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northwest hydraulic consultants ltd

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BC Ministry of Transportation and Infrastructure | Southern Interior Region
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Attention: **Alysha Piccini, EIT**
Hydrotechnical Engineer

Via email: Alysha.Piccini@gov.bc.ca

Re: **MEMO: 08050 Hwy 99 Peacock Brook Culvert Rehabilitation**
Hydraulic Model Updates and Results and
Opinion Regarding Diversion during Construction

1 INTRODUCTION

In 2016, Northwest Hydraulic Consultants Ltd (NHC) was retained by the BC Ministry of Transportation and Infrastructure (MoTI) to complete a hydrotechnical scoping study for the renewal of the 08050 Peacock Brook Culverts at Highway 99, approximately 10 km south of Surrey BC. The crossing consists of a corrugated steel pipe (CSP) horizontal ellipse on the east side (East Culvert) and a smaller round CSP on the west side (West Culvert). Both culverts are heavily deteriorated and require rehabilitation.

As part of the 2016 study, NHC developed a 1-D unsteady hydraulic model of the crossing reach using HEC-RAS (V. 5.0.1; USACE 2015) to evaluate the hydraulic performance of the existing culverts and three proposed renewal options at the 200-year peak flow (both existing and considering future climate change). The geometry of the East Culvert used in the model was based off of MoTI Bridge Inspection Reports from 2011-2015. The geometry of the West Culvert was based off measurements taken by NHC during a channel survey. At the time of the survey, high water levels completely submerged the inlet and outlet of the West Culvert and overgrown vegetation made it difficult to access.

More recently, Associated Engineering (AE) has been retained by MoTI to complete the rehabilitation design for the crossing. In March 2020, AE conducted its own site visit and verified the geometry of both culverts; survey conditions were improved due to lower water levels. AE found the diameter of the West Culvert to be smaller (1300 mm) than measured by NHC in 2016 (1800 mm); it is presumed that in the submerged conditions, NHC had measured a conical collar at the culvert inlet of rather than the culvert itself. AE also measured slightly different dimensions for the East Culvert (2500 mm x 3600 mm) than those used previously by NHC (2400 mm x 3700 mm).

At this time, AE has developed a preliminary design for a slip-liner renewal of both culverts, which will involve inserting and pressure grouting new aluminum culverts inside the existing culverts (AE, 2020).

NHC has now updated the 2016 hydraulic model to reflect the correct existing culvert geometry as well as AE's proposed design. The intent of the update is to re-assess 200-year hydraulics given that the West Culvert is considerably smaller than originally understood. The updating process and results are summarized in the following sections. For background details regarding the project site, hydrology analysis, and hydraulic model development, please refer to *Hydrotechnical Scoping Study – 08050 H99 Peacock Brook Culverts (Contract No. 0830CS0852)* (NHC, 2016).

At the end of this report (Section 4), we provide an opinion as to the suitability of using the smaller of the two culverts (1300 mm CSP) as a flow diversion conduit during construction on the larger culvert.

2 FLOOD SCENARIOS

The hydraulics of the crossing have been re-assessed under the following four flood scenarios. In each scenario the 200-year flood hydrograph is the upstream boundary condition and a tidally influenced, high-water elevation in Serpentine River defines the downstream boundary condition:

1. Existing 200-year flood hydrograph with a 1-year annual high-water level (HWL) of 1.9 m.
2. Future 200-year flood hydrograph with a 1-year HWL of 1.9 m.
3. Existing 200-year flood hydrograph with a present day 10-year HWL of 2.6 m.
4. Future 200-year flood hydrograph with a future 10-year HWL of 3.2 m.

3 HYDRAULIC MODEL UPDATES

NHC has updated the hydraulic model to capture the correct existing culvert geometry as well as AE's renewal design; this required modifying the culvert dimensions, invert elevations, and roughness parameters that are used as inputs to the model. Table 1 summarizes these properties for: i) NHC's 2016 existing conditions; ii) AE's revised existing conditions; and iii) AE's proposed renewal design.

Table 2 compares the hydraulic performance of each of these conditions and each of the four flood scenarios. As expected, the West Culvert has decreased conveyance in the updated model compared to the 2016 model. That said, the conveyance of the East Culvert increases and the maximum flow through both culverts is comparable under all crossing conditions for each given flood scenario. The key parameter to consider, from the standpoint of increased flood risk to adjacent upstream properties, is the maximum headwater elevation. Despite the reduced size of the West Culvert the revised existing conditions experience no increase in maximum headwater elevation. The proposed design conditions result in only minor water level increases of 0.01 m for the future climate 200-year flood scenarios.

AE's proposed culvert renewal design is concluded to have adequate hydraulic capacity for the design events, despite a reduction in culvert size.

Table 1 Culvert Properties for Hydraulic Modeling

Crossing Conditions	East Culvert (2500 mm x 3600 mm Horizontal Ellipse)					West Culvert (1300 mm CSP)			
	Span (mm)	Rise (mm)	Inlet Invert Elevation[1] (m)	Outlet Invert Elevation[1] (m)	Manning's 'n'[2]	Diameter (mm)	Inlet Invert Elevation[1] (m)	Outlet Invert Elevation[1] (m)	Manning's 'n'[2]
NHC 2016 Existing Conditions	2,400	3,700	-2.12	-2.15	0.028	1.8	-1.85	-1.98	0.032
Revised Existing Conditions	2,500	3,600	-2.17	-2.20	0.028	1.3	-1.60	-1.73	0.033
Proposed Design Conditions	2,260	3,200	-2.05	-2.08	0.030	1.2	-1.55	-1.68	0.033

Notes:
1. It has been assumed that the invert elevations and culvert sizes from the 2016 study, though erroneous, can be used to accurately determine the cross-sectional center of each culvert. Invert elevations for the revised existing and proposed design conditions were thus determined by adding half the difference of the new culvert rise/diameter from the original culvert rise/diameter to the 2016 invert elevations.
2. Assumed 6 x 2 in. corrugations (Brunner, 2016).

Table 2 Hydraulic Analysis Summary Results

Crossing Conditions[1]	Flood Scenario	Max Headwater Elevation (m)	Head Loss[2] (m)	Combined Max Flow (m^3/s)	East Culvert (2500 mm x 3600 mm Horizontal Ellipse)				West Culvert (1300 mm CSP)			
					H/D[1,2]	Velocity[3] (m/s)	Max Flow (m^3/s)	Max Velocity (m/s)	H/D	Velocity (m/s)	Max Flow (m^3/s)	Max Velocity (m/s)
NHC 2016 Existing Conditions	200-year Present Climate + 1.9 m Serpentine River HWL	1.20	0.03	6.51	1.38	0.47	5.06	0.73	1.69	0.38	1.44	0.57
	200-year Present Climate + 2.6 m Serpentine River HWL	1.23	0.03	6.63	1.40	0.45	4.96	0.71	1.71	0.41	1.67	0.66
	200-year Future Climate + 1.9 m Serpentine River HWL	1.69	0.04	7.79	1.59	0.48	5.86	0.84	1.97	0.45	1.93	0.76
	200-year Future Climate +3.2 m Serpentine River HWL	1.73	0.03	7.62	1.60	0.44	5.73	0.82	1.99	0.40	1.89	0.74
Revised Existing Conditions	200-year Present Climate + 1.9 m Serpentine River HWL	1.19	0.04	6.46	1.34	0.53	5.75	0.81	2.15	0.33	0.72	0.54
	200-year Present Climate + 2.6 m Serpentine River HWL	1.22	0.04	6.27	1.35	0.51	5.60	0.79	2.17	0.32	0.67	0.50
	200-year Future Climate + 1.9 m Serpentine River HWL	1.69	0.05	8.60	1.55	0.58	7.64	1.08	2.53	0.37	0.96	0.72
	200-year Future Climate +3.2 m Serpentine River HWL	1.73	0.04	7.59	1.56	0.53	6.74	0.95	2.56	0.33	0.85	0.64
Proposed Design Conditions	200-year Present Climate + 1.9 m Serpentine River HWL	1.18	0.07	6.23	1.43	0.68	5.49	0.97	2.28	0.44	0.75	0.66
	200-year Present Climate + 2.6 m Serpentine River HWL	1.21	0.07	6.15	1.44	0.65	5.41	0.95	2.30	0.42	0.74	0.65
	200-year Future Climate + 1.9 m Serpentine River HWL	1.70	0.09	7.84	1.66	0.74	6.90	1.21	2.71	0.48	0.94	0.83
	200-year Future Climate +3.2 m Serpentine River HWL	1.74	0.07	7.72	1.68	0.67	6.80	1.20	2.74	0.44	0.92	0.82

Notes:
1. Refer to Table 1
2. Refers to maximum headwater elevation conditions.
3. This ratio is headwater/rise for the East Culvert and headwater/diameter for the West Culvert.

4 OPINION REGARDING CONSTRUCTION DIVERSION

The West Culvert (1300 mm CSP) should have enough capacity to bypass all flow in Peacock Brook during construction on the East Culvert. Given the small size of the watershed, the base flow will not be high and any occurrence of mild wet whether should not lead to the West Culvert being overwhelmed. Water levels are of a greater concern, as they will rise with the tidal tailwater condition in Serpentine River until the Colebrook Pumps engage. During construction sheet pile isolation walls (or something similar) should be installed upstream and downstream of the crossing to isolate flow and high-water levels to the West Culvert while slip-liner construction on the East Culvert is underway. The setup can then be reversed to allow work on the West Culvert while all flow is diverted through the East Culvert. Some pumping will need to occur within the isolation areas to intercept any seepage.

NHC recommends consulting with the City of Surrey to confirm the water level at which the pumps engage, in order to determine an appropriate design water level for the diversion.

5 CLOSURE

Please feel free to contact Des Goold via email at dgoold@nhcweb.com or by phone at (604) 837-8289 if you have any inquiries or concerns regarding the content of this memo.

Sincerely,

Northwest Hydraulic Consultants Ltd.

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6 REFERENCES

AE (2020). *08050 Peacock Brook Culvert Renewal - 50% Design Drawing*.

Brunner, G. W. (2016). *HEC-RAS River Analysis System. Hydraulic Reference Manual. Version 5.0*. Davis, CA.

NHC (2016). *Hydrotechnical Scoping Study - 08050 H99 Peacock Brook Culverts*. Final Report. Northwest Hydraulic Consultants Ltd., North Vancouver, BC.