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February 23, 2023

District of Squamish
55037955 2nd Ave
Squamish, BC, V8B0A2

Attention: Mr. David Roulston, P.Eng.

RE: Pre-Design Memo – District of Squamish WWTP Outfall Extension

1 Introduction

GreatPacific Consulting Limited (GreatPacific) prepared this memo to detail preliminary considerations associated with the District of Squamish's (The District) Mamquam Wastewater Treatment Plant (WWTP) outfall extension. The existing outfall is required to be extended to a more appropriate discharge location to address ongoing and anticipated future issues associated with poor effluent dilution/ mixing, caused by sediment aggradation and channel shifting at the existing outfall.

This memo provides detail of a conceptual design and preliminary considerations for the project, and provides an associated Class D cost estimate. Additional tasks under the current scope of this project included preparation of a dilution model, and an Environmental Impact Study (EIS). These tasks were completed are discussed briefly in this memo, however further details are available under separate cover within the completed EIS (GreatPacific, January 2023).

This memo summarizes outfall expansion considerations through the following sections:

1. Introduction
2. Background
3. Proposed Outfall Alignment
4. Engineering Considerations
5. Constructability
6. Dilution Modelling
7. Permitting
8. Further Required Studies
9. Opinion of Probable Costs
10. Conclusion

2 Background

2.1 Existing Outfall

The existing WWTP discharges effluent to the Squamish River through a plain ended steel outfall. According to record drawings, there are twinned 400 mm diameter HDPE SDR 26 forcemain pipes which carry effluent along Squamish River Dike Road ("the dike"). Record drawings of the outfall alignment and pipe configuration from the dike to the Squamish River were not

available, however previous inspections by GreatPacific observed two steel outfall pipes, both terminating within a few meters of the bank of the river. One of these was observed to be discharging effluent with a high level of entrained air. The second terminus was observed to discharge either no effluent or a very low volume of effluent (in comparison to the main outfall), and was speculated that this second outfall may function as an emergency overflow.

The existing discharge, within a shallow and potentially hydraulically isolated region of the Squamish River with poor mixing and dispersion characteristics, poses a potential adverse risk to the riverine environment, as well as to public health and safety of those who may recreate on the nearby waters and shoreline.

2.2 Receiving Environment Site Characterization

2.2.1 Hydrogeomorphology

The Squamish River is a hydrogeomorphologically 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 resulted in the currently experienced issues for the existing outfall related to sediment accumulation and channel shifting.

In 2020, Polar Geoscience (Polar) completed an assessment to provide recommendations to mitigate the issues of channel shifting and sediment aggradation occurring at the existing outfall. 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 impact an outfall. This general area (300 m to 450 m downstream of the existing terminus) is hereafter referred to as the Subject Area.

The Subject Area was selected in part due to the understanding that the river avulses on the eastern bank in this area, and aggrades further to the west. Consequently, this region was promising for mitigating the issues with sedimentation near the outfall. Per 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.

2.2.2 General Usage

The Subject Area of the river is navigable water frequently used for recreational purposes. Based on available mapping and records, there were no known submarine utilities charted within this area of the Squamish River. However, based on field investigation (January 2022), an unknown pipe was discovered extending into the river in the vicinity (within approximately 50 m upstream) of Terminus Location #1 (terminus locations are further described in Section 3).

2.2.3 Bathymetry

Prior bathymetric surveys in the vicinity of the Subject 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 river bed. Unfortunately, prior surveyed cross sections did not necessarily coincide with the new outfall terminal locations of interest.

Additional site-specific bathymetry for design and modelling purposes was acquired in January 2022.

2.2.4 Tidal Range

The Subject Area of the Squamish River is understood to be tidally effected. Tidal impacts may include backwater effects, as well as ingress of a saltwater wedge up the river during flooding high tide events. During field investigations supporting the EIS, it was determined that saltwater ingress to the general area considered for the outfall extension was negligible, though the area is subject to backwater effects.

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

Table 1: 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

*Port Atkinson Measurement

2.2.5 River Flows

In 2010, Kerr Wood Leidal (KWL) reported return-period-based flows of the Squamish, Cheakamus, and Mamquam rivers per the below table. It is noted that the Subject Area lies below the confluence of the Mamquam and Squamish rivers. Detailed combined river flow rates will be determined for design purposes during detailed design.

Table 2 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	218
5 Year	1720	506	282
10 Year	2083	650	318
20 Year	2483	803	349
50 Year	3090	1023	385
100 Year	3620	1207	409
200 Year	4213	1407	431

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

The Environmental Impact Study (EIS) prepared by Urban Systems (2014) for the existing outfall, established a 2-year return 7-day (7Q2) low flow of 53.5 m^3/s, which would yield a theoretical dilution ratio of approximately 290:1 (Urban Systems 2014), more than the minimum 10:1 dilution ratio requirement in the *Municipal Wastewater Regulation* (MWR) which makes this a permissible discharge to the Squamish River. Dilution modelling is further described briefly in Section 6, and comprehensively in the GreatPacific EIS.

2.2.6 Substrate

Per the 2020 Polar report, the bed texture in the Subject Area is 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.

3 Proposed Outfall Alignment

3.1 Terminus Location

On July 26, 2021, an Outfall Engineer (Jason Clarke) and a River Geomorphologist (Mike Miles) of GreatPacific's project team conducted a site visit along the Squamish River to assess potential discharge locations within the pre-selected reach of river. Based on the observed riverine characteristics, the two locations described below, and shown in Appendix 1, were identified as appropriate discharge locations for the extended outfall. In the case of both identified locations, it is anticipated that the outfall would extend between approximately 20 m into the river from the eastern river bank.

3.1.1 Terminus Location #1

Location Option 1 was selected as the preferred discharge location and would be the least expensive option due to it's shorter extension distance. This location would necessitate an approximately 320 m on-land forcemain extension along Squamish River Dike Road.

It is understood that the river characteristics in this area are such that avulsion occurs on the eastern bank, whereas accretion occurs further to the west; resulting in the observed sand banks within the center of the river. Due to the avulsing nature of the east bank in the area, it is viewed that this area is an appropriate outfall location to mitigate ongoing issues with sediment accretion. It is noted however that due to these river processes, proper scour protection will need to be considered for the outfall design.

There is an existing stormwater drainage pipe and flood box system at this location (Whittaker Slough), to which the outfall would be proposed to be installed parallel to, and immediately upstream of this pipe to avoid a pipe crossing. As a result of the existing stormwater infrastructure in the area, a clearing in the vegetation is present, which will minimize the need for removal of vegetation within riparian zone. Additionally this will facilitate an easier, more cost effective construction of the outfall.

An unidentified and unmapped pipeline was also observed during January 2022 field investigations in the vicinity of this proposed location. The nature or purpose of this pipeline has yet to be ascertained.

3.1.2 Terminus Location #2

Location Option #2 was selected as an alternative location for the outfall, corresponding to an on land expansion of approximately 510 m. Similar to Location #1, Location #2 lies in an area which is understood to be avulsing, which should assist in mitigating issues with sediment deposition or accumulation near to the outfall. This option, while offering suitable location, does not necessarily offer any appreciable advantages over Option 1.

The Subject Area also lies in the vicinity of an existing stormwater utility. A 375 mm diameter stormwater outfall crosses the dike in this location, and the outfall would be proposed to be extended to the river parallel and immediately upstream of this stormwater outfall. There is less land width between the dike and the river at this location as compared to Option 1, and more riparian vegetation would need to be cleared for access.

3.2 Forcemain Extension

To reach the above noted location(s), landward extensions of approximately 320 m (Option 1), or 510 m (Option 2) will be required to the existing twin forcemain along Squamish River Dike Road. The existing steel/ HDPE forcemain infrastructure along the dike from the WWTP will be maintained (without replacement) in the ultimate configuration.

The proposed extension will be proposed to be laid within the dike similar to the existing forcemain. Given the dike's nature as critical infrastructure, appropriate allowances for proper installation practices will need to be made. During the detailed design phase, this should include the retention of a geotechnical engineer, who will provide appropriate design recommendations and construction field review to ensure that the short- and long-term function of the dike is not compromised.

4 Engineering Design Considerations

During the detailed design phase of the outfall extension, a number of design aspects will need to be further considered and detailed prior to implementation. At a high level, some of these considerations include:

4.1 Outfall Pipe Material

HDPE is proposed to be utilized for the on-land outfall pipe material. It is flexible, hydraulically efficient, robust, economical to transport, assemble and install, and maintains material continuity with the existing on-land pipeline.

The portion of the outfall extending from the riverbank and into the river is proposed to be constructed of steel, with a protective lining and concrete coating to provide added protection, corrosion resistance, and ballast for the outfall. Steel is dense and strong, and can withstand significant impact from rocks and debris (e.g. trees) that are carried downstream by river flows.

4.2 Outfall Weighting and Protection

The outfall will need to be adequately ballasted for on-bottom stability, and protected against potential hazards including river currents, debris strike, bed movement and sediment scour.

The ballasting regime will consider resistance to buoyant uplift and lateral forces due to operational and environmental loads. This may need to include density differentials between the effluent and ambient water, if during high tide events salt water intrudes upstream to the outfall location. Previous site investigations identified a high quantity of entrained air being expelled from the existing outfall, so if this air is not released prior to discharge, this will be another source of buoyancy.

4.3 Hydraulics and Sizing

The proposed alignment for the extension does not demonstrate significant topographic variability. As such, the potential hydraulic impacts to the outfall will primarily result from frictional losses imposed by the additional length of pipe and associated appurtenances. The outfall extension should be of the same diameter as the existing outfall forcemain piping, which is 400 mm. A hydraulics assessment will confirm this during detailed design, however preliminary hydraulics estimates of head losses for a 400 mm diameter extension are presented below in Table 2.

Table 3: Additional Hydraulic Losses (Preliminary)

Parameter	Estimated Conditions of Extension	
	One Forcemain Operational	Both Forcemains Operational
Design Flow	240 L/s*	
Location #1: Additional Frictional/ Major Losses	3.0 m	0.8 m
Location #2: Additional Frictional/ Major Losses	5.1 m	1.4 m

*Design Flow Per WSP Brief (May 6, 2021), corresponding to anomalously high flows during a 2020 storm event.
**Head Losses Per Hazen Williams Equation, assumes: C=140 (typical for HDPE)

4.4 Diffuser Configuration

An appropriate diffuser design will be prepared based on the results of the forthcoming dilution modelling which will need to show that water quality guidelines will not be exceeded beyond the initial dilution zone (IDZ). The ultimate configuration of the diffusor will optimize dilution / mixing at the discharge point, in conformance with the requirements of the MWR. Specifically, the diffusor must facilitate dilution/ mixing such that the initial dilution zone meets the following specifications (MWR 93.1):

> *(a)the height is the distance from the bed to the water surface;*
> *(b)the width, perpendicular to the path of the stream, is the lesser of*
> *(i)100 m, and*
> *(ii)25% of the width of the stream or estuary;*
> *(c)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*
> *(i)100 m downstream, and*
> *(ii)a distance downstream at which the width of the municipal effluent plume equals the width determined under paragraph (b).*

Additionally, as the area is understood to meet the MWR definition of an estuary ("*portion of a receiving water lying below the farthest point upstream of detectable changes in water movement or chemistry through mixing of fresh and salt water and due to tidal action*"), the below IDZ criterion must be considered *(MWR 93.2.b):*

> *"the initial dilution zone must not extend closer to shore than mean low water".*

4.5 Additional Engineering Aspects

Additional engineering aspects which will ultimately need to be considered and refined through detailed design include the following:

- Signage
- Air and/or Vacuum Relief
- Outfall Flushing and Maintenance
- Effluent Sampling
- Constructability, specifically dike construction issues.

5 Constructability

Detailed construction plans will need to be prepared to support construction management services for the implementation of the outfall. Substantial challenges can arise when attempting to implement riverine infrastructure within a dynamic environment, with substantial flow rates/ velocities such as is the case in the Squamish River.

Several construction options were considered at a preliminary level, including the following:

- Berm Based Heavy Equipment
- Barge Based Heavy Equipment
- Trenchless Technology

Of these options, berm-based equipment was identified as likely to be the most practical, and cost effective option. Barge based equipment was considered challenging due to difficulty in maneuvering/ navigating barges in strong, narrow river flows and/or shallow water depths. Directional drilling was generally viewed as challenging due to the tight geometry of the work zone, unfavourable ground conditions involving alluvial gravels, and challenges daylighting the pipe then subsequently attaching the diffuser structure.

The recommended construction method would entail the installation of a temporary rock berm work platform a distance of approximately 10 m to 15 m into the river on the upstream side of the outfall alignment. A long reach excavator would operate from the berm to excavate a trench into the river bed. A suitable method and location will need to be identified for handling spoils, as there will not likely be sufficient free space on the berm or at the immediate riparian river bank to stockpile.

6 Dilution Modelling

GreatPacific prepared an EIS detailing environmental considerations of the outfall extension, which included dilution modelling to determine whether adequate mixing and dispersion can be attained at the proposed terminus location. Mike 21 FM, a depth averaged 2D modelling software was employed to evaluate effluent dilution at the preferred outfall location; Location #1. The modelling demonstrated that this location would be expected to satisfy the requirements of the MWR from a dilution perspective, and hence that the discharge location would be an acceptable site for a new outfall structure.

7 Permitting

To facilitate the extension of the WWTP outfall, the following regulatory considerations and required permits should be included within the planning processes:

- Crown Land Tenure Application: Required to provide usage rights to the District from the Crown for the purposes of installing infrastructure within existing Crown Land. Estimated timing for approval: 6 months.
- Request for Project Review (Department of Fisheries and Oceans): Required to facilitate the installation of infrastructure where activities could cause a harmful impact to fish and marine life. Given the nature of marine construction associated with this project, appropriate Environmental

Management Plans will need to be prepared, and will be submitted to DFO for review/ approval. Estimated time for application processing: 6 Months.

- Change Approval - Water Sustainability Act: Required for non-authorized works or complex changes in and about a stream. Estimated application processing time: 6 Months.
- Navigable Water Act Approval (Transport Canada): Required for infrastructure works which may impact navigation on waters used by the public for transportation. Estimated time for application processing: 4 Months.
- Dike Maintenance Act Approval: Required for works or alterations to regulated dikes within the Province of BC including the Squamish River Dike. Estimated application processing time: 4 Months.

8 Required Further Studies

Additional interdisciplinary studies, which are foreseen as likely to be required to facilitate detailed design include the following:

- Geotechnical Assessment
- Aquatic Effects Assessment
- Archeological Overview
- Arborist Report (Potential – Dependent on selected location, and potential for tree impacts/removals)
- Locate utilities within the corridor, including investigating the nature of the unknown exposed pipe in the Squamish River.

9 Opinion of Probable Costs and Schedule

The estimated construction costs (Class D) for the design, permitting and construction of the outfall extension (Option 1 assumed) are summarized in Table 4. These costs are presented in 2023 Canadian dollars, and if construction will occur in a future year, then the costs should be projected accordingly into the future. This preliminary cost estimate is exclusive of taxes, and public consultation processes (if required). Estimated fees associated with the design, permitting and construction contract administration are preliminary in nature and prepared for the purposes of the District's budget forecasting.

Table 4: Opinion of Probable Costs For Option 1

Activity	Estimated Cost	Estimated Duration
Construction		
Mobilization and Site Prep	$75,000	
340 m Twin 400 mm HDPE Conveyance Piping	$450,000	
30 m Steel River Outfall, Diffuser, Temporary Rock Berm	$375,000	
Air Relief Chamber	$25,000	
Subtotal Construction	$925,000	4 months (Procurement, Assembly, Installation)
Engineering (Investigations, Design, Tender, Construction)	$200,000	8-10 months (Design and Tendering)
Permitting	$40,000	8 months (Application Prep and Regulatory Review)
Subtotal	$1,165,000	
Contingency (30%)	$350,000	3 months
Total	**$1,515,000**	

Also provided is an estimate of the schedule duration of the major items. Generally, in order to have sufficient project details to include in permit applications and be in a position to submit those to regulatory agencies, the design should be developed to at least the 50% level.

10 Summary

The extension of the District's WWTP effluent outfall to approximately 300 m downstream (Location #1) provides a practical solution to mitigate issues with sediment aggradation/ river shifting, and to address the associated risks to the public and the environment.

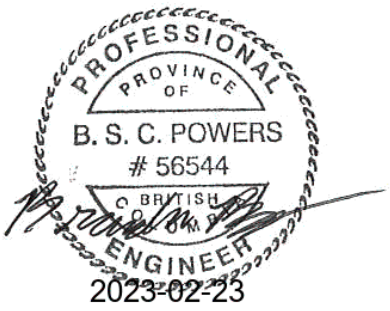
Two specific locations were identified as feasible based on an understanding of the associated geomorphological, environmental, and constructability constraints/ opportunities. The preferred location (Location #1) was advanced through an EIS, and will be the subject of future detailed design.

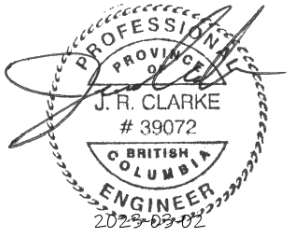
A preliminary order of magnitude estimate for the associated construction works for the outfall extension is approximately $1.52 Million (CAD). Approximately a 2 year timeframe will be required to implement the project assuming no significant periods of project stoppage between project phases.

11 Closure

We trust this document provides suitable documentation for your records at this time. We look forward to assisting the District as needed with this infrastructure.

Sincerely,





Brandon Powers, P.Eng.
Civil Engineer

Jason Clarke, P.Eng
Director

GreatPacific Permit to Practice: 1000737

12 References

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

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

Urban Systems. 2014. Environmental Impact Study – Discharge to the Squamish River. Prepared for 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.

Appendix 1 Outfall Extension Options

BRACKENDALE EAGLES PARK

SQUAMISH RIVER

OPTION 1 DISCHARGE LOCATION

EXISTING OUTFALL (APPROXIMATE)

OPTION 1 IDZ AND PLUME
(CONCEPTUAL)

OPTION 2 DISCHARGE LOCATION

OPTION 2 IDZ AND PLUME
(CONCEPTUAL)

EXISTING 24"Ø SLOUGH CULVERT
(2015 SURVEY)

SQUAMISH RIVER DIKE ROAD

PROPOSED TIE-IN TO
EXISTING TWIN HDPE FORCEMAIN

OPTION 2 ALIGNMENT

DIKE

OPTION 1 ALIGNMENT

EXISTING 15" Ø STORMWATER OUTFALL

WHITTAKER SLOUGH

YEKWAUPSUM
NO 18

LEGEND:

- EXISTING FORCEMAIN (16 FM)
- EXISTING STORMWATER OUTFALL (15)
- PROPOSED OUTFALL EXTENSION OPTION 1
- PROPOSED OUTFALL EXTENSION OPTION 2
- INITIAL DILUTION ZONE
- EFFLUENT PLUME (CONCEPTUAL)

0 100 200 Meters

DATE	DESCRIPTION	DRAWN	DESIGNED	APPROVED
2021-08-26	PRELIMINARY SITE OVERVIEW - REVA	ECL	BP	JC

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PERMIT/STAMP:

PRELIMINARY
NOT FOR IMPLEMENTATION
NOT FOR CONSTRUCTION

NOTES:
1. BATHYMETRY/TOPOGRAPHY PROVIDED BY POLAR GEOSCIENCE. BATHYMETRY/TOPOGRAPHY COLLECTED JANUARY 2015.
2. LOCATIONS OF IN GROUND UTILITIES INFERRED FROM *DISTRICT OF SQUAMISH* WEB MAP. LOCATIONS AND DEPTHS TO BE CONFIRMED.
3. ALL DIMENSIONS IN METERS.

CLIENT: DISTRICT OF SQUAMISH

SQUAMISH OUTFALL EXTENSION
SITE OVERVIEW
OUTFALL OPTIONS 1&2

DRAWING NUMBER: M001

PROJECT NUMBER: 1098–001

SCALE: 1:1000

REV: A

FILE: W:\1098-001 – SQUAMISH – WTP OUTFALL EXTENSION\DRAWINGS\SHEET SET\M001 SITE OVERVIEW.DWG