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25 May 2005

Executive Director
Infrastructure and Operations Division
Manitoba Water Stewardship
200 Saulteaux Crescent
Winnipeg, Manitoba
R3J 3W3

ATTENTION: Mr. Steven Topping, P.Eng.

Re: Review of Manitoba Hydro's SPLASH Model

Dear Mr. Topping:

This report summarizes my review of Manitoba Hydro's Simulation Program for Long-term Analysis of System Hydraulics (SPLASH) model and its suitability for predicting the impact on water levels associated with the construction and operation of a new hydro-electric generating station (*viz.*, Wuskwatim).

The following information was reviewed in the preparation of this report:

- a document entitled "Utilization of the SPLASH Computer Simulation Model to Represent Water Regime in the Manitoba Hydro System," which was provided by Manitoba Water Stewardship; and
- a (Powerpoint) presentation of the SPLASH model that was given by Manitoba Hydro (on 3 May 2005) and the subsequent discussion during said presentation.

1. SPLASH Model Overview

Manitoba Hydro has a mandate to produce power. It currently has an installed hydro-electric capacity of approximately 5000 MW. An additional 4800 MW of hydro-electric capacity is available for future development. In addition, Manitoba Hydro has 470 MW of installed thermal capacity and a future target of 250 MW of wind generating capacity.

Manitoba Hydro's ability to meet power demand depends on hydrologic conditions, existing water regimes, and limitations imposed by licences and agreements. The SPLASH model is used to simulate the operation and future expansion of Manitoba Hydro's hydro-electric system under a range of "what-if" scenarios. The model uses mathematical expressions and relationships to represent the physical properties of a very complex system. The simulation of the system uses the following inputs: energy requirements (domestic and export), energy supply resources (hydro, thermal, wind, import, other), transmission losses, and opportunity market. Linear programming is used to optimize the multi-objective function.

The model has been verified using a hindcasting process; the model is given historic data and the known system configuration, and run to hindcast historic (known) water levels. A location downstream of the outlet of Lake Winnipeg (*i.e.*, on Cross-Lake) was used to verify the integrity of the model. The hindcasting comparison showed that the model provides relatively accurate predictions of absolute (as apposed to relative) water results.

2. Opinion

In my opinion the SPLASH model does a good job of doing what it was designed to do, *i.e.*, simulate the long-term operation of a complex system of (predominantly hydro-) electric generation within an imposed set of constraints. I am not aware of a better decision support system software package.

The SPLASH model represents many years of development by Manitoba Hydro. It is an impressive package! The model has been calibrated and verified. While there are improvements that could be incorporated in to the model (see below), it appears to do a good job of predicting **absolute** water levels; the hindcasting process has confirmed this. More importantly, to assess the impact of a new hydro-electric station the model need only assess the **incremental** impact. I believe the model can do this accurately.

3. Potential Improvements

The extent to which the potential improvements noted below would improve the absolute accuracy of the predictions from the model is not clear *a priori*. Nonetheless, addressing and understanding these shortcomings should lead to an improved model.

- The effects of climate change are not incorporated into the model. The model uses hydrologic flow data from 1912 to 1997. Yet it is known that the period 1900 to 1950 yielded smaller discharges for the Red River than the period 1951-2000; *i.e.*, the latter half of the 1900's was wetter. Adjusting hydrologic data for the (small) changes attributed to climate change might improve the accuracy and reliability of model predictions for future "what-if" scenarios.

- The model does not include the seasonal variability of the price of the import/export market. Including this effect should lead to a small change in the optimized solution.
- The effects of routing (attenuation and timing) are not included in the model. The effects of routing would lead to a slight attenuation in peak discharge and small time delay from reservoir to reservoir.
- The model uses a monthly time step. A finer time step would improve the resolution of the model.

4. Conclusions

In spite of the potential improvements, which I have noted above, **I believe that the SPLASH model can accurately predict incremental water regime impacts on Cross Lake arising from the addition of the proposed Wuskwatim generating station to the existing power system**. It is not surprising that the model predicts a small effect on Cross Lake given that Wuskwatim is a small addition to the installed system capacity.

If you would like any additional comment or clarification of this review and opinion, please do not hesitate to contact the undersigned.

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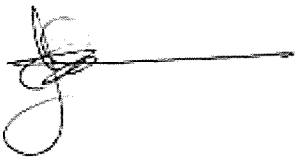

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