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northwest hydraulic consultants

MEMORANDUM

TO:	Kate Miller, Cowichan Valley Regional District	DATE:	August 10,2011
FROM:	Dave McLean P.Eng. {by email}	NO. PAGES:	7
CC:		PROJECT NO.:	3-5526
		REF. NO.:	
RE:	**Effects of Gravel Removal on Flood Levels** **Results of Hydraulic Modelling**		

Northwest Hydraulic Consultants (NHC) was retained by the Cowichan Valley Regional District CVRD to assess the hydraulic effects of removing gravel from two sites on the Cowichan River downstream of Somenos Creek using the Mike Flood hydrodynamic model developed for NHC's Integrated Flood Management Plan (IFMP) in 2008 - 2009[1]. The gravel removal scenarios were identified between July 8th and July 12th in consultation with the CVRD.

1. Background

The following information on the river's overall sediment budget is condensed from NHC (2009). Comparison of cross sections surveyed in 1977 and 2008 indicated there was a total net deposition of 251,000 cubic metres on the Cowichan River downstream of Highway 1. During this period gravel was periodically removed from a number of different sites, including between the railway bridge and Major Jimmy's channel and along the North Branch of the Cowichan. Accounting for these removals, the net overall sedimentation volume was estimated at 450,000 cubic metres. This volume is equivalent to an influx of gravel of 14,500 cubic metres/year upstream of the Allenby Bridge. For illustrative purposes, an estimate of the thickness of deposition was made by spreading the volume uniformly over the length of the channel. Based on this assumption, it was found that the average bed level rise amounted to 0.7 m over the 31 year period (22.5 mm/year).

An independent check was made by reviewing historic Water Survey of Canada stage-discharge measurements at the Allenby Bridge and other stage measurements made by Fisheries & Oceans Canada on Somenos Creek[2]. The data showed bed levels had actually lowered near the Allenby Bridge, probably reflecting the effects of channelization and downstream gravel removals. There was a net increase in water levels on Somenos Creek - Somenos Lake by about 0.5 to 0.7 m over 20 years. Since the water level in

[1] NHC (2009): Lower Cowichan/Koksilah River Integrated Flood Management Plan, Final Report, September 2009, to Cowichan Valley Regional District, 182 pg.
[2] NHC (2005): Somenos Lake Hydraulic Model. Prepared for Fisheries & Oceans Canada, October 2005, 20pg.

Somenos Creek is controlled by backwater from the Cowichan River, this increase reflects changes in bed levels on the Cowichan River and other channel changes that have occurred downstream of the confluence such as changes to the channel alignment and diking.

Figure 1: Site plan

NHC (2009) proposed a longterm gravel maintenance program be carried out on the Cowichan River, with a tentative annual removal rate of 8,000 cubic metres/year. This rate was adopted to minimize adverse effects to fish habitat and to avoid drastically altering the river's overall stability. Previous studies on gravel removal from the Cowichan River indicated that the rate of removals in the 1970's and 1980's created a range of adverse effects (Sutek and Kellerhals, 1989)[3].

[3] Sutek and Kellerhals, 1989. Assessing Gravel Supply and Removal in Fisheries Streams. Report to Dept. of Fisheries and Oceans and B.C. Ministry of Environment.

2. Gravel Removal Scenarios

2.1 Scenario 1: North Branch Excavation

The first scenario involved excavating 30,000 cubic metres of gravel from the North Branch of the Cowichan River, starting at the junction with the South Branch and extending 1,200 m downstream (Figure 1). This volume is substantially greater than the amount proposed in the IFMP. However, it could be justified since gravel has not been removed for a number of years prior to 2010. It is believed that this quantity represents an upper bound on the amount that could be removed in a single year and is not intended as a recommended removal rate. Additional detailed hydraulic and habitat/fisheries studies would need to be carried out prior to actual implementing any longterm gravel removal plan.

The proposed excavation is intended to remove a wedge of sediment that forms a hump in the stream profile (Figure 2).

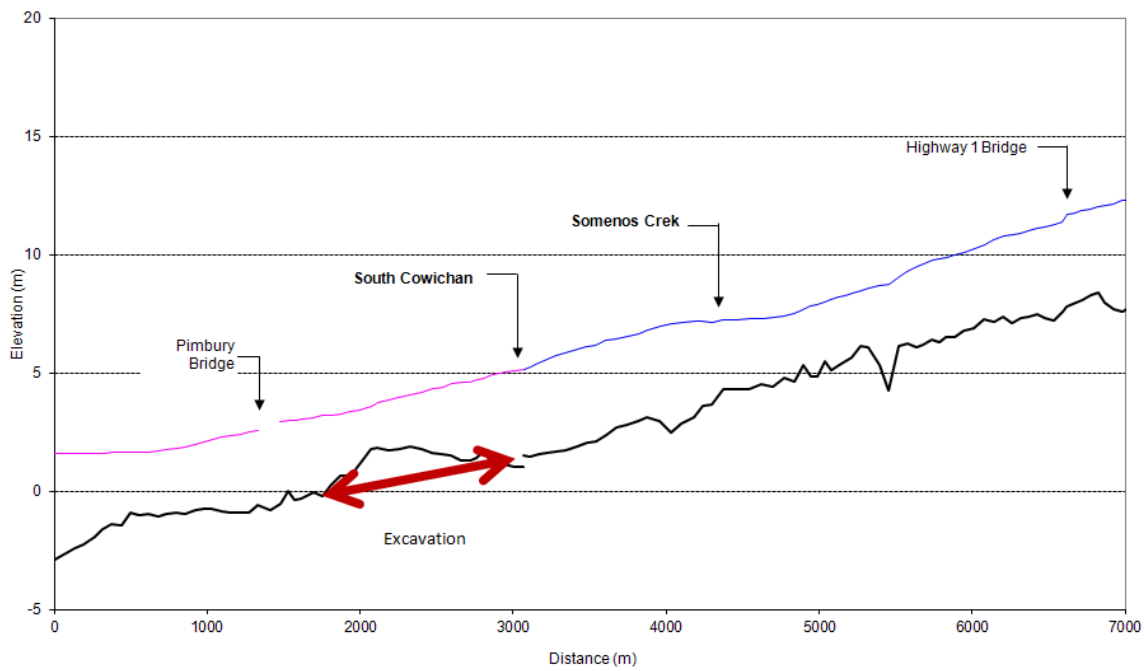

Figure 2: Longitudinal profile of north branch of Cowichan River to Highway 1 Bridge

2.2 Scenario 2: North and South Branch Excavation

In this scenario a total of 60,000 cubic metres of gravel was removed. The removal on the North Branch was the same as in Scenario 1. The removal along the south branch amounted to 30,000 cubic metres, with the excavation starting at the junction and extending downstream for a distance of 1,200 m.

3. MODEL RESULTS

3.1 RUN CONDITIONS

The boundary conditions were set to the Base Case 200 year flood that was used in our previous simulations (NHC March 2011)[4]. This involved using a 200 year inflow hydrograph on the Cowichan River, Koksilah River and Somenos Creek, in conjunction with a normal high tide (the hydrographs and tide peaked simultaneously). The cross section geometry was modified to represent the proposed excavations for Scenario 1 and Scenario 2. No other changes were made to the channel roughness or floodplain. The effect of the gravel removal scenarios was determined as: $WL_{excavation} - WL_{base}$. Output during the rising portion of the hydrograph was reviewed in order to assess the effects at a range of discharges from near bankfull (200 m^3/s) up to the 200 year flood (700 m^3/s).

Water level differences were computed at several locations along both branches as well as in the main channel upstream of the north-south branch junction. Reference locations are summarized in Table 1.

Table 1: Reference locations of model output

Branch	Cross Section	Location (m from junction of north/south branch
North	North Cowichan 1058	1,538 m downstream
	North Cowichan 1518	1,076 m downstream
	North Cowichan 2064	530 m downstream
	North Cowichan 2534	60 m downstream
South	Cowichan 2023	1,044 m downstream
	Cowichan 2516	550 m downstream
	Cowichan 3072	At junction
Main	Cowichan 3220	153 m upstream of junction
	Cowichan 3483	416 m upstream of junction

3.2 SCENARIO 1: EXCAVATION ON NORTH BRANCH

Figure 3 shows water level differences from the Base Case at several locations as a function of discharge during the 200 year flood event. The discharges represent the flow in the channel and do not include flow over the floodplain or other spills. Table 2 summarizes the water level differences (compared to the Base Case) for the range of inflow conditions.

The excavation caused flow to be captured from the south branch, which reduced the water levels along the entire length of the south branch. At a point 550 m downstream of the junction (Cowichan 2516), the water level was lowered from -0.45 m to -0.1 m.

[4] Northwest Hydraulic Consultants Ltd. (2011). Cowichan/Koksilah IFMP Review of Hydraulic Modelling, report dated March 24, 2011.

Flows on the north branch were increased in comparison to the Base Case as a result of flow being captured from the south branch. Water levels on the north branch were decreased in the excavated sections of the reach. For example, 60 m downstream of the junction (North Cowichan 2534), the water level was lowered by -0.17 to -0.1 m. In the lower un-excavated reach, the water levels increased above the Base Case due to the increase in discharge. For example, at a distance of 1,538 m downstream of the junction (North Cowichan 1058), the water levels increased by between +0.4 m to +0.18 m.

The excavation reduced water levels in the main river 153 m upstream of the junction by -0.1 m. The reduction in levels extended approximately 500 m upstream of the north-south branch junction and did not affect levels at the Somenos Creek confluence.

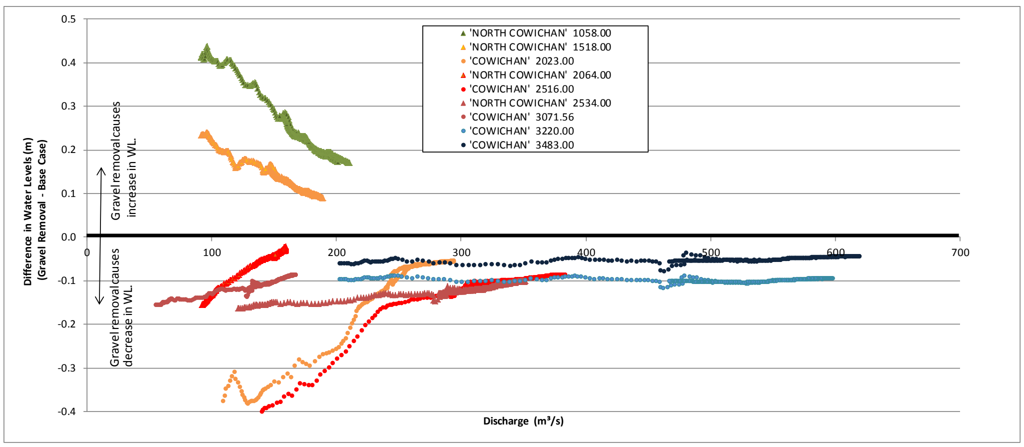

Figure 3: Scenario 1 - Change in water level as a function of discharge.

Table 2: Range in water level differences at various locations.

Branch	Cross Section	Location (distance from junction of north/south branch)	Water Level Difference From Base Case (m)	
			Scenario 1	Scenario 2
North	North Cowichan 1058	1,538 m downstream	+0.4 to +0.18	+0.2 to -0.02
	North Cowichan 1518	1076 m downstream	+0.23 to +0.09	+0.05 to -0.05
	North Cowichan 2064	530 m downstream	-0.17 to -0.03	-0.45 to -0.10
	North Cowichan 2534	60 m downstream	-0.17 to -0.10	-0.5 to -0.23
South	Cowichan 2023	1,044 m downstream	-0.38 to -0.05	-0.2 to -0.02
	Cowichan 2516	550 m downstream	-0.45 to -0.10	-0.48 to -0.09
	Cowichan 3072	At junction	-0.17 to -0.09	-0.48 to -0.20
Main	Cowichan 3220	153 m upstream of junction	-0.1 (constant)	-0.32 to -0.25
	Cowichan 3483	416 m upstream of junction	-0.05	-0.19 to -0.13

3.3 Scenario 2: Excavation on North Branch and South Branch

Removing an additional 30,000 cubic metres of gravel from the south branch reduced the amount of flow captured by the north branch. As a result, Scenario 2 was more effective than Scenario 1 in reducing water levels on the excavated portion of the north branch (Figure 4). Also, the increase in water levels along the lower un-excavated portion of the reach was reduced compared to Scenario 1 (compare the graphs of North Cowichan 1058 in Figure 3 and Figure 4 and Table 2).

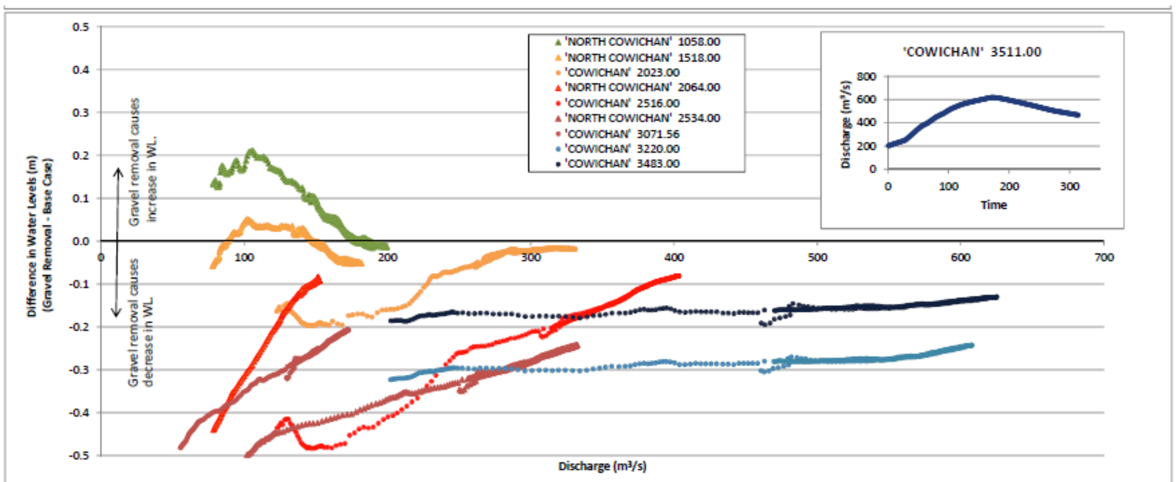

Figure 4: Scenario 2 - Change in water level as a function of discharge.

At a section 60 m downstream of the junction (North Cowichan 2534) the water level was reduced by between -0.5 m to -0.23 m. At a point 530 m downstream of the junction (North Cowichan 2064), the water level was reduced from the Base Case by between -0.45 m and -0.10 m.

In the south branch, the overall water level lowering was reduced slightly compared to Scenario 1. At a point 550 m downstream of the junction (Cowichan 2516), the water level was lowered by between -0.48 m to -0.09 m.

Water level lowering in the main river upstream of the north-south branch junction was greater than in Scenario 1. At a point 153 m upstream of the junction (Cowichan 3220) the water level was lowered by between -0.32 m to -0.25 m. At a distance 416 m upstream of the junction (Cowichan 3483) the water level was lowered by between -0.19 m to -0.13 m. The effect of the excavations did not affect levels at the Somenos Creek confluence.

4. Assessment of Results

The results indicate gravel removals can lower flood levels on limited sections of the river but the effect does not extend far upstream of the excavations. Water level lowering of up to 0.4 m occurred in the excavated sections at conditions below bankfull stage. At the peak of a 200-year flood, the maximum water level reductions were generally in the order of -0.1 to -0.2 m.

The results in these simulations do not account for sediment infilling, which will counter the effect of the gravel removals on water levels. It is appropriate to consider gravel removal as part of a maintenance program to prevent future increases in flood levels, rather than as flood control alternative to reduce flood levels. It would be risky to reduce dike crest levels or lower flood construction levels on the basis of hypothetical reductions in flood levels due to a short-term gravel removal program. This is because it is very possible that any increase in channel conveyance due to excavation will be lost as a result of sedimentation during the peak of the flood.

The model results indicate that removing gravel can change the distribution of flow between the two branches. The model assumes the bed and banks are fixed and does not account for potential erosion or degradation that could develop in response to flow capture. Excavating a large quantity of material from a single branch and the resulting flow capture, could cause bank erosion and widening, resulting in an avulsion and a permanent shift in the river down one branch. This could significantly de-stabilize the channel and induce a wide range of adverse effects. Given these considerations it is recommended that future gravel removals be carried out on both branches to reduce the chance of significantly changing the distribution of flow.

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