DUNVEGAN HYDROELECTRIC PROJECT IMPACT EVALUATION: CHANNEL MORPHOLOGY AND SEDIMENT TRANSPORT

Prepared for:

GLACIER POWER LTD.
200, 622 - 5 Avenue, S.W.
Calgary, AB,
T2P 0M6

TEL: 403-298-0259  FAX: 403-262-8786  email: bill@canhydro.com

Prepared by:

M. MILES & ASSOCIATES LTD.,
645 Island Road,
Victoria, B.C.
V8S 2T7.

TEL: 250-595-0653  FAX: 250-595-7367  email: mmaa@coastnet.com

MAY, 2000
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STATEMENT OF LIMITATIONS OF REPORT

This report was prepared by M. Miles and Associates Ltd. (MMA) for use by Glacier Power Ltd. The conclusions in this report reflect the judgement of MMA staff in light of the information available to MMA at the time of report preparation.

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DUNVEGAN HYDROELECTRIC PROJECT
IMPACT EVALUATION:
CHANNEL MORPHOLOGY
AND SEDIMENT TRANSPORT

1: INTRODUCTION

The effects of the Dunvegan Hydroelectric Project on sediment transport and channel morphology have been described in the report by M. Miles and Associates Ltd. (MMA), 2000a. The present report uses this information to assess potential impacts to existing structures (such as the Dunvegan Bridge and the water supply intake to the town of Fairview) or valued ecosystem components. Comments have also been prepared on the possible effects of some construction and decommissioning activities and the morphologic consequences of structural failure.

2: IDENTIFICATION OF POTENTIAL ISSUES

The following issues have been identified on the basis of the baseline study (MMA, 2000a), comments from regulatory agencies or discussions with members of the study team.

CONSTRUCTION

- Could construction activities significantly increase suspended sediment concentrations?

OPERATION

- Could sediment deposition in the headpond affect boat navigation?
- Could sediment deposition in the headpond affect walleye spawning habitat at Km 17?
- Could bank erosion along the headpond elevate suspended sediment concentrations?
- Could channel downcutting, scour or lateral erosion affect the stability of the Dunvegan Bridge? and
could channel downcutting, scour or lateral erosion affect the water supply intake to the town of Fairview?

STRUCTURAL FAILURE

could failure of the control weir or a break in the Dunvegan structure affect the downstream channel stability?

DECOMMISSIONING

could sediment production following project decommissioning impact downstream channel stability and fish habitat?

Each of these topics is discussed below.

3: CONSTRUCTION

3.1 SEDIMENT PRODUCTION DURING CONSTRUCTION

The major instream works associated with construction of the Dunvegan Project will be undertaken during the period between April and October 2002. As indicated in SECTION 3.2 of MMA, 2000a, background suspended sediment concentrations typically begin to increase in late-March, have elevated levels throughout the period between April and September and decrease to comparatively low levels by mid- to late-September. The timing of the proposed construction work therefore more or less corresponds to the period with high naturally occurring background suspended sediment concentrations.

The initial stages of construction will consist of driving H piles and sheet piling. Neither of these activities are expected to produce large quantities of sediment. All excavation work will be undertaken in contained cells formed by the sheet piling. This will limit the potential for sediment production. If required, the water within the cells could be allowed to settle prior to its removal and sediment laden seepage water could be pumped to a settling pond for treatment. Similar procedures could be undertaken during construction of the proposed weir, fishway and navigation lock.

There is a potential for local channel bed scour to occur during the final stages of construction when portions of the weir and power house have been completed on either side of the river, but the structure has not been closed in the middle. Similarly there is a
potential for erosion downstream of the structure once the turbines housings or sluice gates in the weir are opened. This topic needs to be further assessed during detailed design and erosion protection or other appropriate measures should be undertaken as required.

4: OPERATION

4.1 COULD SEDIMENT DEPOSITION IN THE HEADPOND AFFECT BOAT NAVIGATION?

Church (1995) has reported that post-Bennett Dam sediment deposition in the vicinity of Carcajou has resulted in the formation of mobile gravel bars which adversely affect the ability of small boats to navigate this section of Peace River. Historical air photographs documenting the post-Bennett Dam development of a diagonal bar in the channel downstream of Carcajou are presented in MMA, 2000b and a pre-and post-project comparison is shown on Figure 6.2.1 in MMA, 2000a. These photographs suggest that the Bennett Dam has caused a pre-existing diagonal bar to increase in size such that much of its’ surface is exposed during late-summer conditions.

As discussed in SECTION 5.1 of MMA, 2000a, coarse textured sediments (consisting of cobbles, pebbles and sands) are expected to deposit at the upstream end of the headpond and, over time, these materials will prograde downstream. Given the shallow depth of the headpond and the periodically high water velocities, it is expected that these deposits will form more or less well organized bar forms (see Church and Jones, 1982). The exact form or location of these structures cannot be reliably predicted. It is likely that the existing pattern of point and diagonal bars in the upstream end of the headpond will, at least initially, enlarge in more or less their present position. These structures could affect river navigation by locally restricting water depth. Given the small draft of recreational boats which presently use the river, this problem is not expected to be significant, except possibly under conditions of unusually low discharge. If necessary, buoys indicating the position of main channel could be installed to mitigate this impact.

4.2 COULD SEDIMENT DEPOSITION AFFECT WALLEYE SPAWNING HABITAT ON THE GRAVEL BAR AT KM 17?

The large diagonal bar at Km 17 is a unique feature in this section of river and RL&L Consultants Ltd. (Rick Pattenden, pers.comm.) found that this area is used for spawning by walleye. The sediment in this structure appears to have been derived from both upstream
bed material transport and from sediment being delivered by Hamelin Creek (see Figures 4.2.1 and 4.2.2 in MMA, 2000a). The bar at Km 17 is located within the mid- to upper portion of the headpond. Development of the Dunvegan Project is predicted to reduce water velocities in this area to 63 and 72% of their pre-project value for average flow conditions and the 2-year return period flood, respectively (see Table 5.1.4A in MMA, 2000a). Shear stresses will similarly decrease to approximately 2 N/m² for average flow conditions and 5 N/m² during the two-year flood (Table 5.1.5A in MMA, 2000a). As indicated by Figure 5.1.20 in MMA, 2000c, these shear stresses are capable of entraining uniform-sized sediments of 2.8 and 7 mm, respectively. The average sub-surface sediment size at this site is 13 mm (MMA, 2000a). The average surface size was not measured but it is likely to be in the range of 80 mm. This implies that the post-Project conditions will not be able to mobilize and clean the existing gravels except possibly during large flood flows. A decrease in grain size on this bar and an increase in the percentage of fines is therefore expected. It is, however, difficult to reliably predict the magnitude of this effect even if additional hydraulic information was available.

From a fisheries perspective, the gravel bars which deposit near the upstream end of the headpond are likely to consist of materials which may be similar to those which occur in the diagonal bar at Km 17. Specifically, there is the potential for a diagonal bar to form between the left bank point bar at Km 27 and the top of the right bank island located downstream of Fourth Creek at Km 25. It is expected that this structure would be periodically swept free or cleaned of finer sediments. The time for such a structure to form cannot be reliably calculated. However the data on UMA Section 26+000 (see APPENDIX 1 in MMA, 2000d) indicate the average channel depth is approximately 5 m (at the 50% exceedance flow) and the width is 250 m. Assuming the average annual bedload of 150,000 m³/yr was deposited over a distance of 5 km, then a diagonal bar or other bar forms could reach the river surface within approximately 10 years (even if some percentage of the bedload was deposited over a wider area). Upstream bar development therefore has the potential to replace the comparatively clean gravel deposits which will be submerged in the vicinity of Km 17.

4.3 COULD BANK EROSION ELEVATE SUSPENDED SEDIMENT CONCENTRATIONS?

The report by MMA, 2000a indicates that the Dunvegan Project will inundate over 32 ha of river bank which is above the elevation of commonly occurring pre-Bennett Dam discharges. Current or wave action therefore has the potential to increase the present rates of suspended sediment production if these inundated materials are erosion susceptible. Similarly, the report by AGRA Earth and Environmental Ltd. (AGRA, 2000) indicates that the proposed headpond could locally increase rates of sediment production from the valley
walls. The potential magnitude of both of these effects is difficult to predict reliably. Given the limited extent of valley flat areas and the generally bedrock confined character of the proposed headpond area, it is expected that the actual increase in sediment production will not be dramatic and could be difficult to detect, given the very large suspended sediment loads which are being naturally transported by Peace River during the open water season. What therefore needs to be determined is whether the Dunvegan Project will affect suspended sediment concentrations in the winter when background levels are comparatively low.

As discussed in section 3.2.2 of MMA, 2000a, elevated rates of suspended sediment production typically occur during the spring and summer. Studies by Trillium Engineering Inc. (2000) indicate that the Dunvegan Project will result in an earlier ice cover within the Dunvegan headpond in comparison to present conditions and will reduce the potential for ice jams to disturb the channel banks. Post-project channel shifting on tributary streams (see discussion in section 5.2.3 of MMA, 2000a) is also expected to follow the annual discharge hydrograph and the timing of sediment production is therefore not expected to be significantly affected. These factors suggest that sediment production from within the headpond is likely to follow the pre-disturbance seasonal regime.

4.4 COULD SEDIMENT PRODUCTION FOLLOWING PROJECT DECOMMISSIONING IMPACT DOWNSTREAM CHANNEL STABILITY AND FISH HABITAT?

We have been asked to consider what would occur if the Dunvegan Weir was removed 100 years after construction. At that time the downstream channel should have more or less reached an equilibrium with both the post-Bennett discharge regime and the reduction in coarse textured sediment load which would occur as a result of the Dunvegan Project. The channel would therefore be narrower than at present, many side- or backchannel areas would likely be abandoned and mature vegetation would have established on the pre-Bennett channel banks. These changes would be due principally to regulation by Bennett Dam, rather than the Dunvegan Project.

Removal of the Dunvegan Weir would increase water velocities through the former headpond, allow the mobilization of deposited sediments and result in river bed degradation within the headpond and aggradation in the downstream channel. This process would be expected to increase suspended sediment concentrations and loads until such time as an erosion resistant surface formed within the headpond and sediment delivered to the downstream channel was either moved onto the flood plain or carried into other depositional areas. Elevated rates of sediment transport would be expected to increase the percentage of fine-textured materials on or within the downstream river bed. The maximum
increases in suspended sediment concentrations would likely occur in the first few years after deactivation and occur over the longer term in association with large flood events.

Sediment deposition within the channel downstream of the structure could result in lateral channel instability in areas with low-lying alluvial channel banks. The magnitude of the predicted morphological changes would generally decrease with distance downstream of the former Project site, except that comparatively low gradient sections of river channel could act as preferred areas for sediment deposition.

It is difficult to reliably predict the time scale over which a new equilibrium channel would become established following weir removal. Experience from Bennett Dam suggests that 43% of the predicted reduction in river width has occurred in approximately 30 years (see SECTION 4.2.2 in MMA, 2000a). Erosion of material entrained from the former Dunvegan headpond is expected to occur more rapidly than the post-Bennett adjustments in river width as sediment availability and rates of vegetation growth are controlling the present rate of channel narrowing. If this hypothesis is correct, over half of the effect of dam removal within or adjacent to the headpond might occur within the first 10 to 20 years following deactivation. [The speed could be increased if a number of large floods occurred soon after deactivation; similarly the rate could be retarded if no large flood flows occurred.] Morphologic changes in the downstream channel would generally be delayed with distance downstream of the former dam site. It is presently expected that most post-decommissioning channel changes would be complete within 30 to 50 years. It would, however, be desirable to locate similar case studies to verify these conclusions.

4.5 COULD POST-DUNVEGAN CHANNEL ADJUSTMENTS AFFECT THE STABILITY OF THE DUNVEGAN BRIDGE

The design of the Dunvegan Highway Bridge, which was opened in 1960, is described in reports by McCune (1960) and Lamb and McMamus (1960). This information indicates that the southern of the two in-channel piers is founded on a spread footing keyed 5 m into shale bedrock and 12 m below the stream bed. The north pier is founded in a concrete caisson sunk 21 m below the stream bed. A schematic cross-section is attached as Figure 4.5.1.

At least two surveys have been undertaken to assess the effect of local scour on the Dunvegan Bridge piers (Alberta Department of Highways, 1964 and Hydroconsult, 1996). The 1996 surveys indicate that minimum depths of cover were 8 m and 18 m for the south and north piers, respectively. The Hydroconsult report concludes that the "sustained high discharges through the 1996 summer season have not resulted in significant scour at piers" and that there are "no bed scour or river engineering concerns".
In a review of the Alberta Hydro Committee Project at Dunvegan, previously studied in 1975, G.M. Mazurek (1980), Chief Bridge Planning Engineer, Alberta Transportation and Utilities expressed concern that "channel degradation and resulting bank erosion could adversely affect the stability of the anchors for the suspension bridge".

The information presented in Sections 4.2.3 and 4.2.4 of MMA, 2000a suggests that enlargement of the Hines Creek fan is resulting in a narrower and deeper river cross section at the bridge site. This indicates that, at least within this confined section, the post-Bennett flood regime is capable of periodically mobilizing the layer of cobbles which armour the river bed. The documented trend towards a narrower, deeper river may be resulting in the apparent decrease in the depth of cover on the north pier from 21 m (design) to 18 m (1996 survey) and 12 m (design) to 8 m (survey) on the south bank. Given the trend in channel bed elevation, it would be desirable to determine what effect a further reduction of 2 to possibly 5 m in cover might have on the stability of the foundations, regardless of whether the Dunvegan Project proceeds.

The Dunvegan Project has the potential to exacerbate the potential for downcutting as much or all of the upstream coarse textured sediment supply will be cut off by the proposed headpond. However, as discussed in Section 5.3.1 of MMA, 2000a, the actual amount of incision which might occur is difficult to predict. The potential magnitude of this effect will depend on the stability of the armour layer which protects the channel bed and by land use decisions which affect the amount of sediment being supplied from Hines and Dunvegan Creeks. If the foundation study recommended above indicates that further channel downcutting or local scour could be a problem, then it would be desirable to ensure appropriate remedial measures were undertaken prior to proceeding with the Dunvegan Project.

The comments by Mazurek (1980) suggest that the stability of the bridge suspension anchors could be adversely affected by future channel shifting. The anchors were not inspected as part of the present study. The design specifications discussed in McCune (1960) and Lamb and McMamus (1960) indicates that the north and south anchors are set back approximately 30 and 75 m, respectively from the channel edge. The north bank is located in an area of sediment deposition and future bank erosion is not presently expected to be an issue. The south bank is located within an old slide deposit. This area is potentially more susceptible to bank erosion as a result of progradation of the Hines Creek fan. It would therefore be desirable to undertake a geotechnical and hydrotechnical assessment to determine what effect future bank erosion could have on this site. Given the documented trend in river bed elevations at the base of this slope, it might be prudent for Alberta Infrastructure to undertake this work.
4.6 Could Post-Dunvegan Channel Adjustments Affect the Fairview Water Supply Intake

The town of Fairview obtains their water supply from Peace River at a site 16 km downstream of the proposed Dunvegan Project site. As illustrated on Figure 4.2.6 of MMA, 2000a, the intake is located in a deep scour hole on the outside of a bend. This site is unlikely to be affected by post-Bennett Dam sediment deposition or scour. Similarly, the Dunvegan Project is unlikely to cause significant changes in channel morphometry in this area. There is a potential for small amounts of additional scour to occur due to the reduction in upstream sediment supply. However, this effect is unlikely to affect the stability of the intake as it should have been designed to withstand the effects of large flood flows. These preliminary impressions should be confirmed by an on-site field inspection, a review of the ‘as-built’ drawings and possibly through the collection of local bathymetric soundings to document present conditions and determine the location of the intake in relation to the existing river bed.

5: Structural Failure

5.1 Could Failure of the Control Weir or a Breach in the Dunvegan Structure Affect Downstream Channel Morphology

A structural failure of the Dunvegan Weir is predicted to produce a flood level having a maximum crest height of 3 m at Dunvegan and this would be reduced to less than 1 m at the town of Peace River. Failure of the rubber weir would release a much smaller flood wave which would decrease in height from 1 m at the structure to less than 0.3 m at the town of Peace River (information from project description).

If these failures occurred at low or intermediate flows, the resulting flood waves would be more or less confined within the pre-Bennett Dam high water levels. Removal of bank vegetation, scouring of post-Bennett sediment deposits and other localized effects would undoubtedly occur. However, the underlying channel structure necessary to transport similar sized floods would still be in place.

The hydrologic analyses undertaken by UMA (2000) indicates that the post-Bennett Dam flood flows are 82% of the natural values for a return period of 100 years and flood magnitudes are of equivalent size for a 1 in 500 year event (see Table 3.1.1 in MMA, 2000a). Structural failure is most likely to occur during an extreme event. In this
circumstance, the resulting flood discharge would exceed those which occurred prior to Bennett Dam for the same return interval flood. This would undoubtedly result in the substantial erosion of post-Bennett sediment deposits, removal of post-Bennett riparian vegetation, bank erosion in susceptible materials, reconfiguration of fans at stream confluences, reactivation of side channels, etc. These types of events would be expected to occur during any exceptional flood and the incremental impact of a failure of the Dunvegan Project might be difficult to quantify in a reliable manner.

6: CERTIFICATION

This report was prepared by:

Sandy Gibbins, B.Sc.,

Elizabeth Goldsworthy, B.Sc.

Mike Miles, M.Sc., P.Geo.

May 24, 2000
7: SOURCES OF INFORMATION

7.1 REFERENCES


7.2 **PERSONAL COMMUNICATIONS**

Rick Pattenden  
RL&L Environmental Services Ltd.  
Edmonton, Alberta