Fisheries and Oceans Canada | Pêches et Océans Canada

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FEB 2 1 2011

Ms. Lesley Griffiths / Mr. Herbert Clarke
Co-Chairs – Joint Panel Review
Lower Churchill Joint Review Panel Secretariat
33 Pippy Place
PO Box 8700
St. John's NL A1B 5J6

Dear Ms. Griffiths and Mr. Clarke:

Subject: Lower Churchill Hydroelectric Generation Project – Department of Fisheries and Oceans submission to the Joint Review Panel

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Department of Fisheries and Oceans is pleased to provide the attached written submission summarizing Departmental views on the Environmental Impact Statement and related recommendations to the Joint Review Panel.

Copies of the Department of Fisheries and Oceans presentation material to be delivered at hearing sessions will follow in accordance with the timelines in the public notice of January 24, 2011.

Should you have any questions, please do not hesitate to contact Jason Kelly at (709) 772-8889 or jason.kelly@dfo-mpo.gc.ca.

Yours truly,

<original signed by>

James W. Baird
Regional Director General
Newfoundland and Labrador Region

cc R. D. Finn, Regional Director – Oceans, Habitat & Species at Risk
L. King, Area Director - Central & Labrador

Canada

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NEWFOUNDLAND AND LABRADOR DEPARTMENT OF ENVIRONMENT AND CONSERVATION
CANADIAN ENVIRONMENTAL ASSESSMENT AGENCY
JOINT PANEL REVIEW

APPLICATION OF NALCOR FOR THE LOWER CHURCHILL HYDROELECTRIC GENERATION PROJECT

Submission of

FISHERIES AND OCEANS CANADA (DFO)

Date of Submission

FEB 2 1 2011

Canada

Executive Summary

Nalcor Energy (a crown corporation of the government of the Province of Newfoundland and Labrador, Canada) is proposing to build hydroelectric generating facilities at Muskrat Falls and Gull Rapids on the Lower Churchill River in Labrador. Fisheries and Oceans Canada (DFO) is the federal government department responsible for managing coastal and inland fisheries in Canada, including the effects of development on fish and fish habitat. The Lower Churchill Hydroelectric Generating Project (the Project) would cause impacts to fish habitat that would require authorization by DFO under the habitat protection provisions of the *Fisheries Act*. DFO is thus a Responsible Authority for the environmental assessment of the project under the *Canadian Environmental Assessment Act*.

This document presents an assessment by DFO of the environmental effects of the Project as predicted in the Environmental Impact Statement (EIS) and related submissions by Nalcor Energy to the Joint Review Panel carrying out the federal-provincial environmental assessment of the project. It also presents recommendations by DFO on mitigating environmental effects related to the mandate of DFO.

- DFO generally concurs with the description of environmental effects that would arise during the construction of the Project. DFO recommends, among other things, preparations to address more significant effects than predicted that may arise in connection with reductions in flows downstream of dams during reservoir filling.

- DFO generally concurs also with the description of long-term effects that the Project would have on the aquatic environment, particularly changes to the fish habitat in the areas to be flooded, and the effects of the generating facilities on fish. DFO identifies some uncertainties about the predictions of how soon the reservoirs would stabilize and how fish populations will adapt to these changes. Significant DFO recommendations in relation to these changes include the collection of more pre-inundation baseline data on fish and fish habitat, and the preparation of a fish habitat compensation plan providing necessary details on monitoring and adaptive management.

- DFO expresses some uncertainty about the predictions of the extent of downstream effects of the Project on fish and fish habitat. DFO recommends the collection of additional baseline data, as well as post-project monitoring in areas downstream of the Project, including Lake Melville.

- DFO generally concurs with the predictions about bioaccumulation of mercury in fish. DFO recommends additional monitoring to detect and mitigate possible impacts of this effect from the Project further downstream than currently predicted.

- DFO generally concurs with the predictions made about the effect of the Project on fisheries in the area, and outlines means by which these effects could be mitigated.

- DFO generally concurs with the predictions relating to the management of cumulative effects of the Project, but recommends that cumulative effects be described more comprehensively, particularly in relation to the Upper Churchill hydroelectric project.

- DFO generally concurs with predictions made in relation to differences in impacts predicted for different sequences and timings for construction of components of the Project.

DFO recommendations to the Joint Review Panel are summarized at the end of the document.

1.0 INTRODUCTION

1.1 Background

In January 2009, a Joint Review Panel (JRP) was appointed by Canada's Minister of the Environment and Newfoundland and Labrador's Minister of Environment and Conservation to conduct the environmental assessment (EA) of the proposed Lower Churchill Hydroelectric Generation Project (the Project, CEAR reference number 07-03-26178) according to the *Canadian Environmental Assessment Act* (CEAA) and the *Newfoundland and Labrador Environmental Assessment Act* (NEAA). .

Fisheries and Oceans Canada (DFO) is a department of the federal government which possesses expertise relevant to the Project, and which would be required to issue formal authorization(s) under the *Fisheries Act* for aspects of the Project should it proceed. These authorizations are included as "triggers" under the CEAA *Law List Regulations*. As a result, DFO is a "responsible authority" as set out in the *CEAA,* and must carry out, or participate in, the federal environmental assessment of the Project.

This submission contains DFO observations and comments on the potential environmental effects resulting from the development of the Lower Churchill Hydroelectric Generation Project and the proposed mitigation measures, following a Department-wide review. DFO comments are limited to those matters within the Department's jurisdiction.

DFO considered the following information:

- The Proponents' Environmental Impact Statement (EIS) and supporting documents;
- The Proponents' response to Information Requests (IRs) from DFO and other parties; and
- Meetings on technical issues carried out with the Proponent to clarify existing information and methodologies.

1.2 DFO Mandate

Section 91(12) of the *Constitution Act, 1867* provides the federal government with exclusive authority over sea coast and inland fisheries within Canada's territorial boundaries. This authority is administered by the Minister of Fisheries and Oceans through the *Fisheries Act.* DFO is responsible, on behalf of the

Government of Canada, for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in relation to sea coast and inland fisheries, and oceans in general. DFO is mandated to ensure the sustainable development and integrated management of resources in and around Canada's aquatic environment through programs focusing on the management of oceans, fish habitat and aquatic species at risk.

DFO exercises this authority through, among other things, administration of the *Fisheries Act,* the *Oceans Act* and the *Species at Risk Act (see Appendix A).* Under the *Fisheries Act,* DFO is responsible for the management, protection and conservation of fish (including marine mammals) and their habitats. The *Oceans Act* provides the Minister with authority over oceans management and coast guard and hydrographic services. The Minister of Fisheries and Oceans is designated as a 'competent Minister' for aquatic species under the *Species at Risk Act* (SARA) which is intended to prevent wildlife species from becoming extirpated or becoming extinct, to provide for the recovery of endangered or threatened species, and to encourage the management of species of special concern to prevent them from becoming at risk.

DFO is a national and international leader in marine safety and the management of oceans and freshwater resources.

Departmental activities and presence on Canadian waters help to ensure the safe movement of people and goods.

DFO is committed to sustainable development and integrates environment, economic and social perspectives into decision making to ensure Canada's oceans and freshwater resources benefit this generation and those to come.

When reviewing proposed developments in and around Canadian fishery waters, DFO ensures that the works and undertakings are conducted in compliance with the habitat protection provisions of the *Fisheries Act.* In particular, section 35 of the *Fisheries Act* is a provision which often applies to resource developments in Canada. Subsection 35(2) prohibits the harmful alteration, disruption or destruction (HADD) of fish habitat without an authorization from the Minister of Fisheries and Oceans or through a regulation made by the Governor-in-Council under the *Fisheries Act*.

Section 32 prohibits the destruction of fish by means other than fishing without an authorization from the Minister of Fisheries and Oceans or through a regulation made by the Governor-in-Council under the Act. Decisions under s.32 and s.35(2) of the *Fisheries Act* will not be made until after the Panel's written recommendations on the Project have been reviewed and responded to by the Governor in Council.

In reviewing proposed developments, DFO is guided by its 1986 *Policy for the Management of Fish Habitat* (the "Habitat Policy", see Appendix B) which provides general guidance on the application of the habitat protection provisions of the *Fisheries Act*. The overall objective of the Habitat Policy is to achieve a net gain in the productive capacity of fish habitat for Canadian fisheries resources. The Department applies a guiding principle of "no net loss of productive capacity in existing habitats" on a project-by-project basis. DFO works to achieve this principle by working with Proponents and other agencies to avoid and mitigate impacts to fish and fish habitat. Unavoidable harmful impacts to fish habitat (which require authorization) are balanced through fish habitat compensation.

2.0 DFO ASSESESSMENT OF PREDICTED ENVIRONMENTAL IMPACTS

2.1 Impacts During Project Construction

2.1.1 Effects From Increased Shipping

(EIS Guidelines: 4.3.4 (c)(i & iv))

***EIS Prediction*:**

In the EIS, the Proponent states that Labrador relies heavily on marine services for passenger transportation and shipment of goods. A majority of the freight leaving the island portion of the Province for Labrador is destined for or is distributed via the Goose Bay port, with the shipping season being between June and November. The Project will require approximately 386,000 tonnes of bulk material, with the majority being transported via the port in Goose Bay; however the final determination of shipping route will be made by suppliers of these materials. The port of Goose Bay is located on the western end of Lake Melville and consists of two industrial docks (one being operational). The operating dock is west-southwest in Terrington Narrows and consists of a marginal wharf, storage sheds, asphalt and fuel tanks, a transshipment warehouse and an area of laydown space. During the peak year of construction, the Proponent anticipates that a maximum of 12 ships will require berthing space in the Goose Bay port, with an average of one ship every two weeks. The operational phase of the Project will not have a large requirement for dock facilities. The Proponent does not anticipate constructing any permanent or temporary infrastructure to allow for shipping into the Goose Bay port and plans on using the existing dock facilities. The port as designed can meet Project requirements, however because of its age the Proponent will conduct assessments (diving inspection and structural analysis) to determine whether repairs or upgrades will be required. The Proponent does not anticipate requiring winter shipping for the construction or operation phases of the project.

***DFO Analysis and Assessment*:**

DFO - Canadian Coast Guard (CCG) acknowledges the Proponent's prediction of a maximum of 12 ships, with an average of one ship every two weeks, with the shipping season between June and November. However, given the unpredictability of the Labrador shipping season, uncertainty exists about the Proponent's ability to ensure no winter shipping. A requirement for shipping during the winter season would have an impact on Canadian Coast Guard vessel resources with respect to ice-breaking and in maintaining Aids to Navigation reliability targets. In addition, depending on the time of year, ice breaking could have impacts on local seal populations, ashkuis, and human activities along the shipping route. However given that the Proponent does not anticipate a requirement for winter shipping for the project, the environmental impacts of this activity were not assessed by DFO at this time.

The Department is satisfied with the Proponent's approach to use the existing dock facilities at the Goose Bay port and not construct any temporary or permanent infrastructure.

The Proponent does not indicate whether small craft will be used on the river during the construction and operation phases of the project. The Proponent has not addressed its capacity to respond to environmental spills into the river from boats or barges.

DFO Recommendations:

DFO recommends that in the event that a requirement for shipping during the winter season should arise, the Proponent undertake an assessment of the impacts of this activity and related mitigation measures for review by DFO, and contact DFO as early as possible to discuss ice-breaking service requirements and ice routing advice.

DFO recommends that the Proponent incorporate scenarios for addressing accidents and/or spills involving small craft on the river into the construction, operation and maintenance Environmental Protection Plans (EPPs). In the event of a spill in the marine or freshwater environment the Proponent is advised to contact the Canadian Coast Guard immediately at 1-800-563-9089.

2.1.2 Fish Habitat Protection and Monitoring During Construction

(EIS Guidelines: 4.6.4)

EIS Predictions:

The Proponent has committed to implementing various measures to protect fish habitat during construction from negative impacts associated with sediment/ erosion control, blasting, fuel and chemical storage and containment and watercourse crossings. The Proponent has committed to monitor and report on compliance with these requirements as required by the appropriate regulatory authorities including DFO, and has provided a list of the proposed monitoring programs for the Project. The Proponent has provided information on the frequency duration, geographic extent and reporting of monitoring to the extent that specific information regarding monitoring requirements is available. The Proponent has recognized that regulatory authorities such as DFO may conduct inspections for compliance with various regulatory measures, and has committed to ensuring compliance with these measures, and documenting and reporting on them as required.

DFO Analysis and Assessment:

Environmental monitoring and follow-up programs for construction, operation and maintenance activities are important for verifying the accuracy of the predictions relating to fish and fish habitat made during the environmental assessment and for confirming the effectiveness of fish habitat protection measures. While information on monitoring and follow-up programs for the operations and maintenance activities has been provided, more detailed information is needed on mitigation methods and contingency measures to be used to protect fish and fish habitat during construction, and related monitoring and reporting. These would include site-specific measures to be implemented for sediment/erosion control, site stabilization, site clearing, blasting, fuel and chemical storage and containment, watercourse crossings and maintenance of fish passage. These mitigation methods and contingency measures are normally outlined in a project-specific Environmental Protection Plan (EPP).

DFO Recommendations:

The Proponent should develop an Environmental Protection Plan (EPP) that outlines the mitigations and contingency plans for all aspects of the construction activities. This EPP should be provided to the appropriate regulatory agencies, including DFO, for review and approval prior to start of project activities. The EPP should incorporate a monitoring schedule that includes monthly and annual reporting on the effectiveness of the mitigations and contingency plans to DFO and other regulatory agencies throughout construction.

2.1.3 Reservoir Preparation

(EIS Guidelines: 4.3.4(a), 4.4.3.2.2(a))

EIS Predictions:

Prior to flooding the reservoirs, the Proponent proposes to clear all vegetation within a zone from 3 m above full supply level (to a maximum of 15 m horizontally from the predicted new shoreline) to 3 m below low supply level. The Proponent has committed to leaving intact vegetated buffers of at least 15 m width in place along streams, tributaries and the main stem.

DFO Analysis and Assessment:

DFO supports the removal of all vegetation in reservoir footprints and 3m above full supply level (with the exception of buffer zones described) prior to impoundment in order to lessen the extent of mercury release into the reservoirs and also to expedite the development of substrates suitable for use by fish in nearshore areas.

DFO also strongly supports the maintenance of vegetated buffers around the existing streams and tributaries and along the main stem within the reservoir clearing zone. These buffers provide shade and help moderate water quality, temperature and levels. Given that reservoir preparation may take up to 9 years, some cleared areas could be left exposed to erosion and run off events for extensive periods of time. These buffer zones would protect against degradation of important fish habitats prior to reservoir impoundment. It should be noted that buffer zones normally recommended by DFO would be 20 m + 1.5 times the slope in percent where slope exceeds 30%, as opposed to the 15 m proposed by the Proponent.

DFO Recommendations:

In order to protect fish and fish habitat in tributaries and the main stem in the reservoir areas in the period of time between the start of reservoir clearing and reservoir impoundment, DFO recommends that the Proponent adhere to the buffer zones and other mitigations outlined recommended in the *"Forestry Guidelines for the Protection of Fish Habitat in Newfoundland and Labrador"* during reservoir clearing operations.

2.1.4 Reservoir Filling

(EIS Guidelines: 2.5, 4.3.2.2(g), 4.3.4(b), 4.3.5(a), 4.5)

EIS Predictions

The Proponent proposes to flood the reservoirs by reducing flows at the Muskrat Falls and Gull Island dams to 30% of the mean annual flow. The Proponent proposes to carry out this step in August-September for the Muskrat Falls reservoir and in August-October for the Gull Island Reservoir, and describes related impacts on fish. Depending on actual flows at the time of impoundment, this will result in the Muskrat Falls reservoir filling in 16-17 days and the Gull Island reservoir filling in 48-54 days. The Proponent states that provision of 30% of mean annual flows would provide adequate water flows and levels downstream of the dams to allow fish movement, and provide areas for fish to temporarily seek refuge. There is some risk of harm to eggs laid by fall spawners if flow reductions occur after mid-September.

During the filling of the reservoirs, reduced flows in the Churchill River downstream into Lake Melville could lead to intrusion of saltwater from Lake Melville into the lower reaches of the river. This could have significant effects on fish, including causing mortality. Based on modeling, the Proponent predicts the greatest extent of saltwater intrusion to be 3 km upstream from the mouth or approximately 2 km upriver from Mud Lake. The Proponent suggests that this saltwater intrusion during reservoir filling would be within the normal ranges of natural variation.

DFO Analysis and Assessment

Impacts of reduced flows below dams on fish

The Proponent has provided maps depicting available habitat remaining downstream based on modeling the reduced flows during reservoir filling. These maps show no significant areas of stranding where fish would be trapped. However the maps are at a very coarse scale (1:250,000), and are based on very few bathymetric transects (19 between Gull Island and Muskrat Falls and 7 below Muskrat Falls) in the affected area. The assessment required significant interpolation regarding riverbed geometry between these transects which might not reflect actual constriction in fish habitat (both horizontally and vertically). It is possible that finer scale maps or more frequent bathymetric transects would show more significant areas of discontinuity at low flows. Stranding and concentration of fish in these disconnected areas during reservoir filling could cause stress and mortality due to crowding, competition for food and predation. The Proponent has also calculated minimum flows during impoundment using

Tennant's Method[1], which provides only a rudimentary indication of the extent of dewatering of fish habitat as compared to incremental methods such as the Physical Habitat Simulation (PHABSIM) method which would be more applicable to a river as complex and large as the Churchill River. This introduces further uncertainty about the impacts that reduced flows during reservoir impoundment may have on life stages of various fish species.

Taking into consideration the impacts that reduced flows downstream of dams could have on spawning and eggs of fish species that spawn in the spring and those that spawn in the fall, it appears that reduced flow during reservoir impoundment would have the least negative overall impact on fish if it were to occur from mid-July to mid-September. However the predicted impacts associated with different proposed times for reservoir impoundment are based largely on literature information on fish spawning, incubation, and hatching rather than on observations or studies of fish in the Churchill River. There is thus some uncertainty about the accuracy of these predictions.

Salt water intrusion

Although the modeling appears to indicate little impact from saltwater intrusion, there is some uncertainty about the accuracy of input values used by the proponent for the salinity of Lower Churchill River water. The modeling used an input value for the salinity of water in the Churchill River of 2-3 Practical Salinity Units (PSU), which is slightly brackish. This value came from a hydrology study in the Goose Bay estuary in 1998-1999. It differs from data from several other sources[2] covering this entire area and the entire year, which report the salinity of the water in the Lower Churchill to be below 0.015 PSU (typical of most fresh waters in Labrador and Newfoundland).

In response to previous comments by DFO on this issue, the Proponent has stated that "*…the defined extent of the intrusion (2 or more units above baseline condition) is seen to be similar whether the simulated river salinity is 0 or 2 PSU*". It is unclear whether the modeling has been re-run to support this statement.

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[1] Tennant, D. L., 1976. Instream flow regimens for fish, wildlife, recreation and related environmental resources. *Fisheries* **1**(4):6-10.
[2] Ryan, P.M. 1980. Fishes of the Lower Churchill River, Labrador. Fisheries and Marine Service Technical Report No. 922.

JWEL 1999. 1998 Water and Sediment Quality of the Churchill River. Prepared for Newfoundland and Labrador Hydro *by* Jacques Whitford Environmental Ltd., St. John's, NL.

Minaskuat Limited Partnership. 2007. Water and Sediment Quality in the Churchill River, Environmental Baseline Report (LHP 06-04). Prepared for Newfoundland and Labrador Hydro Report No. MIN0271

DFO Recommendations:

The Proponent should carry out reservoir impoundment during mid-July to mid-September so as to minimize the impacts of reduced flows on fish spawning and the survival of eggs and juvenile fish in areas downstream of the dams. The understanding of potential impacts on spawning, eggs and hatchlings should be improved by data collection (prior to any project construction) on the spawning, incubation, hatching and emergence of fish in the Lower Churchill River system to supplement information from the scientific literature currently considered. Collection of this information is also recommended in association with the issue of changes in fish habitat availability in Section 2.2.1.3.

The Proponent should develop and implement plans to identify and, if necessary, relocate fish stranded in areas downstream of reservoirs while flows are reduced during impoundment. This plan should be reviewed and endorsed by DFO prior to implementation. In addition, the Proponent should request a Section 32 authorization from DFO for any incidental mortalities of fish during impoundment.

In order to confirm that predictions about the extent of saltwater intrusion are accurate, the Proponent should re-run the saltwater intrusion modeling using salinity values for Lower Churchill River waters from available studies.

2.2 Changes to Aquatic Environment From Project

2.2.1 Changes within the Reservoir Footprint Areas

2.2.1.1 Reservoir Attributes

(EIS Guidelines: 4.4.4, 4.4.5(e), 4.4.5(f))

EIS Predictions:

The Proponent has made predictions about physical and biological conditions after stabilization in the Gull Island and Muskrat Falls reservoirs based on comparisons with sections of the existing Lower Churchill River (primarily Lake Winokapau), as well as comparisons with reservoirs associated with other hydroelectric projects.

Lake Winokapau is a long, narrow, deep, steep-sided lake located on the main stem of the Lower Churchill River above Gull Island Rapids. Since the reservoirs will be characterized by water velocities and habitat types similar to those in Lake Winokapau, the Proponent has based many predictions regarding conditions in the future Gull Island reservoir on present conditions in Lake Winokapau. For example, the Proponent predicts that thermoclines are not likely to occur in either of the reservoirs due to the high flushing rate. The proponent states that adequate information has been collected on existing baseline conditions in Lake Winokapau to allow such predictions to be accurate.

The Proponent has also used observations of conditions in the Robert Bourassa Reservoir on the La Grande River in Quebec and the Smallwood Reservoir on the Upper Churchill River to support predictions of long-term conditions in the reservoirs and as a benchmark for time to reservoir stabilization.

Based on all of these comparisons and analyses, the Proponent predicts that the reservoirs will feature physical conditions that support primary biological production, secondary production, and will sustain healthy fish populations.

DFO Analysis and Assessment:

Lake Winokapau

Given the anticipated physical similarity of the future reservoirs to the current Lake Winokapau, it is reasonable to make predictions about conditions in future reservoirs based on current conditions in Lake Winokapau. However this requires that current conditions in Lake Winokapau are thoroughly sampled and well understood. For the reasons outlined below DFO believes that additional baseline information about Lake Winokapau is required in order to support the predictions made based on the conditions in the lake.

Water quality: Relatively small changes in water quality parameters (temperature, total dissolved solids, turbidity and velocity) could have major effects on the health and survivability of the various fish species. Sampling of water in Lake Winokapau to measure parameters such as temperature, turbidity, conductivity, dissolved oxygen, pH, and water clarity was carried out only twice (in 1998 and 2006-2007). The sampling program from these two study periods differed significantly. The 1998 study provided monthly samples from July to October at eight stations throughout the lake, each with several depth intervals. The 2006-2007 study collected monthly samples over a whole year (with weekly samples during May) but from only one station with one sampling depth, This level of sampling is not adequate to describe the temporal and spatial variability in water quality parameters in the lake, and related physical conditions such as the existence and nature of thermoclines.

Primary production and plankton: Phytoplankton and zooplankton form the base of the food web that supports fish populations. The 1998 study conducted to investigate primary production and phytoplankton and zooplankton biomass involved several lakes/reservoirs in the Upper Churchill in addition to Lake Winokapau and Gull Lake in the Lower Churchill River. Sampling for phytoplankton was conducted monthly during July-September, whereas in the previous Upper Churchill studies in the 1970s, sampling progressed from biweekly to weekly, started earlier and ended later, spanning most of the open-water period. Based on the results of the earlier studies, the seasonal schedule followed in the 1998 study could have missed major peaks in phytoplankton production, which introduces unacceptable uncertainty.

Unlike the lakes in the Upper Churchill, Lake Winokapau has a high flushing rate, which can have a marked effect on phytoplankton and zooplankton production and species composition, so direct comparisons are not appropriate. Additionally, sampling in Lake Winokapau was limited to a single station and only the upper 5-10 m of the water column was sampled. The literature strongly shows that a single station is not sufficient to account for horizontal heterogeneity for both phytoplankton and zooplankton populations, particularly in large lakes. As for depth, numerous studies have shown significant zooplankton populations occur in deep water, and have demonstrated that sampling only the upper water column can result in an underestimation of production and abundance due to such factors as diel vertical migration (DVM). The 1998 study provides data for only a single year with extremely limited seasonal coverage, and is of little value for assessing the extent of natural variability.

Benthic macroinvertebrates: With the possible exception of dwarf lake whitefish, all species in the Lower Churchill are benthivores, relying heavily upon macroinvertebrates as a staple food source (including early stages of lake trout and northern pike). These organisms therefore constitute a vital link in the understanding of overall ecosystem functioning. A benthic macroinvertebrate study was undertaken in 1998, with sampling conducted throughout the main stem, including Lake Winokapau and representative tributaries. As most of the existing shallow nearshore habitat in Lake Winokapau will be inundated and Gull Island Reservoir will be characterized by slow velocity and lacustrine habitats, while Muskrat Reservoir is predicted to contain slow and intermediate areas with no lacustrine habitat, the overall relevance of this study will be diminished to a large extent due to impoundment. The slow and intermediate velocity areas sampled should have some value as baseline for future comparisons.

Considering the large size of Lake Winokapau only a few stations were sampled, and most of these were in deep water, with none in shallow nearshore areas. Unlike the remainder of the Lower Churchill, Lake Winokapau is a true lake-type environment with well defined zones (littoral, profundal and pelagic) and in order to address this appropriately a sampling design that is different from the rest of the main stem is required. Lake Winokapau provides a unique opportunity to enable predictions regarding the nature or form of eventual community structure in the shallow nearshore areas of the newly formed reservoirs by virtue of its being in the same system. It could also prove to be a source of colonizing organisms, which is important because populations currently specialized for living in riverine habitat may not adapt to existence in lake-type habitat.

Many reports have stressed the importance of long-term studies of benthic macroinvertebrates to adequately address spatial and temporal variability and this would also be expected to apply for the Lower Churchill River.

Fish Studies: The Proponent has conducted many studies on fish in the Lower Churchill River to assess relevant population parameters that will allow comparisons in the future. Collectively speaking, information on age and growth appears adequate especially since questions related to the use of appropriate bony structures for ageing have been addressed. However, data on fecundity are deficient in that only some fall spawners were sampled (and sample sizes were small), and there is no information on spring spawners. With respect to food and feeding, while it is suggested that sufficient samples were collected, the coarse-scale classification of food organisms severely limits useful comparisons with previous studies and the utility of such as baseline information.

Additionally, in all fish studies conducted, only shallow depths (<30 m) were sampled. Lake Winokapau has a known depth of 206 m and in studies from other deep lakes, catches from deep gillnet sets have resulted in the discovery of two separate morphs of the same fish species; one at depth and the other throughout the water column, including in the shallow nearshore zone (*e.g.*, Arctic charr in Gander Lake and lake trout in Lake Superior). Just as for plankton and benthic macroinvertebrates, conditions prevailing in Lake Winokapau could potentially be used to predict eventual future conditions at depth in the reservoirs.

DFO Recommendations:

In order to support predictions that future reservoir conditions will be similar to the existing conditions in Lake Winokapau, present-day conditions require further study and need to be more fully described. DFO offers the following recommendations to address this issue.

Water quality: The number of water quality stations should be increased with sampling at representative intervals from the surface to the deepest parts of the lake, and be conducted over as many years prior to any construction as possible. A more frequent sampling interval with greater seasonal coverage will likely better define the limits of the thermocline.

Primary production and plankton: A longer sampling period (spanning the entire ice-free period) with more frequent sampling should be undertaken for future studies, conducted over as many years as possible (prior to inundation) in order to assess annual variability. Because of the size of Lake Winokapau, the number of sampling stations should be increased. It is recommended that a link between present plankton dynamics (necessitating the inclusion of taxonomic breakdowns of both phytoplankton and zooplankton) and flushing rates be attempted prior to impoundment to form the basis for comparisons after flooding when the main stem evolves into some form of lake-type environment with a new set of water renewal characteristics.

Benthic macroinvertebrates: Building on information collected in the previous study, slow and intermediate velocity areas should continue to be sampled as baseline for predictive purposes and sampling should be conducted over as many years as possible (prior to inundation) to determine the extent of annual variability, and should be statistically representative spatially. Sampling should start as soon as possible after spring breakup (i.e., prior to major insect emergences) and again in the fall.

Fish studies: More data on fecundity with appropriate sample sizes are required for both spring and fall spawners. Also, classification of food organisms should be attempted to the lowest taxonomic level possible. Additionally, given that certain fish species found in the Lower Churchill have been reported elsewhere to occur in very deep water, sampling should be conducted down to the extreme depths of Lake Winokapau.

Comparison with other reservoirs

There are significant differences between the reservoirs proposed to be created on the Lower Churchill River and other existing reservoirs which were used to make predictions.

The Robert Bourassa reservoir consists largely (92% in terms of area) of flooded taiga type land, whereas the Gull Island and Muskrat Falls reservoirs would consist of a smaller relative proportion (approximately 40%) of flooded boreal type land. There was no removal of vegetation prior to the flooding of the Robert Bourassa Reservoir as is being proposed for the Lower Churchill reservoirs. These differences would likely result in the temporary surge in productivity typically observed in reservoirs after impoundment being significantly less intense and shorter in duration in the Lower Churchill reservoirs than was observed in the Robert Bourassa Reservoir.

The maximum drawdown for the Robert Bourassa Reservoir is 8 m, nearly three times the drawdown proposed for the Gull Island Reservoir and 8 times that proposed for the Muskrat Falls Reservoir.

Water residence time in the Robert Bourassa Reservoir has been estimated at 6.9 months as compared to an estimated 28 days for the Gull Island Reservoir and 10 days for the Muskrat Reservoir. The presence of numerous islands and submerged vegetation in the Robert Bourassa Reservoir suggests complex flow-through patterns that could further enhance water retention. Flow-through for the proposed Lower Churchill reservoirs is along the longitudinal axis, end to end and there will be less of the modifying features such as islands and vegetation that exist in the Robert Bourassa reservoir to slow water movement. These differences suggest that water residence time in the Lower Churchill reservoirs would be significantly shorter than in the Robert Bourassa reservoir.

In addition, the turbine intakes in the Gull Island Reservoir are to be located relatively high in the water column, and the rate of discharge of the surface waters containing the productive photic zone could be relatively higher. It has been shown that water retention time can have a profound effect on nutrient dynamics and uptake patterns as well as production and species composition of phytoplankton and zooplankton, therefore these aspects will likely be markedly different between the Robert Bourassa and the Lower Churchill reservoirs.

The information provided on the other reservoirs showed that collectively, characteristics of each are quite diverse and therefore it is difficult to see how a meaningful comparison to the Lower Churchill could be derived. As a result of all of the above concerns, there is considerable uncertainty around the Proponent’s predictions that post-impoundment habitats will be effectively stable 15 to 20 years after impoundment as the physical and chemical attributes defining productive capacity of the post-impoundment habitats will have stabilized by this time. It is possible that the reservoirs may not stabilize until up to 40 years after impoundment. This may impair the development and functioning of habitats in the reservoirs and negatively impacts fish populations.

DFO Recommendations:

It is recommended that only baseline data, specific to the Lower Churchill River be used to predict reservoir conditions and that such data are collected in a reasonable timeframe so as to permit implementation of appropriate mitigations. Collection of this data is also recommended in relation to the fish habitat compensation and monitoring sections of this document.

2.2.1.2 Reservoir Stabilization

(EIS Guidelines: 2.5, 4.5.1)

EIS Predictions:

The Proponent carried out modeling to predict the stability of shorelines around the reservoirs to be created, levels of suspended sediment in the reservoir waters, and the nature and duration of related impacts on fish and fish habitat. The modeling predicts that raising water levels will generally result in more stable shorelines in areas with consistent or homogeneous soil/sediment types, whereas areas with soil/sediment of different types will be more prone to progressive slumping. Shoreline erosion is expected to be less and slower in the Gull Island Reservoir than the Muskrat Falls Reservoir. Erosion and undermining of the shoreline will continue, potentially for decades, until a stable shoreline develops.

With respect to sediment levels in reservoir waters, the Proponent predicts that total suspended solid (TSS) concentrations will remain relatively low in the Gull Island Reservoir but increase substantially for a number of years after impoundment in the Muskrat Falls Reservoir due to its greater shoreline erosion potential. Based on sediment transport modeling and comparisons with other reservoirs, peak TSS concentrations are projected to occur 5 to 10 years after impoundment and gradually decline as shorelines establish a new equilibrium. It is predicted that TSS concentrations will approach equilibrium in both reservoirs in 20 years.

The Proponent predicts that concentrations of nutrients (modeled as total phosphorous) over a 20 year projection period will begin with a substantial increase followed by 5-6 years of rapid decline and 10-15 years of re-stabilization. Beyond the 20 year model projection period (years 20-50), concentrations will remain near baseline levels and will have stabilized.

Based on modeling, reviews of scientific literature, and comparisons with reservoirs created in other hydroelectric projects (primarily the Smallwood Reservoir on the Upper Churchill River and the Robert Bourassa Reservoir on the La Grande River in Quebec) the Proponent predicts that fish habitat in the reservoirs on the Lower Churchill River would effectively stabilize in 15 to 20 years.

DFO Analysis and Assessment:

Shoreline stability

Bank stability modeling was largely a qualitative desktop exercise using values derived from the literature for such factors as effective wave energy, material erodibility coefficient and slope stability coefficient. It is questionable whether these values are directly applicable to the Lower Churchill, and as a result the predictions from the modeling are subject to significant uncertainty. The modeling also does not factor in local variations in these parameters which likely exist throughout the reservoir areas. The modeling also used wind direction data from Goose Bay to estimate effective wave energy. This may not be representative for the reservoirs, as parts of them would be hundreds of kilometers in distance from Goose Bay. Shoreline stability and erosion predictions would be more reliable if the modeling used input values for various parameters based on sampling or measurement within the project area.

Suspended sediment and nutrient levels

Given the uncertainty in the modeling of bank stability described above, the suspended sediment levels predicted based on these bank stability values are also subject to considerable uncertainty. The suspended sediment modeling also assumed that inputs of sediment to the reservoir would be instantaneously distributed in a homogeneous manner throughout the model cells, which is unlikely to occur in nature. Input values for the sediment modeling (such as the limits used for multipliers in the parameter sensitivity analysis and the “Shoreline Erosion Intensity” scaling parameter) appear to have been based on literature values and/or professional judgment. As a result, there is considerable uncertainty about the accuracy of predictions regarding the magnitude and duration of elevated suspended sediment levels in the reservoirs.

As the potential change to nutrient (total phosphorous -TP) loading was modeled simultaneously with the suspended sediment modeling, the same uncertainty regarding time to reservoir stabilization applies here. It is notable that other reservoirs such as the Williston Reservoir on the Peace River in British Columbia have taken up to 40 years to stabilize.

In consideration of all of the above, there is significant uncertainty around the Proponent’s predictions that the reservoirs to be created on the Lower Churchill River will stabilize within 15-20 years of impoundment. It is possible that reservoir stabilization may take up to 40 years after impoundment. The uncertainties in the predictions about shoreline stabilization and sediment transport are significant in that persistent shoreline instability and elevated suspended sediment levels would likely impair primary productivity, delay colonization of substrates by plants and reduce the suitability of the substrate and water in the reservoirs as habitat for fish. This issue is discussed further in relation to habitat compensation in Section 2.2.1.3.

DFO Recommendations:

In order to increase the certainty of predictions about reservoir stabilization consideration should be given to re-running the models for shoreline stability, sediment transport and nutrient (TP) loading using input values for erosion potential and other parameters based on actual measurements from the project area (instead of literature values and estimates). Relevant data could be collected (prior to inundation) during the sampling program planned as part of baseline monitoring for habitat compensation.

2.2.1.3 Changes in Fish Habitat Availability

Pre and Post-Project Habitat Availability
(EIS Guidelines: 2.5, 4.2.4, 4.4.1, 4.4.4, 4.5.1)

EIS Predictions

The construction of dams at Muskrat Falls and Gull Island and the creation of reservoirs will result in the inundation of some 285 kilometres of the Lower Churchill River and a significant alteration of the existing fish habitat. In order to quantify the habitat available to fish and to predict related impacts for this large area, and the diversity of fish species in it, in a scientifically defensible manner, the Proponent developed a methodology specific to the Lower Churchill River. Using this methodology, the Proponent determined that the equivalent of approximately 33 hectares (ha) of fish habitat would be destroyed under the footprint of dams, and the equivalent of 5,103 hectares of fish habitat would be significantly altered by flooding.

The project will result in all of the fast and intermediate velocity waters (above a velocity of 1.0 m/s) in the reservoir footprints being changed into deeper waters with velocities characteristic of slow rivers and lakes (below 0.60 m/s). DFO has determined that these changes in water depth and velocity will harmfully affect the quantity, quality and distribution of existing fish habitats. This impact would require DFO to issue an Authorization under the *Fisheries Act.* Authorization typically requires the losses of existing fish habitat to be quantified, and offset by fish habitat compensation so as to maintain “no net loss” of the productive capacity of fish habitat overall as per the Habitat Policy.

Based on the same quantification methodology used to measure existing fish habitat, the Proponent predicts that portions of the reservoirs will feature water velocities and depths that will allow them to become, once they stabilize within

15-20 years, productive fish habitat. The Proponent proposes that this incidental creation of 4,814.36 ha of productive fish habitat (1,919.49 ha for Muskrat Falls Reservoir and 2,894.87 ha for Gull Island Reservoir) can serve as compensation for the majority of the harmful alteration of existing habitat.

DFO Analysis and Assessment

DFO has worked closely with the Proponent on the development of methodology used to quantify fish habitat in the existing river system. The data from this methodology served as the basis for the final formal determination by DFO of the harmful alteration, disruption or destruction (HADD) of fish habitat that would require issuance of an authorization under section 35(2) of the *Fisheries Act*.

There are however, considerable uncertainties in predictions by the Proponent about the incidental or natural re-establishment or emergence of productive fish habitat in the reservoirs to be created within 15-20 years. While depths and water velocities in parts of the reservoirs may be suitable for utilization by fish immediately after impoundment, it may take a very long time for water quality conditions to stabilize and substrates to develop that are suitable for use by fish as habitat. Based on observations in other similar reservoirs, time to stabilization may take up to 40 years. Such delays could have significant impacts on the sustainability of fish populations. Fish that are not able to adapt to the changes in availability of habitat may not survive this period.

Although most existing habitat types will also be present in the reservoirs, the relative proportions of these habitats will be significantly different. All of the fast and intermediate velocity stream, tributary and main channel habitat (which is currently utilized and preferred by many fish species) will be replaced by slow velocity and/or lake-type habitat. There is uncertainty whether fish that prefer to spawn in higher velocity water such as streams would find suitable spawning habitat in waters outside of the reservoir footprints, or whether they could adapt to spawning in shallow areas of the new reservoirs. This uncertainty further amplifies the potential impact of the delay in stabilization described above on the sustainability of fish populations. These impacts would be particularly significant for species that utilize fast-moving waters for spawning, such as brook trout, ouananiche, lake trout, whitefish, chub and sculpin.

The summaries of various fish species that were provided contain very limited information on actual habitat in the Lower Churchill River and current use for spawning, as most values are derived from the literature. Spawning areas were identified based only on the presence of mature fish, without consideration of whether any fish observed had partially or completely spawned. It is likely that other spawning areas exist in the current environment. To ensure the availability of adequate amounts of this essential habitat and the continued sustainability of fish populations, it is important that the nature and extent of current spawning habitat is more fully understood. It is important that this information be collected and presented in order to demonstrate how fish species occurring in the Churchill River will be able to carry out this life cycle stage in the habitat types predicted to be available in the future reservoirs.

DFO Recommendations

The Proponent should collect additional baseline information on fish spawning sites throughout the Lower Churchill River (prior to inundation) and develop a map of confirmed and potential spawning areas in the Churchill River and its tributaries (including downstream of Muskrat Falls) as well as data characterizing these areas. This could then be used to compare habitat types in future reservoirs and validate the prediction of no net loss of fish habitat. This information would also serve to identify spawning areas that could be negatively impacted by downstream dewatering during reservoir filling (see same recommendation in Section 2.1.4).

Fish Habitat Compensation
(EIS Guidelines: 4.5, 4.6.1.1, 4.6.4)

EIS Predictions

As described above, the proponent predicts that much of the flooded area that will become accessible to fish after reservoir creation will, after the reservoirs stabilize and suitable substrates develop, become productive fish habitat. In the Fish Habitat Compensation Strategy (Strategy) for the Project, the Proponent proposes that this long-term incidental gain in productive fish habitat can serve as compensation for the majority of the harmful alteration of existing habitat. As part of the Strategy, the Proponent proposes to pre-condition the substrate in certain areas in order to expedite its stabilization and use by fish after being submerged. This will include the removal of all vegetation within a zone between 3 m above full supply level (to a maximum of 15 m horizontally from the predicted new shoreline) and 3 m below lower supply level of the reservoirs and the exposure of substrates through construction of access roads in a strategic manner. The Proponent has also committed to implementing a comprehensive and long-term monitoring program that will compare various parameters in the reservoirs with baseline values and allow confirmation of the emergence and utilization of “incidentally created” habitat.

Another component of the compensation strategy is the construction of various physical works to create habitat types including spawning shoals, nearshore and delta areas and aquatic vegetation. This is intended to provide habitats which are not likely to arise incidentally or naturally in the reservoirs, but which are important for sustainability of species, particularly those supporting fisheries.

The Proponent again proposes to carry out a comprehensive long-term monitoring program to confirm the functioning and effectiveness of these physical compensation works.

The Proponent has also committed to an adaptive management approach informed by the results of monitoring reservoir conditions and stabilization. Under this approach, monitoring will confirm the validity of the Proponent's predictions of post-project physical and biological parameters and fish habitat utilization. If monitoring demonstrates that "cautionary/critical levels" (yet to be established) associated with fish habitat are exceeded, then the compensation strategy will be adjusted and alternative mitigative measures will be developed and implemented.

The Strategy recognizes the importance of having adequate baseline data in order to allow effective comparison of post-impoundment fish habitat with current conditions and with predictions in the EIS. The Strategy also recognizes that "*even with extensive baseline data…that some level of uncertainty exists regarding the effectiveness of compensation mitigation measures".*

DFO Analysis and Assessment

Incidental habitat gains

DFO has generally accepted in principle the Proponent's Fish Habitat Compensation Strategy, including the proposition that gains in fish habitat in newly flooded areas could serve as compensation for harmful impacts from flooding of existing habitat. As described earlier however, there is considerable uncertainty around the length of time it will take for newly inundated areas in the reservoirs to become productive and how stable their productivity will be, given the fluctuations in water level expected in the reservoirs, the possible delays in the development of suitable substrates and the loss of various existing habitats important for some life stages of fish species. The fact that existing spawning sites/zones will be flooded and largely unusable in the future means that any newly-formed spawning areas (other than those created through physical compensation works) will result in desiccation/freezing of eggs of salmonid species and other fall spawners during the annual reservoir drawdowns.

Of particular concern is the change due to inundation of all fast and intermediate velocity riverine habitats into slow velocity and lake-type habitats. This will potentially affect those species which use such habitat types for spawning and rearing of young-of-the-year and juveniles. The Proponent states that existing small streams and tributaries outside of the reservoir footprint will provide intermediate/fast velocity habitats. However these existing habitats may not be able to support additional use by fish, and may not supply significant additional habitat after flooding. Although the Proponent proposes to create or enhance nearshore areas through reservoir clearing and the construction of access roads, it is uncertain whether the amount of new habitat to be created in this manner will offset the loss of preferred habitats for particular life stages of important fish species.

DFO Recommendations

The Proponent should ensure areas to be flooded are pre-conditioned as much as possible prior to inundation in order to expedite the development of substrates suitable for use by fish as habitat, particularly for spawning.

Adequacy of baseline data

As described under Predictions about Reservoir Attributes, the Proponent has to date provided only minimal baseline information on some key parameters that would indicate the quality and utilization of post-impoundment habitat or to inform adaptive management. It is important to have baseline data collected on these key variables for a period of time (prior to inundation) that is long enough to allow a differentiation in the area to be impacted between natural variability and effects due to the project and confirm any incidental gains in fish habitat.

Key variables for which greater baseline data is required include the following physical and biological characteristics:

- *Water quality* – Relatively small changes in water quality parameters (temperature, total dissolved solids, turbidity and velocity) could have major effects on the health and survivability of the various fish species. More data on these parameters should be collected at standard transects throughout both reservoirs.
- *Primary and secondary production and benthic macroinvertebrates* - These form the base of the food web that supports fish populations. Greater baseline data is needed to allow early detection of significant changes after impoundment and inform adaptive management.
- *Species habitat utilization* - The change to the nature and availability of habitat in the reservoirs may affect spawning and young-of-the-year stages of virtually all species. Recruitment of juveniles may be impacted if the anticipated adaptation to newly formed nearshore shallow areas does not occur or is inordinately drawn out especially during the dynamic and unpredictable stabilization period
- *Fish health* - It is important to have baseline data on fecundity, growth, age and feeding to monitor the health and growth of fish species.

DFO Recommendations

The Proponent should collect additional baseline data on physical characteristics (including water quality) and biological characteristics (including benthic macroinvertebrates, primary and secondary productivity, fish health and habitat utilization) prior to the inundation of the Gull Island and/or Muskrat Falls reservoirs. Sampling programs should be designed to provide data that will strengthen predictions of incidental gains in habitat (first level of compensation), allow the evaluation of functioning of post-impoundment fish habitats and identification of possible negative outcomes that should be mitigated to avoid loss of productive fish habitat. Baseline data should be collected for a minimum of 5 years prior to inundation in order to better describe natural variability. Parameters to be measured and sampling regimes should be endorsed by DFO prior to implementation.

As new relevant baseline information becomes available, the Proponent should update the predictions regarding amount of habitat available after reservoir creation, and adjust the compensation strategy and plan accordingly.

Physical compensation works

The Fish Habitat Compensation Strategy provides a brief outline of the types of physical works that may be undertaken by the Proponent to offset losses of fish habitat resulting from the project. The physical works proposed have been described separately for each reservoir. For the Muskrat Falls Reservoir, the Proponent has proposed delta creation, enhancement of spawning shoals and placement of artificial spawning materials, specifically for northern pike. For the Gull Island Reservoir, the Proponent has proposed the creation of a large, shallow spawning and rearing area on the Gull Island Plateau, and the creation of delta habitat at the mouths of four rivers that empty into this reservoir. While the Strategy is acceptable in principle to DFO, more detail is required about the commitment to construct specific works, predicted amount and types of habitat to be created, construction methods and timing and contingency plans should the proposed works not function as planned. These specific details would be required in the final Fish Habitat Compensation Plan, which would be required by DFO as a condition of the *Fisheries Act* Authorization pursuant to section 35(2).

DFO Recommendations

The Proponent should ensure that physical fish habitat creation/enhancement is implemented to offset the loss of the required fish habitats that will be lost and not re-established incidentally as a result of reservoir creation.

The Proponent should continue to develop its proposed physical compensation works in close consultation with DFO, in order to provide the required level of detail (re: firm commitment of works to be constructed, construction methods and timing, better informed predictions and contingencies) needed to finalize the Fish Habitat Compensation Plan.

Compensation-related monitoring

As described previously, there is significant uncertainty about how long it will take for newly flooded areas to become productive fish habitat. There is also some uncertainty about how long it will take for constructed habitats to become productive. There is additional uncertainty about how stable productivity in both of these areas will be for this project given the fluctuations in water level expected in the reservoirs. DFO and the Proponent have considerable experience in monitoring the functioning of habitat constructed for compensation at other sites, and it is likely that an appropriate and effective monitoring program can be designed and implemented for both the incidental habitat gains and the physical works in question. Further work is required by the Proponent however, to identify parameters to be monitored.

DFO Recommendations

Monitoring programs for incidentally gained habitat and physical compensation works should be designed to provide data that will allow the evaluation of stability, functioning and productivity of habitats for a minimum of 25 years. Parameters to be measured and sampling regimes should be endorsed by DFO prior to implementation.

Adaptive management

The adaptive management program proposed by the Proponent under which compensation measures would be adjusted in response to results of monitoring in the reservoirs is acceptable in principle. While DFO has accepted this approach, many more details are required on the “cautionary/critical” levels that remain to be established as thresholds for triggering adjustments to compensation measures, and how they will serve to maintain levels of productive fish habitat overall.

DFO Recommendations

The Proponent should develop and identify key cautionary/critical levels for various biological and physical parameters that will act as thresholds for triggering adaptive management of fish habitat compensation measures so as to maintain the productivity of fish habitat overall. Parameters to be measured and sampling regimes should be endorsed by DFO prior to implementation.

2.2.2 Changes Downstream of Muskrat Falls

(EIS Guidelines: 4.3.4(b), 4.3.5(a), 4.5.1)

EIS Predictions

Based on modelling, the Proponent predicts that water flow rates and patterns below the proposed Muskrat Falls Reservoir would not differ significantly from those currently observed. The Proponent predicts that sediment transport to downstream reaches below Muskrat Falls would be reduced from current levels, but that this would not cause measureable changes to fish productivity in downstream areas including in Goose Bay. The Proponent predicts that water temperatures downstream of Muskrat Falls would be 1 to 3 ^{o}C higher than current levels throughout the ice-free period. This is predicted to result in delaying the formation of ice in the main stem downstream of Muskrat Falls by an average of 2 weeks and delaying ice break up by one week (overall one week less with ice cover each year). No changes are predicted to ice cover in Goose Bay or Lake Melville. Overall the Proponent predicts that changes to the aquatic environment downstream of the project (*i.e.*, downstream of Muskrat Falls) with respect to sedimentation, nutrients, water temperature and ice dynamics will be insignificant or localized, within the normal range or variability and would not significantly affect fish.

DFO Analysis and Assessment

Sediment and nutrient transport

While the Proponent acknowledges the potential for the reservoirs to trap sediment, the possible impacts of this were not fully explored or analyzed. The placement of a dam on a fast moving river can cause most of the sediment load in the river to settle out. In the Lower Churchill River, such an effect in the Gull Island and Muskrat Falls reservoirs could lead to a net loss of sediment in the river bed and a deeper river channel downstream of the Muskrat Falls dam. The likelihood of this occurring in the Lower Churchill River is increased by the relatively high erodibility of substrate and soils in the lower reaches. The area downstream of Muskrat Falls, including the delta area at Lake Melville, is currently characterized by shallow meandering channels and features habitat that is especially valuable for juvenile fish. Should this entire section of river become a single deep channel, these rearing habitats could be lost, which could negatively affect fish production in that area.

Reductions in sediment transport can also affect the transport of nutrients. The Proponent predicts that 90% of the phosphorus in the water column is expected to be bound to clay particles which would normally be part of the sediment load. If the dam(s) and resultant reservoir(s) act as sediment traps as described above there could be a significant reduction in the transport of this essential nutrient to

Lake Melville. While the Proponent considers briefly the potential changes in nutrient loading (phosphorus) and the consequences for primary production, consequences for secondary production and possible effects on fish productivity and food web shifts were not considered. Since the Churchill River is the primary source of fresh water for Lake Melville, a significant reduction in nutrient levels in this source could have a significant effect on productivity in the lake.

DFO Recommendations

Given the uncertainty associated with the Proponent's predictions for downstream areas it is recommended that the Proponent:

- Collect (prior to inundation) baseline data and carry out post-project monitoring on fish habitat and its utilization for the Lower Churchill River downstream of Muskrat Falls and around the delta of the river in Lake Melville;
- Collect (prior to inundation) baseline data and carry out post-project monitoring on nutrients and primary production levels in Lake Melville.

Water temperature and ice dynamics:

The increase in water temperature predicted to occur downstream of the project is stated to be within the seasonal variability of this area, and is predicted to have no resulting effects on fish, with the exception of possibly slightly advancing the annual spawning season. These predictions related to fish bioenergetics, growth and production are based on thermal models alone. The predictions did not incorporate biological data or information for the resident fish species in the area. The Churchill River is located at a northern latitude with fairly low summer water temperatures. Many of the fish species present in this area are at, or near, the northern limit of their range and have adapted to this environment. It is very likely that a relatively small shift in water temperature, on the order of 2 ^{o}C, may indeed have significant biological effects on fish growth and production. Some of these effects may be positive.

The Proponent did not conduct modeling of the possible impact of the change in water temperature on ice formation outside of the mouth of the Lower Churchill River at Goose Bay, as changes to the thermal and ice regimes of the bay were predicted to be localized and small. However, the predicted increase in water temperature in the Lower Churchill River could affect the timing of ice formation around the mouth of the river in Goose Bay. This could have important implications as the ice in this area is used extensively by local residents for transportation and to access fishery resources in this area (seals, ice fishing etc.).

In summary the Proponent appears to over simplify the effects of the possible change in water temperature downstream of Muskrat Falls. There is more uncertainty about the extent and significance of effects on fish growth and behaviour, and on the formation of ice than presented by the Proponent.

DFO Recommendations

Pre-project baseline data should be collected and post-project monitoring should be carried out to assess changes in fish growth, condition and spawning times in the Lower Churchill River from Muskrat Falls to the Churchill River delta area.

The effect of the anticipated change in water temperature on ice formation in Goose Bay and Lake Melville should be modelled, and the timing and extent of ice formation around the mouth of the Churchill River and Lake Melville should be monitored before and after reservoir impoundment.

2.2.3 Effects of Dams on Fish

(EIS Guidelines: 4.3.2.2, 4.4.4.2(g), 4.5.1, 4.7)

EIS Predictions

The construction of the two dams at Muskrat Falls and Gull Island will effectively prevent the movement/migration of various fish species between the two reservoirs. This could affect the sustainability of fish populations should there be a preference or requirement by fish to move between these reservoirs, for example to access spawning grounds. The Proponent conducted a radio-telemetry monitoring study in 1998-99 to monitor fish movements and habitat use in the current Lower Churchill River between Goose Bay and Churchill Falls. The Proponent states that this study and previous published studies indicate that no migrations or movements of fish significant at the population level currently occur past either Muskrat Falls or Gull Island Rapids. The Proponent proposes that all habitat types required by life stages of various fish species will be available in both reservoirs, and predicts as a result that there will be no population-level impacts caused by the dams interfering with movement of fish past Gull Island and Muskrat Falls.

Fish in the reservoirs near the dams may become drawn into or entrained in the intakes of the turbines. The Proponent has made predictions about the level of injuries and mortality that fish may sustain from such entrainment, as well as related predictions about population-level effects of these injuries and mortalities. The predictions are based on a review of existing scientific literature on fish entrainment and survival for similar type turbines, coupled with information on fish movement from a radio tagging study. Estimates of both mortality and injury were modeled for the Muskrat Falls facility, whereas only injury was estimated for that at Gull Island facility. For the Muskrat Falls facility it was estimated that between 2% to 22% of all fish entrained in the turbines would be injured, with an estimated 6% of juvenile fish and 14% of adult fish entrained being killed. The injury rate at Gull Island facility was estimated to be between 3% and 34%. It was also predicted overall that salmonids would be the species most susceptible to entrainment due to their pelagic lifestyle. The Proponent predicts that these levels of injury and mortality would not be significant at the population level.

DFO Analysis and Assessment

Effects of dams on movement and migration of fish

The telemetry study described the movements of adults of various fish species in the vicinity of the two proposed generation facilities. While the study may accurately describe habitat utilization patterns and movements of adult fish it does not provide a complete picture of all fish movements, including downstream migration. The telemetry study provides information only on the largest individuals in the population of certain species, which constitute a relatively small proportion of the population as a whole. Most of the movement or migration from spawning sites to rearing areas would be carried out by juveniles, which were not sampled during the telemetry study. A review of existing data from other sites with similar species assemblages should be conducted to assess and predict population level effects of fragmentation of the river by dams.

Effects of entrainment

Although data from the scientific literature on entrainment that was reviewed is somewhat dated, and only covers actual survival/injury rates (and not the mechanics behind entrainment), the information and analysis presented on anticipated fish entrainment in turbines and the related mortality and injury rates appears generally sound. There is more uncertainty about impacts at the Gull Island facility but this may be possible to reduce once design criteria for this dam are finalized.

A source of uncertainty with the analysis of the impacts of entrainment is with the predictions of impacts that anticipated entrainment mortality and injury rates would have at the population level. The Proponent's analysis relies heavily on information from the telemetry/movement study. This study sampled only a very small number of fish, and only in one year. It is also important to point out that this 'snapshot' was developed during pre-project conditions, which will change drastically once the reservoirs are created. The assumption that fish movement patterns will remain the same in the slower velocity environment of the reservoirs as in the current high velocity river environment introduces a high degree of uncertainty with respect to the overall analysis and predictions on impacts of entrainment. It is possible that injuries and mortalities from entrainments could have more significant effects on fish populations than predicted. There may be a requirement to implement additional mitigation measures to reduce entrainment mortalities.

DFO Recommendations:

In order to better predict the impacts of construction of dams at Gull Island Rapids and Muskrat Falls on fish population assemblages and dynamics, DFO recommends that the Proponent conduct a review of data from other sites with similar species assemblages to investigate the effects of fragmentation of river systems from dam construction on movement and migration of all life stages of fish species and associated population level effects.

After construction of each facility, the Proponent should monitor to determine actual injury and mortality rates from entrainment of fish under normal operating conditions, with adequate sample sizes to properly assess related population level effects.

The Proponent should request a Section 32 authorization from DFO for fish mortalities related to entrainment.

2.3 Bioaccumulation of Mercury in Fish

(EIS Guidelines: 4.6.4)

EIS Predictions

Mercury is a ubiquitous contaminant of freshwater biota. While it is found in low levels even in fish in pristine environments, elevated levels of methyl-mercury are typically observed in fish in recently flooded reservoirs. The dominant pathway of mercury uptake in aquatic biota is through food and the contaminant is biomagnified up through the food chain. The highest levels are generally found in large piscivores (fish eaters), particularly in lakes with long food chains. The elevated mercury levels typically observed in hydroelectric reservoirs generally do not have significant negative effects on fish, but can cause health problems in humans if fish with elevated levels of mercury are consumed.

Mercury levels in fish in the reservoirs to be created are predicted to be less than twice the current background levels. This is similar to or less than observed increases in the Smallwood Reservoir following its creation. Peak levels are predicted to occur within ten years for fish at lower trophic levels and between 5 and 15 years for piscivores. The return (to background level) times are predicted to be less than 35 years. The Proponent predicts that mercury bioaccumulation will occur only in fish in the reservoirs and in areas immediately downstream of them. Another prediction is that fish below the dams that feed on fish from the reservoirs, that have been injured or killed by the turbines, may result in peak mercury levels being immediately below the dams for some species. It is predicted that advisories recommending limited consumption of fish by humans will be required for most species for some periods after reservoir creation.

DFO Analysis and Assessment

The Proponent's predictions are consistent with the current state of knowledge about the evolution of mercury levels in fish in boreal reservoirs in general. Based on empirical studies by both NALCOR and DFO, there is a good understanding of how mercury levels in fish evolved in the Smallwood Reservoir following flooding, and it is expected that reservoirs in the Lower Churchill River would exhibit similar patterns. However, the accuracy of predictions of peak levels and timing of peak mercury levels anticipated in the Lower Churchill projects is uncertain. The assumptions and the data used in the modeling exercise do not support a precise determination of these values. The effects of changes in primary productivity and changes in fish habitat were also not factored into the modeling of mercury bioaccumulation. As a result, mercury bioaccumulation in the reservoirs could occur to a different extent and for a different duration than predicted.

There is significant uncertainty in the Proponent's prediction that mercury bioaccumulation will occur only in fish in the reservoirs and in areas immediately downstream of them. A recent study by DFO[3] (Anderson, 2010) has documented mercury bioaccumulation associated with the creation of the Smallwood Reservoir in some fish species as far downstream as Goose Bay. The extent and duration of bioaccumulation appear to depend on the trophic position and habitat preferences of the individual species. Similar effects are likely for reservoirs proposed for the Lower Churchill River, and it is possible that mercury bioaccumulation as a result of the project may be observed as far downstream as Goose Bay.

As discussed under "Sequencing of Project Components", both the magnitude and duration of mercury bioaccumulation in fish in the Muskrat Falls Reservoir and further downstream would be affected by the timing of the construction of the Gull Island Reservoir.

In summary, it is possible that mercury bioaccumulation as a result of the Project may be observed at a greater magnitude, for longer periods and further downstream than predicted.

[3] Anderson, M. R. 2011. Duration and extent of elevated mercury levels in downstream fish following reservoir creation. River Systems. In Press

DFO Recommendations

The Proponent should develop a comprehensive program to monitor spatial and temporal changes in mercury, in fish within the reservoirs and downstream, including at Goose Bay following reservoir creation. The frequency and timing of sampling should support a clear assessment of the magnitude and timing of these changes, and inform determinations of risks to human health and implementation of related fisheries management measures. More baseline data should be collected on mercury levels in estuarine fish downstream of Muskrat Falls and in Goose Bay in advance of inundation.

2.4 Impacts on Fisheries

(EIS Guidelines: 4.4.4.4 (b), (c) and (d), and 4.4.4.6)

EIS Prediction:

Fishing has traditionally been an important recreational and subsistence activity for land and resource users in Labrador, and the Proponent states that while access points for angling will change as a result of the project, there should be no net loss in access.

The Lower Churchill River Fish Consumption and Angling Survey and interviews conducted as part of the Land and Resource Baseline Report indicate that fishing has been limited on the Lower Churchill River itself; with brook trout, lake trout and ouananiche being the most common species angled upstream of Muskrat Falls, and brook trout, Atlantic salmon and smelt more commonly pursued downstream of Muskrat Falls. Preferred areas fished by central Labrador anglers in the lower Churchill River include the Churchill Falls tailrace, Muskrat Falls and Gull Island.

The Proponent indicates that sea-run brook trout and Atlantic salmon are taken in the domestic gillnet fishery in Lake Melville with major netting sites located at the mouths of Kenamu River and North West River and the area between Sebaskachu River and Mulligan River. The northern resident (non-Aboriginal) gillnet fishery in Lake Melville is limited to 160 licences annually and an in-season closure is implemented annually to conserve multi sea winter salmon.

In winter, ice fishing for trout, smelt and rock cod is a popular activity in Lake Melville, while seals (ringed and harp) are mainly harvested in Lake Melville in the winter with lesser numbers taken in the spring. The commercial harvest of harp and ring seals is May 15 to November 15 and April 25 to December 1, respectively. Commercial trout licences are available for Lake Melville, however none are in use.

The Churchill River is within the boundaries of Trout Management zones 4 (western Labrador) and 5 (central Labrador) as well as two special Trout Management Areas; Eagle Plateau Management Zone (Labrador) and the Churchill River Drainage Basin Watershed (Labrador).

The Proponent indicates that the ecological boundary of the assessment is restricted to those fish populations that reside within the main stem and accessible tributaries of the main stem of the Churchill River from Churchill Falls to the mouth of the Churchill River at Goose Bay and that the Project will not affect the fisheries on Lake Melville. The Proponent also states that while the creation of the Muskrat Falls and Gull Island reservoirs will lead to a net total increase in habitat use for angled species, access to preferred angling locations such as upriver of Muskrat Falls and Gull Island may be affected. Fishing locations below Muskrat Falls are expected to be accessible below the tailrace. At Gull Island, the dam location and infrastructure will be unavailable; however, the tailrace and downriver will most likely be accessible to anglers.

With respect to the potential for increased access and therefore increased competition for resources, the mitigation in place to limit adverse effects on other types of harvesting are also applicable to fishing (*i.e.*, restricted access to the project's road and work areas during construction; removal of stream crossings along access roads as construction and reservoir preparation is completed; a no-harvesting policy will also be in effect for all project employees). The Proponent notes that angling practices at the Churchill Falls tailrace and locations outside of the Lower Churchill River are not expected to be affected.

While there may be some changes in angling patterns as a result of the project, the Proponent indicates that non-project factors such as the management of fish stocks by both the provincial and federal governments and seasonal restrictions to manage fish resources can moderate these effects.

DFO Assessment and Analysis:

DFO recognizes and is supportive of the Proponent's effort to implement a no fishing policy for workers during the construction phase of the project. This policy will have a significant effect on controlling fishing activity within the project site. However, workers will have the opportunity to travel to areas outside the site and participate in recreational fishing activities, and being in close proximity to normally remote areas will likely increase fishing effort. The Department works closely with Aboriginal Fishery Guardians and Provincial Government enforcement agencies in an effort to conserve and protect salmon and trout stocks. Enforcement activities include conducting regular patrols on the land, sea and in the air. Conservation & Protection resources are typically directed toward regionally set priorities, including activities that result in increased fishing pressures or where there have been complaints provided in respect to an issue.

DFO has the ability through regulations made pursuant to the *Fisheries Act* to vary (change) fishing seasons, daily and seasonal bag and possession limits and to close specific areas to fishing and will continue to fulfill its mandate and responsibilities to manage fisheries in the area (i.e. along the Churchill River, its tributaries and Lake Melville). The Department has capacity in the area through an office in Goose Bay with Conservation & Protection and Resource Management staff, as well as offices in Grand Falls-Windsor and St. John's that are actively involved in fisheries management in Labrador.

A structured advisory process exists for the various fisheries in the area enabling local stakeholders to raise issues of concern such as changes in fishing patterns and over-exploitation. DFO also monitors changes to or increased fishing effort and if there are changes or increased fishing pressures as a result of the Project, DFO has the ability to respond through the implementation of changes to management measures.

There are some uncertainties as to the long-term impact on fishing access, patterns, locations, etc in Lake Melville. However, the Department will endeavor to monitor this over time and consult stakeholders. Where required, adjustments can be made to existing management measures or through the introduction of new measures. In Lake Melville, there are various fishing activities such as sealing, salmon and trout. The importance of these fisheries to their participants is understood and DFO will work with them to ensure the long-term sustainability of these resources.

In addition to the 160 trout licences referenced by the Proponent for Lake Melville, DFO also issues Food, Social and Ceremonial (FSC) licences to the Nunatsiavut Government (NG), and Innu Nation. These licences include such species as salmon, trout, Arctic char, smelt, and seals. The salmon fishery is considered to be an important fishery to these Aboriginal groups, including in the Upper Lake Melville area.

DFO Recommendations:

The Proponent is encouraged to implement its no fishing policy for workers during the construction phase of the project. This policy will have a significant effect on controlling fishing activity within the project site.

2.5 Cumulative Effects

(EIS Guidelines: 4.5.3)

EIS Predictions:

The Proponent predicts that any potential interactions between existing, past or future projects and the proposed Lower Churchill project on fish and fish habitat are not likely to be significant. This includes projects such as the hydroelectric development on the Upper Churchill River and projects such as a possible uranium mine in the Postville area.

DFO Analysis and Assessment:

While the Proponent provided a summary of potential interactions of the proposed Lower Churchill project with existing and future projects, the cumulative effects assessment did not include an adequate discussion of residual effects from the Upper Churchill project on the aquatic environment, particularly in relation to fish mercury burdens. As previously mentioned, some fish in the lower Churchill River may still have elevated mercury levels, which can be attributed to the Upper Churchill development. Mercury levels in these fish thus do not represent natural background mercury levels. Additional bioaccumulation of mercury in these fish from the project on the Lower Churchill would represent a cumulative effect.

Other cumulative effects also warrant further discussion. As witnessed already in communities in the Lake Melville region, population growth in the area resulting from employment opportunities associated with this and other projects will likely change current hunting and fishing practices, and place increased pressure on fisheries resources. Fishing activity is anticipated to increase also as a result of the construction of access roads and an increase in the number of off-road recreational vehicles likely to be purchased.

Additionally, given the significant and rapid changes in ice conditions that local residents have been observing in Lake Melville in recent years, some discussion and more detailed analyses of possible project effects interacting with regional climate change scenarios should be explored. In particular, the influence of more extreme weather events such as high wind conditions in the fall and spring and extreme spring storms, all of which could create scenarios where ‘small scale changes’ in the amount of open water in the Goose Bay narrows area, could potentially lead to more significant changes in the timing of spring break-up as well as freeze-up. In addition to impacts to local seal populations, this could have socio-economic impacts (i.e., community sea-ice travel, wood harvesting activities and access to country food resources).

DFO Recommendations:

The Proponent should provide a more thorough assessment of cumulative effects associated with the Upper Churchill hydroelectric project, particularly in relation to mercury bioaccumulation in fish, as well as effects of this and other anticipated projects on fisheries resources due to increased access, and also interactions with recent climate change scenarios.

2.6 Sequencing of Construction of Project Components

(EIS Guidelines: 4.3.2.2)

EIS Predictions

The Proponent has described differing sequences of construction for the project, including construction of the facilities at either Gull Island or Muskrat Falls first, with either an overlap or complete separation in the timing of construction for the two facilities. The Proponent has predicted that there would not be a significant difference overall in the environmental effects of different construction sequence scenarios.

The Proponent has predicted that separating the timing of construction of the Gull Island and Muskrat Falls facilities would extend the period of time during which elevated mercury bioaccumulation in fish would be observed overall.

The Proponent has predicted that construction of the Muskrat Falls facility first would result in fewer impacts on fish and fish habitat since the reduction in flows associated with filling of the Gull Island Reservoir would not negatively affect downstream fish habitat if the Muskrat Falls Reservoir and generating facility were already in place at that time.

DFO Analysis and Assessment

DFO generally accepts the predictions made by the Proponent in relation to the timing of construction of various phases of the project.

Although the Proponent acknowledges that separating the timing of impoundment of the Gull Island and Muskrat Falls reservoirs would extend the period of time for which elevated levels of mercury would be observed in fish, there does not appear to be a recognition that there may be an additive effect on the magnitude of mercury bioaccumulation observed from the two components of the project. The magnitude of mercury bioaccumulation observed in the Muskrat Falls (downstream) reservoir would likely be greater if the Gull Island (upstream) reservoir is impounded before mercury levels in the Muskrat Falls reservoir return to background levels. This additive effect would be lessened with increasing separation in the timing of reservoir impoundment.

DFO agrees that constructing the Muskrat Falls facility first would likely result in less impact to downstream fish habitat overall, as habitat below the Gull Island dam would not be susceptible to the dewatering that would occur under the construction sequence originally planned. However, it is possible that the water level of Muskrat Falls Reservoir could fall below normal levels during the period of time that it would take to impound the Gull Island Reservoir, which could jeopardize nearshore fish habitat (including physical compensation works) predicted to be established in the Muskrat Falls Reservoir.

The methodology used to assess and quantify effects of the project on availability of fish habitat has allowed impacts from the Gull Island and Muskrat Falls facilities to be considered separately. Given the uncertainty around when each facility would be built, fish habitat compensation plans should be developed in order to allow impacts in each reservoir to be managed separately.

DFO Recommendations

The Proponent should prepare and implement fish habitat compensation plans to address negative impacts on fish habitat from the Muskrat Falls and Gull Island facilities separately or independently for each reservoir.

3.0 SUMMARY OF RECOMMENDATIONS

1. DFO recommends that in the event that a requirement for shipping during the winter season should arise, the Proponent undertake an assessment of the impacts of this activity and related mitigation measures for review by DFO, and contact DFO as early as possible to discuss ice-breaking service requirements and ice routing advice.

2. DFO recommends that the Proponent incorporate scenarios for addressing accidents and/or spills involving small craft on the river into the construction, operation and maintenance Environmental Protection Plans (EPPs). In the event of a spill in the marine or freshwater environment the Proponent is advised to contact the Canadian Coast Guard immediately at 1-800-563-9089.

3. The Proponent should develop an EPP that outlines mitigations and contingency plans for all aspects of the construction activities. This EPP should be provided to the appropriate regulatory agencies, including DFO, for review and approval prior to start of project activities. The EPP should incorporate a monitoring schedule that includes monthly and annual reporting on the effectiveness of the mitigations and contingency plans to DFO and other regulatory agencies throughout construction.

4. In order to protect fish and fish habitat in tributaries and the main stem in the reservoir areas during the period of time between the start of reservoir clearing and reservoir impoundment, DFO recommends that the Proponent adhere to the buffer zones and other mitigations outlined recommended in the *"Forestry Guidelines for the Protection of Fish Habitat in Newfoundland and Labrador"* during reservoir clearing operations.

5. The Proponent should carry out reservoir impoundment during mid-July to mid-September so as to minimize the impacts of reduced flows on fish spawning and the survival of eggs and juvenile fish in areas downstream of the dams. The understanding of potential impacts on spawning, eggs, and hatchlings should be improved by data collection (prior to any project construction) on the spawning, incubation, hatching and emergence of fish in the Lower Churchill River system to supplement information from the scientific literature currently considered. Collection of this information is also recommended in association with the issue of changes in fish habitat availability in Section 2.2.1.3.

6. The Proponent should develop and implement plans to identify and, if necessary, relocate fish stranded in areas downstream of reservoirs while flows are reduced during impoundment. This plan should be reviewed and endorsed by DFO prior to implementation. In addition, the Proponent should request a Section 32 authorization from DFO for any incidental mortalities of fish during impoundment.

7. In order to confirm that predictions about the extent of saltwater intrusion are accurate, the Proponent should re-run the saltwater intrusion modeling using salinity values for Lower Churchill River waters from available studies.

8. In order to support predictions that future reservoir conditions will be similar to existing conditions in Lake Winokapau, present-day conditions require further study and need to be more fully described. DFO offers the following recommendations to address this issue.
   a. *Water quality:* The number of water quality stations should be increased with sampling at representative intervals from the surface to the deepest parts of the lake, and be conducted over as many years prior to any construction as possible. A more frequent sampling interval with greater seasonal coverage will likely better define the limits of the thermocline.
   b. *Primary production and plankton:* A longer sampling period (spanning the entire ice-free period) with more frequent sampling should be undertaken for future studies, conducted over as many years as possible (prior to inundation) in order to assess annual variability. Because of the size of Lake Winokapau, the number of sampling stations should be increased. It is recommended that a link between present plankton dynamics (necessitating the inclusion of taxonomic breakdowns of both phytoplankton and zooplankton) and flushing rates be attempted prior to impoundment to form the basis for comparisons after flooding when the main stem evolves into some form of lake-type environment with a new set of water renewal characteristics.
   c. *Benthic macroinvertebrates:* Building on information collected in the previous study, slow and intermediate velocity areas should continue to be sampled as baseline for predictive purposes. Sampling should be conducted over as many years as possible (prior to inundation) to determine the extent of annual variability, and should be statistically representative spatially. Sampling should start as soon as possible after spring breakup (i.e., prior to major insect emergences) and again in the fall.
   d. *Fish Studies:* More data on fecundity with appropriate sample sizes are required for both spring and fall spawners. Also, classification of food organisms should be attempted to the lowest taxonomic level possible. Additionally, given that certain fish species found in the Lower Churchill

have been reported elsewhere to occur in very deep water, sampling should be conducted down to the extreme depths of Lake Winokapau.

9. It is recommended that only baseline data, specific to the Lower Churchill River be used to predict reservoir conditions and that such data are collected in a reasonable timeframe so as to permit implementation of appropriate mitigations. Collection of this data is also recommended in relation to the fish habitat compensation and monitoring sections of this document.

10. In order to increase the certainty of predictions about reservoir stabilization, consideration should be given to re-running the models for shoreline stability, sediment transport and nutrient (TP) loading using input values for erosion potential and other parameters based on actual measurements from the project area (instead of literature values and estimates). Relevant data could be collected (prior to inundation) during the sampling program planned as part of baseline monitoring for habitat compensation.

11. The Proponent should collect additional baseline information on fish spawning sites throughout the Lower Churchill (prior to inundation) and develop a map of confirmed and potential spawning areas in the Churchill River and its tributaries (including downstream of Muskrat Falls) as well as data characterizing these areas. This could then be used to compare habitat types in future reservoirs and validate the prediction of no net loss of fish habitat. This information would also serve to identify spawning areas that could be negatively impacted by downstream dewatering during reservoir filling (see same recommendation in Section 2.1.4).

12. The Proponent should ensure areas to be flooded are pre-conditioned as much as possible, prior to inundation in order to expedite the development of substrates suitable for use by fish as habitat, particularly for spawning

13. The Proponent should collect additional baseline data on physical characteristics (including water quality) and biological characteristics (including benthic macroinvertebrates, primary and secondary productivity, and fish health and habitat utilization) prior to inundation of the Gull Island and/or Muskrat Falls reservoirs. Sampling programs should be designed to provide data that will strengthen predictions of incidental gains in habitat (first level of compensation), allow evaluation of the functioning of post-impoundment fish habitats and identification of possible negative outcomes that should be mitigated to avoid loss of productive fish habitat. Baseline data should be collected for a minimum of 5 years prior to inundation in order to better describe natural variability. Parameters to be measured and sampling regimes should be endorsed by DFO prior to implementation.

As new relevant baseline information becomes available, the Proponent should update predictions regarding the amount of habitat available after reservoir creation, and adjust the compensation strategy and plan accordingly.

14. The Proponent should ensure that physical fish habitat creation/ enhancement is implemented to offset the loss of required fish habitats that will be lost and not re-established incidentally as a result of reservoir creation.

15. The Proponent should continue to develop the proposed physical compensation works in close consultation with DFO, in order to provide the required level of detail (re: firm commitment of works to be constructed, construction methods and timing, better informed predictions and contingencies) needed to finalize the Fish Habitat Compensation Plan.

16. Monitoring programs for incidentally gained habitat and physical compensation works should be designed to provide data that will allow the evaluation of stability, functioning and productivity of habitats for a minimum of 25 years. Parameters to be measured and sampling regimes should be endorsed by DFO prior to implementation.

17. The Proponent should develop and identify key cautionary/critical levels for various biological and physical parameters that will act as thresholds for triggering adaptive management of fish habitat compensation measures so as to maintain the productivity fish habitat overall. Parameters to be measured and sampling regimes should be endorsed by DFO prior to implementation.

18. Given the uncertainty associated with the Proponent's predictions for downstream areas it is recommended that the Proponent:
    - Collect (prior to inundation) baseline data and conduct post-project monitoring on fish habitat and its utilization for the Lower Churchill River downstream of Muskrat Falls and around the delta of the river in Lake Melville;
    - Collect (prior to inundation) baseline data and conduct post-project monitoring on nutrients and primary production levels in Lake Melville.

19. Pre-project baseline data should be collected and post-project monitoring conducted to assess changes in fish growth, condition and spawning times in the area of the Lower Churchill River from Muskrat Falls to the Churchill River delta area.

20. The effect of the anticipated change in water temperature on ice formation in Goose Bay and Lake Melville should be modelled, and the timing and extent of ice formation around the mouth of the Churchill River and Lake Melville monitored before and after reservoir impoundment.

21. In order to better predict the impacts of construction of dams at Gull Island Rapids and Muskrat Falls on fish population assemblages and dynamics, DFO recommends that the Proponent conduct a review of data from other sites with similar species assemblages to investigate the effects of fragmentation of river systems from dam construction on movement and migration of all life stages of fish species and associated population level effects.

22. After construction of each facility, the Proponent should monitor to determine actual injury and mortality rates from entrainment of fish under normal operating conditions, with adequate sample sizes to properly assess related population level effects.

23. The Proponent should request a Section 32 authorization from DFO for fish mortalities related to entrainment.

24. The Proponent should develop a comprehensive program to monitor spatial and temporal changes in mercury in fish within the reservoirs and downstream including at Goose Bay following reservoir creation. The frequency and timing of sampling should support a clear assessment of the magnitude and timing of these changes, and inform determinations of risks to human health and implementation of related fisheries management measures. More baseline data should be collected on mercury levels in estuarine fish downstream of Muskrat Falls and in Goose Bay in advance of inundation.

25. The Proponent is encouraged to implement its no fishing policy for workers during the construction phase of the project. This policy will have a significant effect on controlling fishing activity within the project site.

26. The Proponent should provide a more thorough assessment of cumulative effects associated with the Upper Churchill hydroelectric project, particularly in relation to mercury bioaccumulation in fish, as well as effects of this and other anticipated projects on fisheries resources due to increased access, and also interactions with recent climate change scenarios

27. The Proponent should prepare and implement fish habitat compensation plans to address negative impacts on fish habitat from the Muskrat Falls and Gull Island facilities separately or independently for each reservoir.

4.0 APPENDICIES

4.1 Appendix A: Acts and Regulations

Fisheries Act
http://laws-lois.justice.gc.ca/PDF/Statute/F/F-14.pdf

Oceans Act
http://laws-lois.justice.gc.ca/PDF/Statute/O/O-2.4.pdf

Species at Risk Act
http://laws-lois.justice.gc.ca/PDF/Statute/S/S-15.3.pdf

Canadian Environmental Assessment Act
http://laws-lois.justice.gc.ca/PDF/Statute/C/C-15.2.pdf

Constitution Act
http://laws-lois.justice.gc.ca/eng/const/PRINT_E.pdf

4.2 Appendix B: Policy for the Management of Fish Habitat (1986)

http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14155/fhm-policy/pdf/policy-eng.pdf

4.3 Appendix C: Forestry Guidelines for the Protection of Fish Habitat in Newfoundland and Labrador

http://www.dfo-mpo.gc.ca/Library/225525.pdf