**Lower Churchill Management Corporation**

nalcor energy
LOWER CHURCHILL PROJECT

# LCP ICE FORMATION ENVIRONMENTAL EFFECTS MONITORING PLAN

## Nalcor Doc. No. MFA-PT-MD-0000-EV-PL-0003-01

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Note: 1. "LCP" coded documents require all Project Managers' approval.

## Additional Approvals

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## TABLE OF CONTENTS

**PAGE**

# 1 PURPOSE

The purpose of this Ice Formation Environmental Effects Monitoring Plan (IFEEMP) is to monitor the presence of ashkui within the lower Churchill River watershed as well as the development of ice cover in relation to the Mud Lake Crossing, an ice road / ice bridge across the Churchill River to Happy Valley-Goose Bay, approximately 30 kilometres (km) downstream of the Muskrat Falls reservoir. The IFEEMP will:

- identify any adverse environmental effects of construction and operation of the Lower Churchill River Hydroelectric Generation Project (the Project) on the Mud Lake Crossing (e.g., delayed formation of a safe ice thickness) and determine appropriate mitigation;
- establish a program for monitoring the effectiveness of mitigation measures; and
- identify the location and size of ashkui, areas of early open water, within the lower Churchill River watershed prior to the conduct of the Waterfowl-Ashkui surveys as described in the Avifauna Protection and EEMP (Nalcor 2013).

To comply with commitments made in the Environmental Impact Statement (EIS) and conditions of the EA release, this IFEEMP approach includes consideration of:

- Mitigation objectives – performance objectives in respect of each adverse environmental effect;
- Mitigation – measures planned to achieve the mitigation objectives;
- Metrics and targets – specific, quantifiable, relevant and time constrained;
- Follow-up or Monitoring Programs – how the Project will include follow-up or monitoring surveys to confirm that mitigation strategies are meeting the mitigation objectives; and
- Contingency – plan to be implemented should monitoring reveal that mitigation measures have not been successful.

The IFEEMP builds on existing information (Nalcor 2009a; Hatch et al. 2007, Hatch 2008, 2010a; SNC Lavalin 2012a,b), commitments made in the Environmental Impact Statement (EIS) (Nalcor 2009a) and through the Joint Review Panel (Panel) process, data collected since the release of the EA including the results of ice formation reports completed since 2013 (Golder 2013, 2014, 2015, 2016, 2017).

# 2 SCOPE

This plan addresses the environmental effects of ice formation on the lower Churchill River following the impoundment of the Muskrat Falls Reservoir.

## 3 DEFINITIONS

**Environmental Assessment**: An evaluation of a project's potential environmental risks and effects before it is carried out and identification of ways to improve project design and implementation to prevent, minimize, mitigate, or compensate for adverse environmental effects and to enhance positive effects.

**Environmental Management**: The management of human interactions with the environment (air, water and land and all species that occupy these habitats including humans).

**Environmental Management System**: Part of an organization's management system used to develop and implement its environmental policy and manage its environmental aspects.

**Environmental Protection Plan**: Document outlining the specific mitigation measures, contingency plans and emergency response procedures to be implemented during the construction or operations of a facility.

**Environmental Effects Monitoring**: Monitoring of overall Project effects to confirm the predictions of EA and to fulfill EA commitments.

**Environmental Compliance Monitoring**: Monitoring of Project activities to confirm compliance with regulatory requirements and commitments made through the EA process.

**Integrated Project Delivery Team**: The integration of the Nalcor Energy and SNC Lavalin Inc. Environmental and Regulatory Compliance Teams.

## 4 ABBREVIATIONS & ACRONYMS

| | |
|---|---|
| **CEAA** | Canadian Environmental Assessment Act |
| **EA** | Environmental Assessment |
| **EEMP** | Environmental Effects Monitoring Plan |
| **EMP** | Environmental Management Plan |
| **EPP** | Environmental Protection Plan |
| **EMS** | Environmental Management System |
| **ERC** | Environment and Regulatory Compliance |
| **ERP** | Emergency Response Plan |
| **Gen** | Generation |
| **HSE** | Heath Safety and Environment |
| **HVac** | High voltage alternating current |
| **LTA** | Labrador Transmission Asset |

**LCP** Lower Churchill Project

**OSEM** On-Site Environmental Monitor

## 5 INTERNAL REFERENCES

| | |
|---|---|
| LCP-PT-MD-0000-PM-PL-0001-01 | LCP Project Execution Plan |
| LCP-PT-MD-0000-PM-CH-0001-01 | LCP Project Charter |
| LCP-PT-MD-0000-EA-PL-0001-01 | LCP Generation Environmental Assessment Commitment Management Plan |
| LCP-PT-ED-0000-EA-SY-0001-01 | Environmental Impact Statement and Supporting Documentation for the Lower Churchill Hydroelectric Generation Project |
| LCP-PT-ED-0000-EV-RG-0001-01 | Lower Churchill Project Permit Registry |
| LCP-PT-MD-0000-SM-ST-0001-01 | Post Environmental Assessment Release |
| LCP-PT-MD-0000-RT-PL-0001-01 | Regulatory Compliance Plan |
| LCP-PT-ED-000-EN-PH-0031-01 | Design Philosophy for Environmental Rehabilitation |
| LCP-PT-ED-0000-EN-PH-0007-01 | Design Philosophy for Environmental Mitigation |
| LCP-PT-MD-0000-HS-PL-0001-01 | Health and Safety Plan |
| LCP-PT-MD-0000-HS-PL-0004-01. | LCP Emergency Response Plan |
| LCP-PT-MD-0000-IM-PL-0003-01 | Information Management Plan |
| LCP-PT-MD-0000-EV-PL-0002-01 | LCP Integrated Environmental Management Plan |

## 6 PROJECT DESCRIPTION

### 6.1 Muskrat Falls Generation

The Muskrat Falls Generation Project (Figure 6-1) will include the following sub-components which are broken down under the five principal areas of the development:

- 22 km of access roads, including upgrading and new construction, and temporary bridges;
- A 1,500 person accommodations complex (for the construction period); and
- A north roller compacted concrete overflow dam;
- A south rock fill dam;
- River diversion during construction via the spillway;
- 5 vertical gate spillway;
- Reservoir preparation and reservoir clearing;
- Replacement of fish and terrestrial habitat;
- North spur stabilization works, and:

- A close coupled intake and powerhouse, including:
  - 4 intakes with gates and trash racks;
  - 4 turbine/generator units at approximately 206 MW each with associated ancillary electrical/mechanical and protection/control equipment;
  - 5 power transformers (includes 1 spare), located on the draft tube deck of the powerhouse; and
  - 2 overhead cranes each rated at 450 Tonnes

**Figure 11-1 Muskrat Falls Generating Facility**

### 6.2 Labrador Transmission Asset (LTA)

LTA consists of the AC transmission line system from Churchill Falls to Muskrat Falls, specifically (Figure 6-2):

- Churchill Falls switchyard extension;
- Muskrat Falls switchyard;
- Transmission lines from Muskrat Falls to Churchill Falls: double-circuit 315 kV ac, 3 phase lines, double bundle conductor, Single circuit galvanized lattice steel guyed suspension and rigid angle towers; 247 km long; and
- 735 kV Transmission Line at Churchill Falls interconnecting the existing and the new Churchill Falls switchyards.

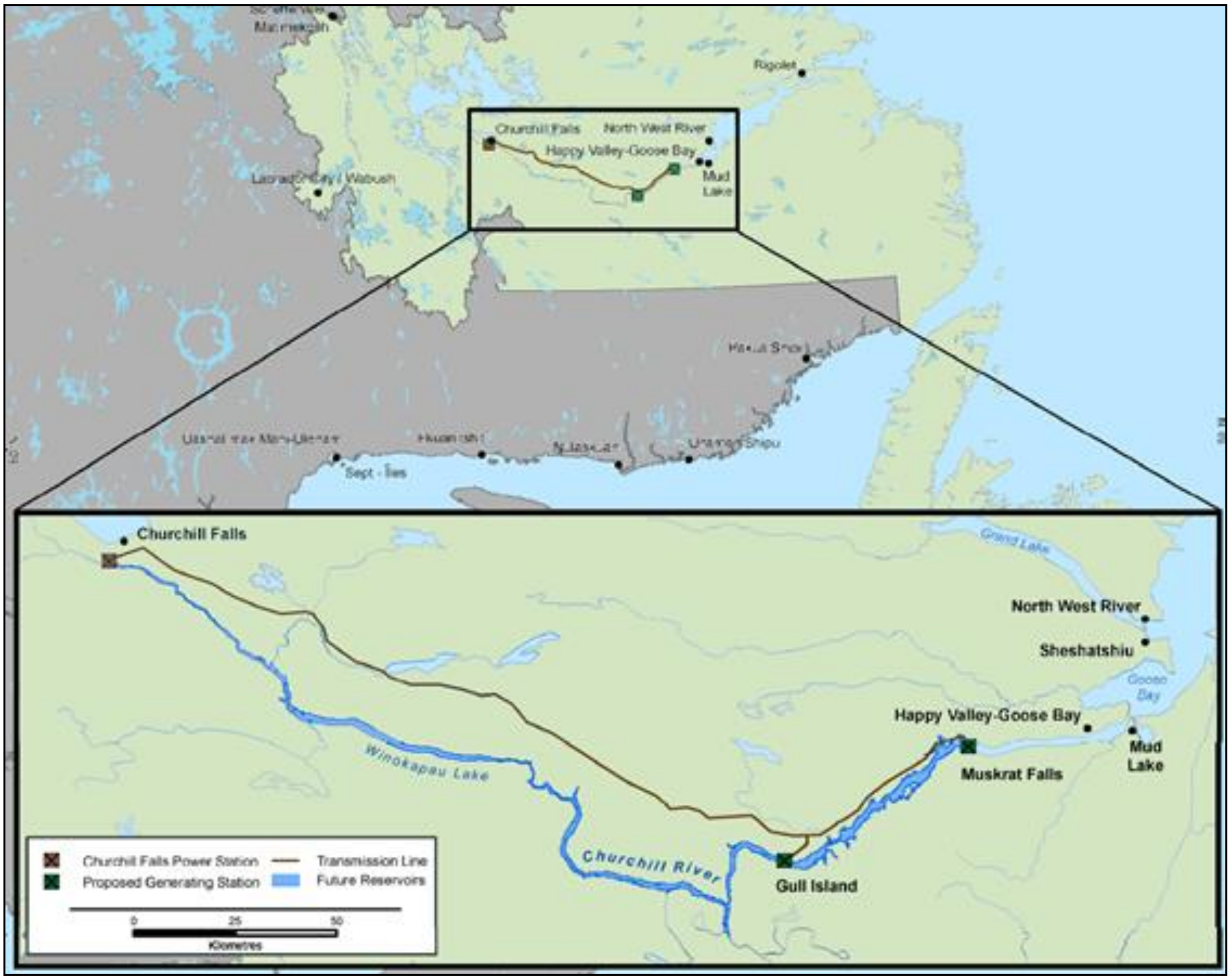


**Figure 11-2 Labrador Transmission Asset**

## 7 EXISTING INFORMATION

Existing information regarding ice formation within the lower Churchill River watershed area is summarized from the following sources:

- data compiled for Nalcor's Environmental Impact Statement (EIS) for the Project (Nalcor 2009a), which was based on a literature review, Project-specific baseline surveys, and component studies (Hatch et al. 2007; Hatch 2008) related to ice, and other sources including traditional environmental knowledge (Innu Nation 2009) and current land and resource use in the lower Churchill River watershed (Minaskuat Inc. 2009);
- historical data collected for the Mud Lake Crossing (JRP 2009);

- data collected since EIS submission, including that reported by Hatch (2010a,b) and SNC Lavalin (2012a,b); and
- Ice formation surveys completed to date for the EEM program (Golder 2014, 2015, 2016, 2017).

### 7.1 ICE FORMATION AT THE MUD LAKE CROSSING

Ice formation is a complex process controlled largely by flow characteristics, temperature and precipitation (Weber et al., 2003). Ice formation processes along the Churchill River are dynamic in nature and ice coverage can change dramatically over a short period of time (Nalcor 2009a). The typical ice formation processes commence as air temperatures fall below freezing; frazil ice forms in areas of turbulent open water and then frazil ice joins together to form larger pieces of surface ice or slush pans (Hatch et al. 2007). As frazil and slush pans accumulate on the leading (upstream) edge of the ice cover, the ice cover progresses up the river. The rate at which the ice cover forms and progresses upstream is highly dependent on factors including air temperature, river velocities, and river width (Hatch 2008).

The formation of ice during the freeze-up period and decay of river ice cover during the break-up period is important to evaluate the stability of ice and risk of flood, and to address the resulting adverse effects. The LCP is interested in ice formation below Muskrat Falls following Project construction at a few locations including, in particular, Mud Lake.

During consultation for the Project, Mud Lake residents expressed concerns relating to changes that may occur to the ice conditions on the Churchill River with the Project in place (e.g., delay of the formation of the ice bridge) (Nalcor 2009a). Mud Lake residents rely on the Churchill River as their transportation link to Happy Valley-Goose Bay, using boats to cross the river in summer and snowmobiles in winter. In winter, Mud Lake residents make between 80 and 140 snowmobile crossings of the Churchill River per week (JRP 2009).

When ice conditions are considered safe and the weather acceptable, non-Mud Lake residents also travel by snowmobile across the Churchill River to access cabins located on the south side of Lake Melville and for other recreational activities such as ice-fishing, sight-seeing, and informal snowmobile racing. Residents' concerns relate to Project effects on the timing of formation, duration and integrity of the Mud Lake Crossing between Mud Lake and Happy Valley-Goose Bay, especially during the four to seven day period in the late fall / early winter and in the spring when it is unsafe to cross the river by either boat or snowmobile. The residents of Mud Lake are concerned that the duration of unstable ice conditions will increase as a result of the Project.

The community of Mud Lake provided information on the ice freeze-up and break-up of the Churchill River in the Mud Lake area, including a long-term record of ice freeze-up and break-up dates (Nalcor 2009a). Dates of the first crossing of the Churchill River by Mud Lake residents by snowmobile and boat have been recorded in 1972 and from 1975 to 2017 as presented in Table 7.1. The average date of first snowmobile crossing is November 29, with the earliest and latest first snowmobile crossings recorded as November 13 in 1986 and January 7 in 2011, respectively (Golder 2017). The average date of first boat crossing is May 15, with the earliest and latest first boat crossings recorded as April 20 in 2010 and June 5 in 1972 respectively (Golder 2017).

**Table 11-1** Record of Break up and Freeze up at the Mud Lake Crossing

| | **Date** | |
|---|---|---|
| **Year** | **Freeze-up (first snowmobile crossing)** | **Break-up (first boat crossing)** |
| 1972 | 22 Nov 72 | 5 Jun 72 |
| 1973 | - | - |
| 1974 | - | - |
| 1975 | 25 Nov 75 | 30 May 75 |
| 1976 | 17 Nov 76 | 17 May 76 |
| 1977 | 30 Nov 77 | 15 May 77 |
| 1978 | 19 Nov 78 | 27 May 78 |
| 1979 | 24 Nov 79 | 14 May 79 |
| 1980 | 29 Nov 80 | 17 May 80 |
| 1981 | 23 Dec 81 | 15 May 81 |
| 1982 | 28 Nov 82 | 1 Jun 82 |
| 1983 | 29 Nov 83 | 14 May 83 |
| 1984 | 23 Nov 84 | 15 May 84 |
| 1985 | 18 Nov 85 | 28 May 85 |
| 1986 | 13 Nov 86 | 7 May 86 |
| 1987 | 28 Nov 87 | 23 Apr 87 |
| 1988 | 1 Dec 88 | 12 May 88 |
| 1989 | 24 Nov 89 | 15 May 89 |
| 1990 | 1 Dec 90 | 22 May 90 |
| 1991 | 2 Dec 91 | 26 May 91 |
| 1992 | 19 Nov 92 | 27 May 92 |
| 1993 | 13 Nov 93 | 17 May 93 |
| 1994 | 27 Nov 94 | 22 May 94 |
| 1995 | 29 Nov 95 | 11 May 95 |
| 1996 | 1 Dec 96 | 4 May 96 |
| 1997 | 23 Nov 97 | 24 May 97 |
| 1998 | 30 Nov 98 | 12 May 98 |

| | | |
|---|---|---|
| 1999 | 23 Nov 99 | 10 May 99 |
| 2000 | 25 Nov 00 | 11 May 00 |
| 2001 | 4 Dec 01 | 14 May 01 |
| 2002 | 22 Nov 02 | 22 May 02 |
| 2003 | 7 Dec 03 | 17 May 03 |
| 2004 | 7 Dec 04 | 18 May 04 |
| 2005 | 11 Dec 05 | 8 May 05 |
| 2006 | 4 Dec 06 | 4 May 06 |
| 2007 | 30 Nov 07 | 19 May 07 |
| 2008 | 5 Dec 08 | 7 May 08 |
| 2009 | 9 Dec 09 | 18 May 09 |
| 2010 | 7 Jan 11 | 20 Apr 10 |
| 2011 | 2 Dec 11 | 12 May 11 |
| 2012 | 2 Dec 12 | 15 May 12 |
| 2013 | 2 Dec 13 | 1 May 13 |
| 2014 | 24 Nov 14 | 19 May 14 |
| 2015 | 1 Dec 15 | 18 May 15 |
| 2016 | 5 Dec 16 | 17 May 16 |
| 2017 | TBD | 21 May 17 |
| **Long Term Average** | **29 Nov** | **15 May** |
| **Average (Last 10 Years)** | **5 Dec** | **12 May** |

The Lower Churchill Project (LCP) is committed to understanding how changes in ice formation downstream of Muskrat Falls could affect the residents' travel across the ice. In addition to the historical ice data, the LCP has been observing ice processes on the lower Churchill River in relation to the Project since 2006 to improve its understanding of current river ice processes for consideration in Project design and construction, and to allow for predictions of post-Project ice conditions (SNC Lavalin 2012a). The LCP has also incorporated an analysis of ice freeze-up and break-up timing during Project operations (i.e., consideration for how Project operation [e.g., water volumes released, temperature of water release] may influence downstream hydrology) into modeling studies (Hatch et al. 2007, Hatch 2008).

Ice dynamics studies completed by Hatch et al. (2007) (Hatch 2008, 2010a) modeled water temperatures and ice generation under existing and post-Project conditions. Subsequent studies by SNC Lavalin in 2011 and 2012 included a review of ice study work to date (SNC Lavalin 2012a) and the Churchill River Ice Observation Study (SNC Lavalin 2012b). This ice observation program consisted of helicopter surveys, acquisition of satellite imagery near Gull Island and Mud Lake, collection of Environment Canada web camera (webcam) imagery at Grizzle Rapids and Mud Lake, a water temperature observation program, ice thickness measurements downstream of Muskrat Falls and at the Mud Lake Crossing, and a volumetric ice flow rate analysis. The 2010-2011 Ice Observation Study documented the ice processes near Mud Lake (SNC Lavalin 2012a).

Based on the data collected, Nalcor (2009a) predicted that during Project operations, the ice conditions below Muskrat Falls, including at the Mud Lake Crossing, would be sufficient (i.e., thickness and stability) to form ice roads. However, following Project construction, ice formation near Mud Lake is expected to be approximately two weeks later, and ice break-up is likely to be one week later (Nalcor 2009a; JRP 2009; Hatch 2010a). Therefore, the safe operational period of the Mud Lake Crossing is expected to be shortened by approximately one week over the winter season.

Increased temperatures in the fall, winter and spring due to climate change will no doubt have an effect on the ice conditions of the Churchill River. In theory, higher air temperatures would correspond to a lower rate of ice generation, which would correspond to a delay in ice bridging. Increased temperatures would also increase the period of time that the river has open water, and this would increase the relative use of boat transportation.

Ice monitoring on the Churchill River below the reservoir and at the Mud Lake Crossing location is ongoing to collect additional baseline information and information on the 'ice bridging' process prior to and during Project construction, as well as during Project operations, to help the LCP verify the predictions made in the EIS (Nalcor 2009a).

In addition, the 2010-2011 Ice Observation Study (SNC Lavalin 2012a) showed that, even in the absence of upstream development, the ice formation and freeze-up processes along the Churchill River are not as predictable as previously thought. This information will be useful in the future if issues arise regarding changes in timing and duration of ice cover in relation to the Project.

### 7.2 ASHKUI IN THE LOWER CHURCHILL WATERSHED

Ashkui are areas where open water appears earlier in the spring than elsewhere or where water remains open (i.e., unfrozen) year-round on rivers, lakes and estuaries. Water temperature, depth and velocity are important factors for ashkui formation (Nalcor 2009a). Ashkui tend to be located where water flows are rough, such as at the confluences of rivers, and are known to exist at Muskrat Falls and the mouths of other rivers entering the Churchill River (e.g., Cache River, Pinus River) (Minaskuat Inc. 2009).

Ashkui provide important habitat for wildlife, with concentrations of waterfowl, fish and other wildlife found at these locations due to the presence of light and open water. Ashkui have special importance in the spring, but appear to have limited importance during the rest of the winter (Environment Canada 2002). In spring, ashkui provide staging habitat for migratory waterfowl such as surf scoter and Canada geese that rely on open water areas when interior wetlands are still ice-covered. In winter, ashkui are used by river otters as haul out sites; however, their primary importance for wildlife relates to waterfowl.

Ashkui are considered important by Innu for drinking water, fishing and hunting (Nalcor 2009b; JRP 2009), and are often sites of contemporary Innu family camps (Minaskuat Inc. 2009). For Innu, the importance of the ashkui is in the overall relationship between the ashkui and the surrounding environment (Gorsebrook Research Institute 2001).

The Ashkui Project is a collaborative study between Environment Canada, Innu Nation, the Gorsebrook Research Institute of Saint Mary's University and Natural Resources to better understand ashkui and includes the study of the relationship between the hydraulics, hydrology and morphology of water bodies. Results from the Ashkui Project were considered in the prediction of ice conditions during Project operations (JRP 2009). During ice-cover conditions, several factors will influence the formation and size of ashkui. The locations where tributaries join the lower Churchill River, and therefore the location of ashkui, will be changed with reservoir creation. While some ashkui on the main stem of the lower Churchill River will likely be lost, the LCP has predicted that after reservoir creation ashkui will continue to form, but at different confluence locations and at higher elevation than they do now (based on formation under similar thermal and hydraulic conditions) (Nalcor 2009a; JRP 2009).

The identification and mapping of the location of ashkui as part of this IFEEMP is in relation to the completion of Waterfowl-Ashkui surveys to understand ashkui size and distribution, and use by waterfowl during Project construction and operations. The Panel concluded that any loss of ashkui would result in a loss in habitat for waterfowl, but would likely not be significant given the abundance of alternate habitat available (JRP 2011).

# 8 REGULATORY COMPLIANCE

The Newfoundland and Labrador (NL) government does not regulate or permit ice roads. As such, the Mud Lake Crossing is not regulated or permitted; the crossing is used for snowmobile traffic only, by residents in the vicinity of Mud Lake, and is overseen by the Mud Lake Improvement Committee. There are no regulations related to ashkui in the lower Churchill River watershed. Although there are no regulatory requirements associated with the Mud Lake Crossing or with ashkui, the LCP made commitments during the Joint Panel Review process regarding ice formation monitoring in relation to both.

To comply with commitments made the LCP has, or will:

- conduct ice formation surveys to identify the location and size of ashkui on the Churchill River within the full supply level of the reservoir and downstream past Mud Lake (Nalcor 2009a);
- conduct ice formation surveys below Muskrat Falls and at the Mud Lake Crossing during Project construction and operation;
- identify mitigation options to support continued, safe use of the Mud Lake Crossing;
- conduct monitoring or follow-up, as appropriate, to determine the success of mitigation; and
- if required, implement contingency plans if the mitigation is found to be unsuccessful.

The intent of the IFEEMP is to allow the LCP to:

- evaluate and respond appropriately to the findings of the follow-up or monitoring programs as they relate to the Project effects during construction and operation on the viability of the ice bridge at the Mud Lake Crossing during the winter season; and
- identify suitable locations to conduct Waterfowl-Ashkui surveys.

In addition, the NL Reg. 18/12, also referred to as the *Lower Churchill Hydroelectric Generation Project Undertaking Order* releases the Project from environmental assessment and sets conditions for this release that LCP must meet. The release of the Project from environmental assessment under section 3 is subject to the following conditions:

(a) Nalcor Energy shall abide by all commitments made by it in the Environmental Impact Statement dated February 2009, and all the Environmental Impact Statement Additional Information Requests made by the Lower Churchill Hydroelectric Generation Project Environmental Assessment Panel and consequently submitted by Nalcor Energy, and the submissions made by Nalcor Energy during the panel hearings and, subsequent to the hearings, to the panel, unless one or more of the commitments, or a part of a commitment is specifically waived by the minister;

(e) Nalcor Energy shall prepare and abide by the requirements of environmental effects monitoring plans for all phases of the project, and those plans shall be submitted to and approved by the Minister of Environment and Conservation or the appropriate minister of the Crown before the commencement of an activity which is associated with or may affect one or more of the following matters:

(vii) ice formation

Submission of this EEMP satisfies the condition/requirement in NL Reg. 18/12 that Nalcor Energy prepare and submit to the Minister of Environment and Conservation or the appropriate minister of the Crown, an environmental effects monitoring plan for all phases of the project, before the commencement of an activity which is associated with or may affect the following matters:

(vii) ice formation

# 9 ENVIRONMENTAL EFFECTS MANAGEMENT

The effects management plans (i.e., mitigation measures outlined in the EIS [Nalcor 2009a] and the Generation and LTA Environmental Protection Plan and the commitments made by the LCP during the Information Request responses and the Joint Review Panel review process as they relate to ice formation at the Mud Lake Crossing location include:

- Conduct an ice observation monitoring program throughout the reservoir, downstream of Muskrat Falls to the mouth of the Churchill River, and Lake Melville to develop a better understanding of the ice processes, including timing of ice formation and break-up, area covered, and identification of open water areas including ashkui;
- Conduct satellite-based monitoring of ice progression and stability in the vicinity of Mud Lake and Happy Valley-Goose Bay;
- Monitor ice thickness at select locations on the Churchill River, and issue public advisories on the condition of ice (Nalcor 2009a Exec Summ, Land and Resource Use) to the communities affected;
- Consider alternative transportation options in the event that the transition period between use of the Mud Lake Crossing for snowmobile travel during the winter and boat travel in the spring across the Churchill River is lengthened by more than two weeks.
- The LCP will continue to consult with the residents of Mud Lake to discuss alternative means of traveling to Happy Valley-Goose Bay, if the duration of the transition period is extended by the Project (JRP 2009).
- The LCP and the Province will negotiate an agreement with the residents of Mud Lake, and the LCP will provide residents of Mud Lake alternative means of transportation if the time the residents are unable to cross the Churchill River during freeze-up or break-up exceeds two weeks, without requiring proof that the Project has caused the problem. Given the natural variability of ice formation among years, it is difficult to identify a reasonable threshold date from which to measure a two week exceedance. Therefore, the LCP and the residents of Mud Lake will communicate regularly to establish whether alternate transportation is required for a certain period of time.

It is noted that climate change may be a factor in any future changes in ice formation on the lower Churchill River (JRP 2011), and ice monitoring programs implemented by LCP, and other sources may provide long-term information on climate change effects on ice formation, as well as support the LCP's commitments in relation to this IFEEMP.

# 10 ENVIRONMENTAL EFFECTS MONITORING

This IFEEMP contains both:

Follow-up Programs – studies or surveys designed and implemented to evaluate the predictions of the environmental assessment and to determine the effectiveness of any measure taken to mitigate the adverse environmental effects of the Project; and

Monitoring Programs – studies or surveys designed and implemented to determine whether the Project is implemented as proposed, and that mitigation measures proposed by the LCP to minimize the Project's environmental effects are implemented and effective.

## 10.1 SURVEY PROTOCOLS

The LCP has committed to conduct follow-up and monitoring programs to evaluate the effectiveness of the effects management plans, and to determine if expansion or reduction or deletion of the indicated programs is appropriate (with justification). This would apply to the following, as appropriate:

- data collection during construction;
- data collection during operations; and
- follow-up and monitoring reporting.

Protocols for the data collection are discussed in the following subsections. Data collection includes metrics that are specific, quantifiable, relevant and time constrained. The goal is to collect meaningful data in a focused, defendable, repeatable approach, within an appropriate timeline to ensure that the mitigation is appropriate. Where it is determined that the mitigation is not appropriate or can be improved, a contingency plan would be presented that the LCP would incorporate as per their adaptive management approach.

### 10.1.1 Baseline Data Collection

Baseline data collection refers to the determination of relevant data regarding ice formation and ice break-up at the Mud Lake Crossing of the Churchill River between Mud Lake and Happy Valley-Goose Bay, and the presence of ashkui in the lower Churchill River watershed. Ice data related to the Mud Lake Crossing has been collected for more than 40 years by residents of Mud Lake with valuable knowledge pertaining to the ice formation along the Mud Lake Crossing and has been summarized in the Existing Information section, Table 7-1. In addition, the LCP has undertaken ice monitoring specific to the lower Churchill River and, specifically, the Mud Lake Crossing since 2010 (Hatch 2010a; SNC Lavalin 2012a,b; Golder 2014, 2015, 2016, 2017).

Baseline surveys have been conducted to document the presence of ashkui in the lower Churchill River watershed in the Project area. The survey results are presented in Minaskuat (2009) and are integral to data collection during construction and considered the initial part of that process. Surveys were also conducted by Stantec in 2014 and presented elsewhere (Stantec 2014).

##### *10.1.1.1 Data Collection during Construction*

The LCP initiated the collection of ice data in 2010, to be continued during Project construction. Reservoir creation involves construction to the winter head pond (water level at ~25 m) in 2017, and reaching the full supply level (39 m) in 2019. The surveys discussed in the following subsections are being, and will be conducted, during the construction period. The section of the lower Churchill River monitored spans 40 km and covers an area of approximately 60 $km^2$. The width of the river varies between 100 m to 3200 m, with the elevation ranging from 15 m at Muskrat Falls to 0 m at the mouth of the river. The largest accumulation of ice occurs just below Muskrat Falls where the river suddenly widens and quickly narrows again, trapping enormous amounts of ice. Ice build-up here is a result of the powerful rapids that push ice under the existing ice cover in this area.

##### *10.1.1.2 Ice Observation Program– Ice Formation and Ice Break Up*

Satellite-based ice monitoring will be focused on the lower Churchill River from Muskrat Falls to Mud Lake during the ice formation (November to December) and ice break-up (mid-April to mid-June) periods, with the objective of verifying ice progression and stability in the vicinity of Mud Lake and Happy Valley-Goose Bay, including the stability of the Mud Lake Crossing.

A total of 20 images will be acquired using the COSMO-SkyMed (CSK) constellation (a resolution data (2.5 m) consisting of four SAR (synthetic-aperture radar) satellites), the S1 constellation (consisting of two SAR satellites) and L8, which is an optical satellite. Image orders for CSK will require a primary and a secondary (i.e., back-up) plan. When a primary image is not acquired, the secondary image will be obtained, which was typically 12 hours later. L8 images may also be obtained to fill a gap in the image plan when no SAR images are available for acquisition.

The preparation of image acquisition plans considers several factors including spatial resolution, incidence angle, look direction, and the area of interest. These factors are defined by the particular application and can restrict image availability and coverage. The 20 images to be acquired consist of a combination of high, medium, and low resolution SAR images and one, medium resolution optical image.

The analysis of radar satellite imagery will include the following:

- Generation of ice products indicating ice front location (i.e., grey scale image showing the extent of the ice cover) and classification (i.e., three classes: water, intact ice, consolidated ice) – for each image;
- Generation of ice products indicating cover change (i.e., change in backscatter observed in pairs of successive images) – for each available image pair; and
- Review of and comparison of the results with ice products from previous years to identify changing ice conditions.

The following ice classification protocols will be used:

- Ice classification is based on ortho-rectified images that have been calibrated
- An unsupervised classification method is used for ice classification
- For each satellite image, ice products will be generated indicating ice front and classification
- Ice cover change products will be generated from all available image pairs

An ice floe concentration analysis will be performed on the lower Churchill River using classified satellite images acquired during the freeze-up and break-up processes. Ice floe analysis will be conducted for the purpose of studying the changing ice cover during the freezeup and break-up over the reach between Muskrat Falls and Lake Melville. Separate analyses will be conducted for ice break-up and freeze-up periods. Seven areas have been selected for analysis based on the locations of analyses completed in the previous studies, and then buffered to include a distance of two kilometers to provide a comparable analysis to previous years (see Figure 10-1). The results of the ice floe analysis are based on the river ice classification. Non-consolidated and consolidated ice classes are combined representing ice cover and a percentage was calculated. Open water percentages were calculated from the open water class.

#### *10.1.1.3 Ashkui Survey*

Pre-impoundment, a survey will be conducted that involves the identification and mapping of ashkui. As indicated in the Waterfowl-Ashkui survey protocol described in the Avifauna Protection and EEMP (Nalcor 2013), a qualified avian biologist will conduct the ice monitoring survey to identify open water areas (ashkui) suitable as habitat for waterfowl such as surf scoter (see Stantec 2014 for more specific information). The Waterfowl-Ashkui survey will subsequently be conducted to observe waterfowl use of the ashkui as staging areas prior to dispersal to breeding locations, and will include observations of the ashkui as well.

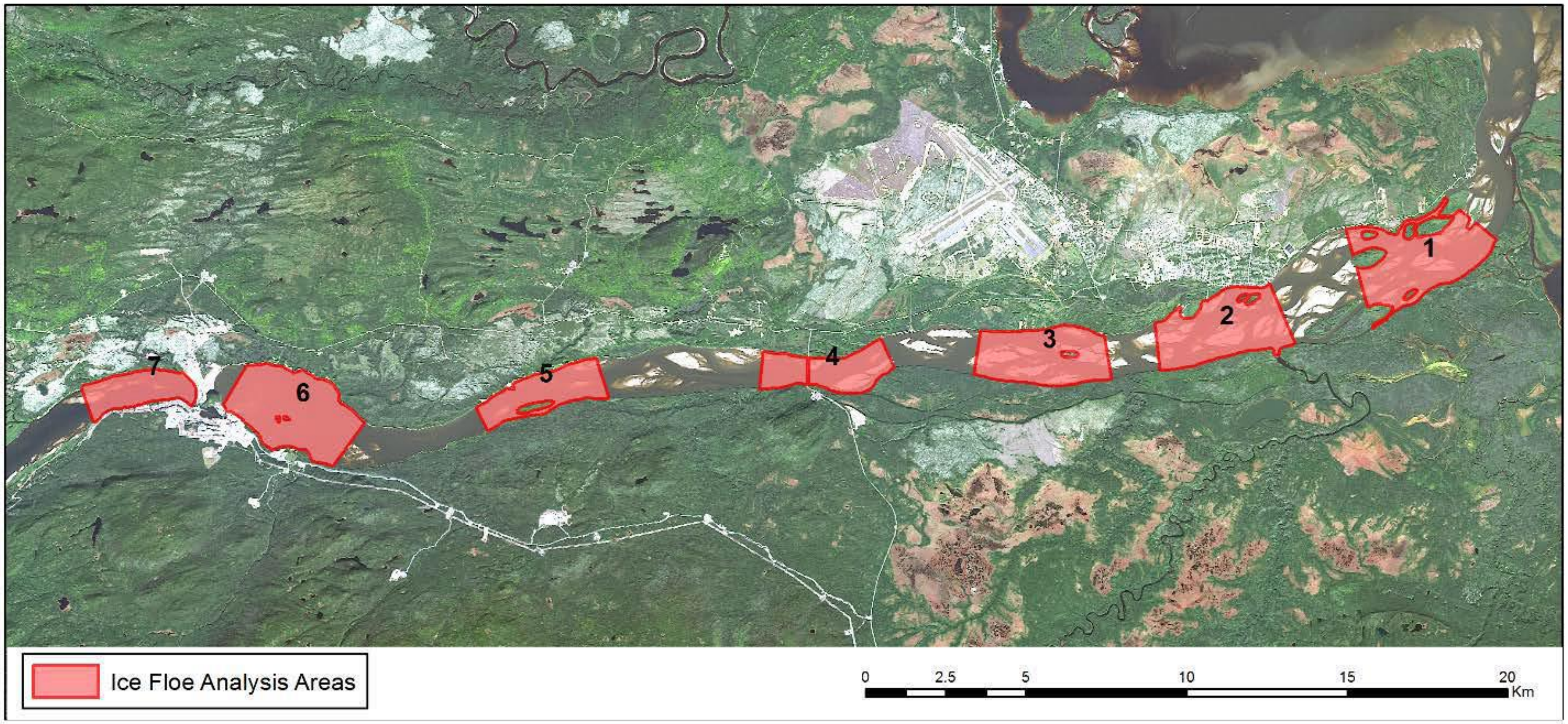


**Figure 10-1 Locations to be used for ice floe analysis**

### 10.1.2 Data Collection during Operations

#### *10.1.2.1 Post- Impoundment Ice Observation Survey – Ice Formation and Ice Break-Up*

As described in Section 10.1.1.2 for the construction period, during operations (i.e., once reservoir full supply level has been reached) data collection will continue for the first five years. The objective will be to identify the timing of ice formation at the Mud Lake Crossing, for comparison with the time of ice formation prior to and during construction.

A satellite based ice monitoring will continue on the lower Churchill River from Muskrat Falls to Mud Lake during the ice formation (November to December) and ice break-up (mid-April to mid-June) periods once reservoir full supply level has been reached (i.e., during Project operation). As for the survey during Project construction, the objective will be to verify ice progression and stability in the vicinity of Mud Lake and Happy Valley-Goose Bay, including the stability of the Mud Lake Crossing. Image acquisition will be based on recommendations made following the analysis conducted during the Project construction phase, and analysis will be completed as described for the construction period.

#### *10.1.2.2 Askhui Survey*

Five years post-construction, an ice break-up survey will involve the identification and mapping of ashkui to support the Waterfowl-Ashkui survey protocol described in the Avifauna Protection and EEMP (Nalcor 2013). A qualified avian biologist will be included in the ice monitoring survey to identify open water areas (ashkui) suitable as habitat for waterfowl such as surf scoter. The Waterfowl-Ashkui survey will subsequently be conducted to observe waterfowl use of the ashkui as staging areas prior to dispersal to breeding locations, and will include observations of the ashkui as well.

#### *10.1.2.3 Ice Measurement Survey – Mud Lake: Operations*

In preparation for the operations phase of the project, methods to provide ice thickness measurements during freeze up and break up, as committed during the EA, that can be safely executed, are being investigated. LCP will explore the use of ground penetrating radar during the 2017-18 ice season as a pilot study to determine the most suitable methodology to meet this commitment during the operations phase. A comprehensive river ice survey will be performed using a helicopter mounted Ground Penetrating Radar (GPR) system.

The results of the ice measurement survey will be reported following the completion of the study in 2018.

### 10.1.3 Follow-up Program

A final Follow-up and Monitoring Report will be generated based on compilation of information as discussed in the following subsections.

#### *10.1.3.1 Follow-up*

The Follow-up portion of the report will include the collation of all data related to ice formation in relation to the Mud Lake Crossing and ashkui locations collected during the pre-construction and construction periods, and during operations. The report will consider the data and discuss the effects observed in relation to the predictions made in the EIS in relation to the Mud Lake Crossing (i.e., a delay in freeze-up suitable for ice crossing formation by two weeks and delay in ice break-up by one week).

The ashkui data will be reported in the Avifauna Environmental Effects Monitoring Report in 2014 and in 2024 during the operations phase.

#### *10.1.3.2 Monitoring*

The Monitoring portion of the report will summarize mitigation efforts undertaken and demonstrate that mitigation measures to minimize the Project's adverse environmental effects on the Mud Lake Crossing were implemented appropriately. A subsection to address Compliance Monitoring will be included to ensure Project compliance with commitments made in the EIS, the responses the LCP provided to the information requests, and conditions of EA release. In the case that significant changes to ice formation downstream are observed and considered attributable to the MF Project, the LCP will consider mitigation options as per LCP's adaptive management approach.

Reporting will include a summary of field results after each survey. The data will be compiled once each year and evaluated to determine the timing of ice formation and break-up along the river and, specifically, for the Mud Lake Crossing.

The LCP will provide the report to the Water Resources Management Division of NL Department of Municipal Affairs and Environment for review.

### 10.1.4 Reporting

Reporting will include a summary of field results after each survey. The data will be compiled once each year and evaluated to determine the timing of ice formation and break-up along the river and, specifically, for the Mud Lake Crossing.

The LCP will provide the report to the Water Resources Management Division of NL Department of Municipal Affairs and Environment for review.

Satellite imagery will be provided to Water Resources Management Division as soon as it is available.

#### 10.1.5 Contingency Plan

At this time, contingency plans are not anticipated in relation to ice formation at the Mud Lake Crossing and any changes to the LCP's procedures or mitigation plans would be addressed through the adaptive management approach, if and as appropriate. The LCP is anticipating that the ice thickness and stability of the Mud Lake Crossing will be maintained for safe use during the winter season during Project operations, and therefore it will not be necessary for the LCP to provide or arrange for alternate means of transportation across the Churchill River. Any changes proposed by the LCP would be based on the findings of the Follow-up and Monitoring Programs.

If any effects are attributable to the Project, contingencies will be provided through alternate ground routes such as snowmobile trails or helicopter as deemed necessary.

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