On February 20th, 2004 northwest hydraulic consultants (nhc) submitted a proposed scope of work for additional 2D numerical modelling for the Dunvegan Hydroelectric Project. The intention of this analysis was to provide information to Canadian Project Ltd (CPL) and Canadian Hydro Developers (CHD) so a preferred spillway location can be selected and a construction sequence scenario can be developed.

This memorandum focuses on a June 9th, 2004 sub-task requesting that additional modelling be conducted to evaluate the impact the spillway location may have on flow patterns at the Dunvegan Bridge located approximately two kilometres downstream of the proposed project.

This modelling effort is a continuation of previous analysis conducted by nhc and submitted to CPL as part of the 2D Numerical Modelling Technical Report (March 2003). For brevity please reference the Technical Report for the Project Background and Overall Modelling Objectives.

**Background and Objectives**

By revisiting the 2-D numerical modelling effort for alternative spillway locations, CPL hopes to identify the hydraulic impacts, if any, various proposed layout geometries may have on flow patterns, and hence bed scour, at the Dunvegan Bridge which is located approximately two kilometres downstream from the Project. The intent of this memorandum is to compare velocity distribution across transects located 500, 1000, and 2000 m downstream of the Project under pre-construction conditions and various post-construction Project layouts. These comparisons will be interpreted, along with previous analysis, to anticipate changes in flow patterns at the Dunvegan Bridge.

The results presented in this memo provide a good representation of the general flow patterns downstream of the Project. However, it should be noted that 2D models compute the “depth-averaged” velocities and will not provide accurate results where flow patterns are highly three-dimensional in nature.
Project Geometry
The project geometry examined in this memorandum consists of a powerhouse facility, a seven bay control weir, and two rock-fill ramp fishways. The flows issuing from the ten fish sluiceways intended for downstream fish passage and the right bank navigation lock were not considered in the model. The three alternative project layouts simulated include:

- “40-0” Layout - The powerhouse geometry with all forty (40) turbine units (Units 1 - 40) extending from the south side of the river channel and the control weir spillway extending from the north side to the powerhouse section. (Refer to the March 2003 Technical Report for pre-construction and 40-0 project layout).
- “30-10” Layout - The powerhouse geometry divided into two sections: one section consisting of thirty (30) turbine units (Units 1 – 30), extending from the south side of the river channel; and, the second section, consisting ten (10) turbine units (Units 31 – 40), extending from the north side of the river. The two sections were separated by the control weir spillway. (Refer to the June 1, 2004 Technical Memorandum for 30-10 project layout)
- “20-20” Layout - The powerhouse geometry divided into two equal sections: one section consisting of twenty (20) turbine units (Units 1 – 20), extending from the south side of the river channel; and, the second section, also consisting of twenty (20) turbine units (Units 21 – 40), extending from the north side of the river. Again, the two sections were separated by the control weir spillway.

In each layout the turbines were arranged into multiple groups of five units each. The two rock-fill fishway ramp structures will be located on each riverbank and adjacent to the powerhouse sections.

Channel Geometry
The riverbed bathymetry required for numerical modelling was adopted from the information provided by CPL, with localized changes in the vicinity of the fishway ramp entrances incorporated to reflect the proposed bathymetry in these areas when modelling the post-construction conditions. A 2,700 m reach of river was adopted for modelling the pre-construction channel conditions. The 40-00 Layout geometry was simulated over a 2,000 m long reach of the river, beginning at the downstream face of the powerhouse and spillway structures and extending downstream to the Dunvegan Bridge. The 30-10 and 20-20 Layouts geometries were simulated over a 1000 m long reach of the river, also beginning at the downstream face of the powerhouse and spillway structures. The numerical model pre-processor software, SMS, was able to incorporate information provided by CPL as baseline data to be used in developing the meshes. Refer to the March 2003 Technical Report and June 1, 2004 Memorandum for additional details on the modelled bathymetry.

Mesh Generation
Four computational meshes were developed to define the spatial and hydraulic characteristics of the channel bed - one for each of the pre-construction and project layout alternatives. Refer to the March 2003 Technical Report and June 1, 2004 Memorandum for the mesh layouts.


Boundary Conditions
The 100-flow event considered in the present analysis was adopted to reflect the Annual Rule Curve data provided by CPL. The 100-year flow in the Peace River was given as 10,300 m$^3$/s. Under this condition, the control weir and the powerhouse overflow weir are designed to pass 5,057 m$^3$/s and 5,098 m$^3$/s, respectively. The balance, 145 m$^3$/s, will pass through the low level fish sluices.

Pre-Construction / Post-Construction Comparisons
A comparison between the pre- and post-construction velocity distributions for the alternative Project geometries were considered 500 and 1,000 m downstream of the Project. The location of the sections are included in Figure 1. The resulting velocity comparisons are presented in Figures 2 and 3.

![Figure 1 – Location of Control Weir and Downstream Sections](image-url)
Based on these results, it is reasonable to expect that for 100-year flood events (10,300 m$^3$/s) flow conditions associated with both the 30-10 and 20-20 Layouts will more closely resemble pre-construction conditions than that predicted for the 40-00 Layout. Velocity distributions across both sections illustrate that the location of the maximum velocities associated with both the 30-10 and 20-20 Layouts approximate the location predicted for the pre-construction conditions.
Furthermore, comparing the 30-10 Layout to the 20-20 Layout illustrates that slightly higher velocities along the left side of the channel are predicted for the 30-10 Layout, which more closely matches the predicted pre-construction flow conditions. It also becomes evident that flow patterns associated with the 30-10 Layout are expected to more closely the match pre-construction flow patterns when comparing the alignment of the pre-construction maximum velocities over the entire length of the modelled reach. Figure 4 plots the alignment of the maximum velocities predicted for the pre-construction conditions, superimposed on the channel bathymetry. The figure also shows the alternative locations for the control weir for the three alternative Project layouts. It is notable that the control weir location for the 30-10 Layout is well aligned with the pre-construction maximum velocities.

It should also be noted that the shift in velocities along the banks evident in Figures 2 and 3 can be primarily attributed to adopting unique computational meshes for each of the pre-construction- and post-construction analysis. Although the precise location of the migration corridors may appear to have shifted due to this computational inconsistency, the actual width and velocity distribution within the migration corridor should not be significantly impacted.

![Figure 4](image_url)

**Figure 4 – Location of High Velocity under Pre-Construction Conditions relative to Alternative Layouts and Channel Bathymetry**

The initial modelling effort, presented in the March 2003 Technical Report, extended downstream to the Dunvegan Bridge. Figure 5, presented below, illustrates the predicted velocity distribution immediately upstream of the bridge for the pre-construction and 40-00 Layout.
Based on the results presented in Figures 2 through 4, it is reasonable to expect that, for 100-year flood event (10,300 m$^3$/s), the flow patterns associated with both the 30-10 and 20-20 Layout alternatives should more closely resemble pre-construction velocity distribution at Dunvegan Bridge than that illustrated above for the 40-0 Layout. Based on these results, it is reasonable to deduce that there should be no significant impacts at the Dunvegan Bridge for any of the three project layout alternatives.

**Summary**

On the basis of the results presented herein, it is reasonable to expect that there will be no significant impacts on the flow patterns and hence bed scour in the vicinity of the Dunvegan Bridge associated with any of the three modelled layout geometries.

It is also reasonable to expect that, comparing the three alternative layout geometries, flow patterns associated with proposed 30-10 Layout will most closely resemble pre-construction flow conditions during a 100-year flood event.