TECHNICAL MEMORANDUM

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TO
Ministry of Transportation and Infrastructure

CC Michael Carreira (Binnie), Robert McMahon (Ausenco)

FROM Emilio Martinez, MSc, PEng **EMAIL emilio.martinez@wsp.com**

SILVER-SKAGIT ROAD FLOOD MITIGATION – 38.4 KM SITE HYDROTECHNICAL ASSESSMENT

1.0 INTRODUCTION

WSP has been retained by the Ministry of Transportation and Infrastructure (MOTI) to provide hydrotechnical engineering and design services for flood response mitigation and recovery works on the Silver-Skagit Road near Hope, BC. The project is divided into multiple sites depending on their location and level of urgency along the corridor. This memorandum describes the hydrotechnical considerations and assessment carried out to provide mitigation design for the 38.4 km site.

The 38.4 km site requires road surface repairs and culvert replacement, as well as restoration of the main drainage channel towards Klesilkwa River across the Silver-Skagit Rd. The culvert replacement and road repairs are required due to washout from runoff and debris flows from the upper drainage across the Silver-Skagit Rd. The proposed culvert replacement and channel restoration returns the main drainage path towards Klesilkwa River to its original path prior the November 2021 flood event. Road alignment, geotechnical design, fill materials and geometry for road repairs were provided by the Highway Design Engineer (R.F. Binnie & Associates Ltd.) and geotechnical consultant (Wood PLC), and are outside of the hydrotechnical scope of work.

2.0 SITE CLIMATE AND HYDROLOGY

2.1 General Climate and Precipitation

Based on the Köppen climate classification, Hope has an oceanic climate with warm summers and moderately cold winters. Temperatures in Hope over the course of the year typically range from -2 ºC to 25 ºC and are rarely below -10 ºC or above 31 ºC with a distinct warm season between June and September, and a cold season between November and February. The hottest month of the year is typically August with an average high temperature of 24 ºC, and the coldest month is typically December with an average low of -2 ºC.

The chance of wet days in Hope varies significantly throughout the year. The wetter season is typically between October and April with the wettest month generally being November with an average rainfall of 199 mm; the driest month is generally August with an average rainfall of 34 mm. Wet days are comprised of rain only, snow only, and rain and snow events. The month with the most snow is January, with an average snowfall of 276 mm.

2.2 Watershed Hydrology and Peak Flows

Klesilkwa River is the main branch of the Skagit River, which flows toward south and drains to Ross Lake at the US-Canada border approximately 48 km south of Hope, BC; the river is approximately 26 km long from the upper reaches in the Cascade Range to Ross Lake and originates at around km 28 of Silver-Skagit Rd. The portion of the watershed draining to Klesilkwa River at the 38.4 km site is approximately 1.4 km² ² and consists of steep mountain terrain draining towards Klesilkwa River across the Silver-Skagit road. Similar to other tributary catchments, the area draining to Klesilkwa River at the 38.4 km site is subject to debris floods. The 38.4 km watershed exhibits elevations ranging from approximately 2164 masl to 552 masl at the Silver-Skagit Road crossing.

WSP carried out an analysis of nearby hydrometric stations within 30 km of Silver-Skagit Road for unregulated streams to establish a relationship between the catchment area and peak flows based on historical flow measurements. The stations included in the analysis are Chilliwack River above Slesse Creek (08MH103), Coquihalla River above Alexander Creek (08MF068), Coquihalla River below Needle Creek (08MF062), Slesse Creek near Vedder crossing (08MH056), and Tulameen River below Vuich Creek (08NL071). For a contributing catchment of 1.4 km², the resulting 200-yr return period peak flow (Q200) is approximately 4.8 m³/s, not accounting for climate change.

The location of the stations included in this analysis are shown in Figure 1. Although these gauges are for larger drainage areas, they have been selected to best represent potential runoff at this site and are considered to be adequate for the purposes of this report.

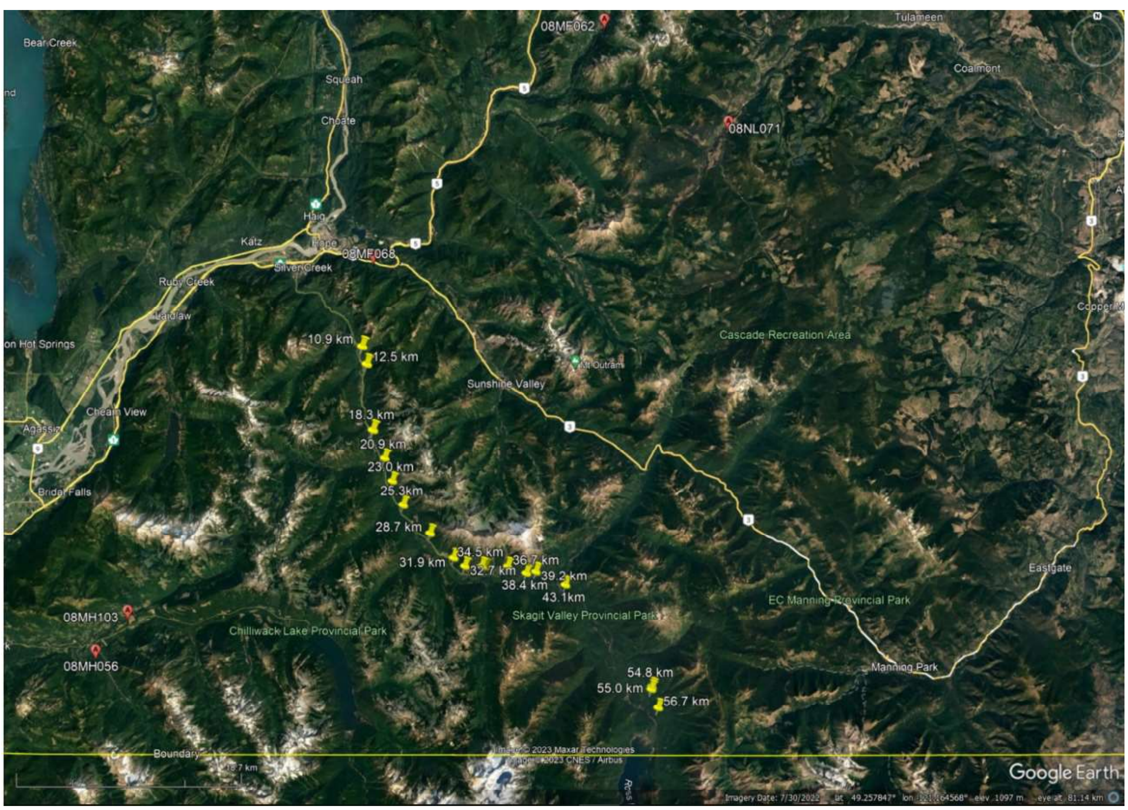

Figure 1 Hydrometric Stations near Hope, BC

2.3 Climate Change Considerations

Climate Change considerations within the design scope are applicable to small surface water drainage culvert sizing, water levels, erosion protection to the road embankment for the permanent design scope and estimates for the 200-yr return period peak flow. This section provides a summary of the climate change assessment carried out for the conceptual mitigation design at the 38.4 km site, which follows the professional practice guidance from EGBC on climate change-resilient highway infrastructure (2020).

The Pacific Climate Impacts Consortium (PCIC) station hydrologic model outputs for historic (1981-2010), mid-century (2040-2069), and end-of-century (2070-2099) periods under RCP 4.5 and RCP 8.5 scenarios were used to estimate projected increases to streamflow for the 200-year return period event at four hydrometric stations: Fraser River at Hope, Coquihalla River above Alexander Creek, Harrison River near Harrison Hot Springs, and Chilliwack River at Vedder Crossing. It was assumed that the increase in streamflow for these larger rivers was applicable to the site catchment. The projected peak flows during a 200-yr return period event were estimated by applying the average median percent increase in streamflow for the RCP 8.5 end-of-century scenario between the four stations (18%) to the 200-yr flow rate under current conditions.

As a check to the projected flow increases based on the PCIC hydrologic model results, the IDF-CC Tool, Version 6.5, created by Western University was used to estimate projected precipitation increases for the area to the end of the century under RCP 8.5. The results indicate that 100-year, 24-hour events could increase in intensity by 19%, which is reasonably close to the results obtained with the PCIC data.

The resulting Q200 considering climate change is 5.7 m^3/s.

3.0 HYDRAULIC ANALYSIS

WSP carried out a hydraulic analysis for the 38.4 km site to evaluate the design flow for the proposed culvert and channel replacement during the Q200 events. The design peak flow was then used to size the proposed culverts and channel and provide erosion protection along the channel. The results of the analysis are summarized in the following sections.

Detailed site topography was not available during the conceptual design phase. This design assumes a headwater control on culvert discharge and a slope of 2.7% for both the upstream channel and culvert. Re-analysis is recommended for detailed design.

3.1 Culvert and Channel Design

The resulting peak flow at the 38.4 km site during the Q200 was adjusted to account for potential debris floods at the culvert location. Based on a Melton ratio of 1.4 for the watershed, which corresponds to the potential for “debris floods”, the water-only peak flow for the location was adjusted by a debris flood bulking factor of 2.0. Once adjusted, the Q200 flows for the culvert and channel at the 38.4 km site is 11.4 m^3/s.

Several culvert type options were considered for the ultimate future replacement; the options included corrugated steel pipe (CSP) and pre-cast concrete box culverts. Based on the debris flood potential at the site and considering future maintenance requirements and durability, the ultimate future design (bulked Q200) would likely include pre-cast concrete box culverts. Due to material availability and ease of installation, the selected culvert type for the mitigation is a CSP and added pre-cast concrete box culverts for the Q200.

WSP carried out a hydraulic analysis for the proposed culvert configuration for a culvert sizing of two pre-cast concrete box culvert barrels of 2700 mm (span) x 1500 mm (rise) for the Q200. No provisions for fish passage across the culvert have been accounted for, as no fish populations have been identified at the site. Culvert outlet velocity for the Q200 design flow has been estimated as 4.6 m/s.

In addition to the culvert design, WSP evaluated the required drainage channel size to convey the design flow into the proposed culvert. The resulting channel consists of a trapezoidal open channel with 2H:1V side slopes and a minimum base width of 3 m for the Q200 design flow.

3.2 Erosion Protection

Erosion protection to the drainage channel has been provided via a riprap layer. Riprap sizing has been estimated following recommendations from Section 1000 of the MoTI Bridge Design Specifications (MoTI, 2019, Section 1000) and the Transportation Association of Canada (TAC) design guidelines, for the Q200 design flow and channel configuration described above. The resulting riprap consists of Class 500 kg riprap and extends along the drainage channel up to 3.0 m upstream from the culvert inlet, and 6.0 m downstream of the culvert outlet. Approximate rock particle mass and sizes for Class 500 kg riprap, based on spherical rock particles with a specific gravity of 2.50, are provided in Table 1.

Table 1 – Class 500 kg Riprap Mass and Gradation

Percent Smaller (by Mass)	Mass (kg)	Intermediate Dimension (mm)
100	2,500	1,250
85	1,500	1,050
50	500	725
15	50	340

4.0 CLOSURE

We trust that this information is sufficient for your requirements. Should you have any questions regarding the above, or if you require further information, please do not hesitate to contact our office.

WSP CANADA INC.

Engineers & Geoscientist
BC Permit #1000200

PROFESSIONAL
PROVINCE OF
K. D. HENSHAW
34301
BRITISH COLUMBIA
ENGINEER

May. 12 2023

Emilio Martinez, MSc, PEng
Hydrotechnical Engineer

Kevin Henshaw, PEng
Lead Hydrotechnical Engineer

EM/KH

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