						0.0104	0.00876	0.00920	0.00956	0.00816	<0.00010
beryllium, total	mg/L	0.0001	<=0.00013						<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
bismuth, total	mg/L	0.00005							<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	mg/L	0.01	<=1.2						0.013	<0.010	0.011	0.040	<0.010	<0.010
cadmium, total	mg/L	0.000005	<=0.000018		<=0.00003	<=0.00004			<0.0000050	0.0000100	0.0000071	0.0000085	0.0000089	<0.0000050
calcium, total	mg/L	0.05							6.40	7.46	6.45	8.68	7.55	<0.050
cesium, total	mg/L	0.00001							0.000027	0.000028	0.000025	0.000050	0.000026	<0.000010
chromium, total	mg/L	0.0005	<=0.001			<=0.001			<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
cobalt, total	mg/L	0.0001	<=0.004		<=0.11				0.00017	<0.00010	0.00012	0.00013	<0.00010	<0.00010
copper, total	mg/L	0.0005				<=0.002 Hardness <82 gm/L			0.00071	0.00091	0.00064	0.00101	0.00065	<0.00050
iron, total	mg/L	0.01			<=1	<=0.3			0.404	0.155	0.257	0.290	0.078	<0.010
lead, total	mg/L	0.00005	<=0.00344		<=0.003	<=0.001			<0.000050	0.000120	<0.000050	<0.000050	<0.000050	<0.000050
lithium, total	mg/L	0.001							0.0024	<0.0010	0.0017	0.0014	<0.0010	<0.0010
magnesium, total	mg/L	0.005							0.879	0.792	0.827	1.52	0.792	<0.0050
manganese, total	mg/L	0.0001	<=0.768		<=0.816	<=0.2	<=2		0.0207	0.00477	0.0143	0.0240	0.00263	<0.00010
mercury, total	mg/L	0.000005	<=0.00001			<=0.000026			<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
molybdenum, total	mg/L	0.00005	<=5.1		<=46	<=0.073			0.000534	0.000665	0.000553	0.000619	0.000716	<0.000050
nickel, total	mg/L	0.0005	<=0.025			<=0.025			<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
phosphorus, total	mg/L	0.05							<0.050	<0.050	<0.050	0.087	<0.050	<0.050
potassium, total	mg/L	0.05	<=373						0.965	0.572	0.774	2.76	0.575	<0.050
rubidium, total	mg/L	0.0002							0.00140	0.00101	0.00127	0.00311	0.00098	<0.00020
selenium, total	mg/L	0.00005	<=0.001			<=0.001			0.000083	<0.000050	<0.000050	0.000059	<0.000050	<0.000050
silicon, total	mg/L	0.1							5.32	6.94	5.76	8.58	7.06	<0.10
silver, total	mg/L	0.00001	<=0.00005		<=0.0001	<=0.00025			<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, total	mg/L	0.05							3.55	2.60	3.14	10.5	2.63	<0.050
strontium, total	mg/L	0.0002							0.0469	0.0479	0.0454	0.0577	0.0494	<0.00020
sulfur, total	mg/L	0.5							1.96	2.10	1.86	3.24	2.50	<0.50
tellurium, total	mg/L	0.0002							<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
thallium, total	mg/L	0.00001	<=0.0008			<=0.0008			<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
thorium, total	mg/L	0.0001							<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
tin, total	mg/L	0.0001							<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
titanium, total	mg/L	0.0003	<=2						0.00230	0.00474	0.00135	0.00040	0.00050	<0.00030
tungsten, total	mg/L	0.0001							<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
uranium, total	mg/L	0.00001	<=0.0085						0.000040	0.000030	0.000032	0.000019	0.000028	<0.000010
vanadium, total	mg/L	0.0005	<=0.006						0.00088	0.00248	0.00128	0.00227	0.00238	<0.00050
zinc, total	mg/L	0.003	<=0.0075		<=0.033	<=0.007	<=0.037		<0.0030	<0.0030	<0.0030	0.0070	<0.0030	<0.0030
zirconium, total	mg/L	0.0002							<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020

Evaluations

No Spec	No Spec
Within Limit	Within Limit
Exceeds Limit	Exceeds Limit

GREATPACIFIC
ENGINEERING & ENVIRONMENT

			Guidelines											
			British Columbia Approved and Working Water Quality Guidelines (FEB, 2021)			Canada CCME Canadian Environmental Quality Guidelines (SEP, 2021)		Canada Guidelines for Canadian Recreational Water Quality (APR, 2012)						
			Freshwater Aquatic Life			Freshwater Aquatic Life								
			Long-Term Chronic	Phototoxic	Short-Term Acute	Long Term	Short Term							
Sample														
Name									#1 Squamish River - Upsteam	# 2 Mamquam River	#4 Proposed Outfall (Surface)	#3 Existing Outfall (50 m Downstream)	Duplicate (#2)	#6 Blank
Sampling Date									27-01-2022	27-01-2022	27-01-2022	27-01-2022	27-01-2022	27-01-2022

Appendix 2 Predicted Concentration of Effluent Parameters with Dilution

GREATPACIFIC
ENGINEERING & ENVIRONMENT

Parameter	Unit	Urban Systems 2014 (Max)	Assumed Effluent Concentration		Aug/Sep 2013 (Max)	Jan-22	Ambient	Concentration at IDZ with 59:1 Dilution Absolute	Above/Below Ambient	BC A-WQG Long Term	BC A-WQG Short Term	CCME Long Term	Conservative WQG	Dilution Requierd to Achieve Guideline (#1)	Dilution Requierd to Achieve Guideline	Factor of Safety (Predicted Dilution / Dilution Requried)
TSS	mg/L	45	45		501	3.4	501	493	0.76	10%			550	12	12:1	5
TSS	mg/L	45	45		12	<1	1	2	0.76	5			5	13	13:1	5
BOD5	mg/L	45	45					-	0.76					n/a	n/a	NC
Ammonia (as N)	mg/L	6.39	6.39	0.04	0.207	0.0204	0.21	0.31	0.11	3.4			3.4	3	3:1	19
Nitrate	mg/L	12	12		0.0682	0.0612	0.07	0.27	0.20	3.7			3.7	4	4:1	14
Nitrite	mg/L	0.437	0.437	0.08	0.0020	<0.0010	0.0800	0	0.01					n/a	n/a	NC
Total Phosphorus	mg/L	3.37	3.37		0.463	0.0112	0.46	0.51	0.06					n/a	n/a	NC
Orthophosphate	mg/L	3.24	3.24	0.021	0.031	0.0054	0.03	0.084	0.05					n/a	n/a	NC
pH @ 15°C	PH	7.0-7.39	7.0-7.39		6.3-7.8		6.3-7.8	-	NC	7.0-8.7			70.-8.7	NC	NC	NC
Temperature	°C	18-22	21.6		14.5	2.7	3	3.0	0.4	1			1	13	13:1	4
Turbidity	NTU	-	-				-	-	NC	8				n/a	n/a	NC
																NC
Enterococci	CFU/100 mL		0E+00			3	3.00	3	0					n/a	n/a	NC
Fecal Coliforms	CFU/100 mL	200	2E+02			7	7.00	10	3	200			200	2	2:1	28
Metals - Total																
aluminum, total	mg/L	0.032	0.0320		3.740	0.122	3.74	3.68	0.000542373	<=0.05 Dissolved pH> 6.5)	<=0.1 Dissolved pH> 6.5	<=0.1 pH >=6.5	0.050	-0.022	0:1	-2655
antimony, total	mg/L	<0.0005	<0.0005		<0.00050	<0.00010	-	-	-	<=0.009			0.006	NC	NC	NC
arsenic, total	mg/L	0.00061	0.0006		0.004	0.00026	0.0044	0.00434	1.0339E-05	<=0.005		<=0.005	0.005	9	9:1	6
barium, total	mg/L	<0.020	<0.020		0.035	0.010	0.035	-	-	<=1			1	NC	NC	NC
beryllium, total	mg/L	<0.0010	<0.0010		<0.0010	<0.000100	-	-	-	<=0.00013			0.00013	NC	NC	NC
bismuth, total	mg/L		-			<0.000050	-	-	-					n/a	NC	NC
boron, total	mg/L	0.24	0.24		<0.10	0.013	0.013	0.02	0.004067797	<=1.2			1	1	1:1	49
cadmium, total	mg/L	0.000066	0.000066			0.0000100	0.0000100	0.000011	1.11864E-06	<=0.000018	<=0.00003	<=0.00004	0.000018	11	11:1	6
calcium, total	mg/L	13	13			7.460	7.5	7.55	0.220338983					n/a	NC	NC
cesium, total	mg/L		-			0.000028	0.000028	-	-					n/a	NC	NC
chromium, total	mg/L	<0.0010	<0.0010			<0.00050	-	-	-	<=0.001		<=0.001	0.001	NC	NC	NC
cobalt, total	mg/L	0.00038	0.00038			0.00017	0.00017	0.00	6.44068E-06	<=0.004	<=0.11		0.004	1	1:1	52
copper, total	mg/L	0.0072	0.0072		0.00770	0.00091	0.00770	0.0077	0.000122034			<=0.002 Hardness <82 gm/L	0.002	-2	-2:1	-37
iron, total	mg/L	1.61	1.61		2.360	0.404	2.360	2.35	0.027288136		<=1	<=0.3	0.3	-1	-1:1	-64
lead, total	mg/L	<0.00050	<0.00050		0.001	0.000	0.001	-	-	<=0.00344	<=0.003	<=0.001	0.001	NC	NC	NC
lithium, total	mg/L	<0.0050	<0.0050		0.003	0.002	0.003	-	-					n/a	NC	NC
magnesium, total	mg/L	4.7	4.7		1.620	0.879	1.620	1.67	0.079661017					n/a	NC	NC
manganese, total	mg/L	0.0501	0.0501		0.078	0.021	0.078	0.08	0.000849153	<=0.768	<=0.816	<=0.2	0.2	2	2:1	29
mercury, total	mg/L	<0.000010	<0.000010		<0.00001	<0.0000050	-	-	-	<=0.00001		<=0.000026	0.000010	NC	NC	NC
molybdenum, total	mg/L	<0.0010	<0.0010		<0.0010	0.000665	0.001	-	-	<=5.1	<=46	<=0.073	0	NC	NC	NC
nickel, total	mg/L	0.0016	0.0016		0.0016	<0.00050	0.002	0.00	2.71186E-05	<=0.025		<=0.025	0	1	1:1	52
phosphorus, total	mg/L		-			<0.050	-	-	-					n/a	NC	NC
potassium, total	mg/L	14.9	14.9		<2	0.965	0.965	1.20	0.252542373	<=373			373	1	1:1	57
rubidium, total	mg/L		-		<0.00010	0.001	0.001	-	-					n/a	NC	NC
selenium, total	mg/L	0.00013	0.00013			0.000083	0.000083	0.000084	2.20339E-06	<=0.001		<=0.001	0.0010	1	1:1	48
silicon, total	mg/L		-			6.940	6.940	-	-					n/a	NC	NC
silver, total	mg/L	0.000042	0.000042		<0.000020	<0.000010	-	-	7.11864E-07	<=0.00005	<=0.0001	<=0.00025	0.0001	NC	NC	NC
sodium, total	mg/L	44.8	44.8000		2.100	3.550	3.550	4.24	0.759322034					n/a	NC	NC
strontium, total	mg/L		-			0.048	0.048	-	-					n/a	NC	NC
sulfur, total	mg/L		-			2.100	2.100	-	-					n/a	NC	NC
tellurium, total	mg/L		-			<0.00020	-	-	-					n/a	NC	NC
thallium, total	mg/L	<0.0020	<0.0020		<0.00020	<0.000010	-	-	-	<=0.0008		<=0.0008	0.00080	NC	NC	NC
thorium, total	mg/L		-			<0.00010	-	-	-					n/a	NC	NC
tin, total	mg/L	<0.0005	<0.0005		<0.00050	<0.00010	-	-	-					n/a	NC	NC
titanium, total	mg/L	<0.010	<0.010		0.115	0.005	0.115	-	-	<=2			2	NC	NC	NC
tungsten, total	mg/L		-			<0.00010	-	-	-					n/a	NC	NC
uranium, total	mg/L	<0.00020	<0.00020		<0.00020	0.000040	0.000	-	-	<=0.0085			0.0085	NC	NC	NC
vanadium, total	mg/L		-		0.006	0.002	0.006	-	-	<=0.006			0.0060	NC	NC	NC
zinc, total	mg/L	0.0434	0.0434		0.021	<0.0030	0.021	0.0212	0.000735593	<=0.0075	<=0.033	<=0.007	0.0070	-4	-4:1	-16
zirconium, total	mg/L		-			<0.00020	-	-	-					n/a	NC	NC
			-								0.05			n/a	NC	NC

Predicted Dilution 59

Source: BC Approved-WQG Freswater Aquatic Life
BC Working or Interim - WQG Marine Aquatic Lfe
CCME - Short Term
[1] B.C. Recreational Water Quality Guideline
[2] B.C. Municipal Wastewater Regulation