Keeyask Generation Project

Socio-Economic Monitoring Plan

Socio-Economic Monitoring Report

SEMP-2023-01

KEEYASK

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2022 -2023

KEEYASK GENERATION PROJECT

SOCIO-ECONOMIC MONITORING PLAN

REPORT #SEMP-2023-01

SOCIO-ECONOMIC MONITORING REPORT

APRIL 2022 TO MARCH 2023:

YEAR ONE OPERATION

Prepared by

Manitoba Hydro

JUNE 2023

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SUMMARY

The Keeyask Generation Project ("the Project" or "KGP" or "Keeyask") Environmental Impact Statement (EIS), completed in June 2012, provides a description of the existing environment, a summary of predicted effects, and planned mitigation for the Project. Technical supporting information for the socio-economic environment, including a description of the existing environment, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the Socio-Economic Environment, Resource Use and Heritage Resources Supporting Volume.

The environmental assessment for the KGP used both technical science and Aboriginal Traditional Knowledge (ATK[1]). Mitigation measures were carefully planned and designed to prevent or reduce (to the extent practical), adverse effects from the Project. However, there were uncertainties associated with predicted effects and the effectiveness of planned mitigation measures. To address these uncertainties, many of the predictions and mitigation measures identified in the KGP EIS are supported by monitoring to enable testing of the predictions and timely response when actual results differ from the predictions.

The KGP Socio-Economic Monitoring Plan (SEMP) is a commitment made by the Keeyask Hydropower Limited Partnership (KHLP) in Chapter 8 of the KGP EIS. The SEMP is intended to monitor changes over time for certain socio-economic Valued Environmental Components (VECs). During the construction phase, the SEMP focused on key pathways of effect to, and components of, the socio-economic environment, including:

- Economy;
- Population, Infrastructure and Services; and
- Personal, Family and Community Life.

On Sept. 8, 2022, the Waciye Water Ceremony and Blessings was held at the Keeyask site to acknowledge all generating units being brought online and the effects and the changes made to the land and waterways. This Ceremony acknowledged the efforts of all the partners involved in addition to the people of the four nations, the territory, and Keeyask as a whole community to bring Keeyask into operation.

Going forward, the SEMP report during operations reviews the monitoring outcomes and activities of 1) Population in Gillam and 2) the Mercury and Human Health Risk Management Plan. The SEMP also outlines a commitment to report on water levels at Split Lake to select communities. This information is provided in the annual Physical Environment Monitoring Plan report and also

[1] The term 'Aboriginal Traditional Knowledge' (ATK) was used during the Keeyask planning and licensing phases and in subsequent regulatory reports. After discussing terminology with partner First Nation communities, each community indicated a different preference in using 'Aboriginal Traditional Knowledge" versus "Indigenous Traditional Knowledge". For consistency with past reports, the term ATK continues to be used in this report.

presented in the SEMP. This Year 1 Operation report focuses on SEMP monitoring activities for the Project after March 31, 2022.

Key learnings of the SEMP Program over the 2022/23 period and next steps are presented below by monitoring topic area.

POPULATION:

- The most recent changes to population observed in 2020-2021 for Gillam are consistent with trends observed over time. The slight decreases in population across the community does not suggest a significant pattern of operation related in- or out-migration.

MERCURY AND HUMAN HEALTH:

- Manitoba Hydro and the partner First Nations have worked together since 2007 to study the issue of mercury and human health, and consider related past experience, Aboriginal Traditional Knowledge and scientific information. The Mercury and Human Health Implementation Group, on behalf of the KHLP, prepared a Mercury and Human Health Risk Management Plan in consultation with provincial and federal regulators and oversees its implementation. Local implementation of program activities that support the goal of the risk management plan is achieved through a 'Mercury Community Coordinator' role in each partner First Nation with support from MHHIG members.
- This reporting period's key outcomes include:
    - Mercury Community Coordinators serve as local information resources about mercury and human health and coordinate activities to build understanding about the risks and benefits of eating fish. Examples of activities include local information / education sessions with youth, fishing events, and work towards Cree-informed communication materials.
    - To provide an opportunity to understand mercury levels in one's body, Mercury Community Coordinators hosted (free and confidential) hair sampling events and offered sampling to individuals, as requested. Results showed that 100% of the 82 participants' hair mercury levels were within levels considered acceptable by World Health Organization and Health Canada. A wild foods survey, offered in conjunction with hair testing, showed that most participants harvest, share and/or eat fish locally and primarily from non-Keeyask impacted or off-system waterbodies.
    - Results from annual monitoring of fish in Gull Lake[2] show fish mercury concentrations in pickerel, jackfish and whitefish are within expected levels and below predicted peak concentrations. Average fish concentrations of pickerel and jackfish in Stephens Lake have approached predicted peak concentrations (0.5 parts per million) yet remain within historically observed levels. Monitoring will continue annually in both lakes.

[2] Also referred to in other monitoring reports as the Keeyask or Gull Reservoir.

- A Project toxicologist reviewed fish monitoring results and determined that fish consumption recommendations developed for post-impoundment (peak) conditions in Gull and Stephens lakes remain current.
- Keeyask Communication Products containing safe fish consumption recommendations have been distributed to communities, including Safe Catch Posters and fish tape for Gull and Stephens lakes. ‘Safe Catch’ signage and government-issued Public Notices were installed at two Stephens Lake boat launch locations in the Gillam area.
- Mercury levels in wildlife (e.g., beaver, moose, caribou, ducks, and geese) and plants (e.g., blueberries and Labrador tea) consumed by community members were expected to remain healthy wild food options after impoundment. Beaver and muskrat samples collected in 2022 through the Terrestrial Effects Monitoring Plan remain low in mercury showing there is no risk associated with the Project to consuming this wildlife. Community members are also encouraged to submit samples of wildlife for mercury analysis to help confirm predictions.

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1.0 INTRODUCTION

Manitoba Hydro, on behalf of the KHLP, received regulatory approval to commence construction of the Keeyask Generation Project in July 2014. In preparation for this license, the environmental assessment for the KGP considered both technical science and Aboriginal Traditional Knowledge. Monitoring efforts and mitigation measures were carefully planned and designed to prevent or reduce (to the extent practical) adverse effects from the Project. A range of monitoring programs have been established to confirm predicted effects and effectiveness of planned mitigation measures and/or inform adaptive management, if required.

The construction phase ended March 9, 2022. Due to this transition, SEMP reporting requirements have changed and will no longer include monitoring related to construction, business opportunities, income, housing, infrastructure and services, road traffic volume, public safety and worker interaction, road-based travel, access and safety, and cultural, heritage and spirituality components.

During the operations phase, the SEMP committed to reporting on the following of the socio-economic environment components including:

- Population changes in Gillam (to be implemented annually over first five years of the operation phase);
- Information on monitoring of water levels at Split Lake (to be implemented annually, reported to TCN and YFFN only); and
- Updated HHRAs (approximately every five years after peak mercury levels have been reached, until mercury levels return to baseline conditions; for review with the partner First Nations and with federal and provincial health authorities) to include:
    - Food surveys, to be undertaken in the partner First Nations communities (approximately every five years after peak mercury levels have been reached, until mercury levels return to baseline conditions; for input into the HHRAs);
    - Hair monitoring, to be undertaken on a voluntary basis in the partner First Nations communities (approximately every five years after peak mercury levels have been reached, until mercury levels return to baseline conditions; for input into the HHRAs); and
    - Documenting annual progress made of the implementation of the RMP, associated engagement with KCNs communities, other stakeholders, and summary results from the AEMP, TEMP and HHRA (where applicable).

This Year 1 Operation report focuses on SEMP monitoring activities for the Project after March 31, 2022, and reports on the monitoring outcomes and activities of 1) Population in Gillam and 2) Mercury and Human Health Risk Management Plan. The SEMP outlines a commitment to report on water levels at Split Lake to select communities. This information is provided in the Annual Physical Environment Monitoring Plan Report and included within this Report.

On Sept. 8, 2022, the Waciye Water Ceremony and Blessings was held at the Keeyask site to acknowledge all generating units being brought online and the effects and the changes made to the land and waterways. The gathering was attended by leadership, elders, youth and advisors from the partner First Nation communities, and representatives of Manitoba Hydro. The partner First Nations community representatives and Keeyask Employee Retention Services staff were involved in conducting the gathering's activities, which included remarks, a pipe ceremony, a water ceremony, prayers, and a feast shared by all. This Ceremony acknowledges the efforts of all the partners involved in addition to the people of the four nations, the territory, and Keeyask as a whole community in bringing Keeyask into operation.

Photo 1: Waciye Ceremony at Keeyask

2.0 OVERVIEW OF PROJECT

The Keeyask Generation Project is a 695 megawatt (MW) hydroelectric generating station located approximately 180 km northeast of Thompson and 40 km southwest of Gillam at Gull Rapids on the lower Nelson River. The Project consists of four principal structures: a powerhouse complex, spillway, dams, and dykes. In 2020, a reservoir was created upstream of the principal structures. Supporting infrastructure consists of temporary facilities required to construct the principal structures and permanent facilities required to construct and operate the Project. Temporary infrastructure consists of work areas, cofferdams, rock groins, and an ice boom. Permanent supporting infrastructure consists of North and South Access Roads, a transmission tower spur, a communications tower, some borrow areas, excavated-material placement areas, boat launches, and a portage to enable river traffic to bypass the dam.

Map 1 shows the Socio-Economic Study area applied to the environmental assessment and the SEMP construction monitoring phase. For reference during operation phase, it includes the location of partner First Nations' communities, relative to Keeyask, of Tataskweyak Cree Nation (TCN) at Split Lake, War Lake First Nation (WLFN) at Ilford, York Factory First Nation (YFFN) at York Landing and FLCN at Fox Lake/Gillam and the Town of Gillam. In addition to being home to FLCN members living on and off-reserve, the Town of Gillam is Manitoba Hydro's northern operations base.

3.0 OVERALL OBJECTIVES AND APPROACH

The KGP EIS identified primary effects to the socio-economic VECs and defined the process, scope, methods, documentation, and application of the socio-economic monitoring for the Project. Overall, the intent of Manitoba Hydro and the partner First Nations has been to reduce adverse effects of the Project and to enhance Project benefits to the extent feasible and practical. Monitoring information is intended to assist in this management task. The SEMP is intended to monitor changes over time for certain VECs to, where applicable:

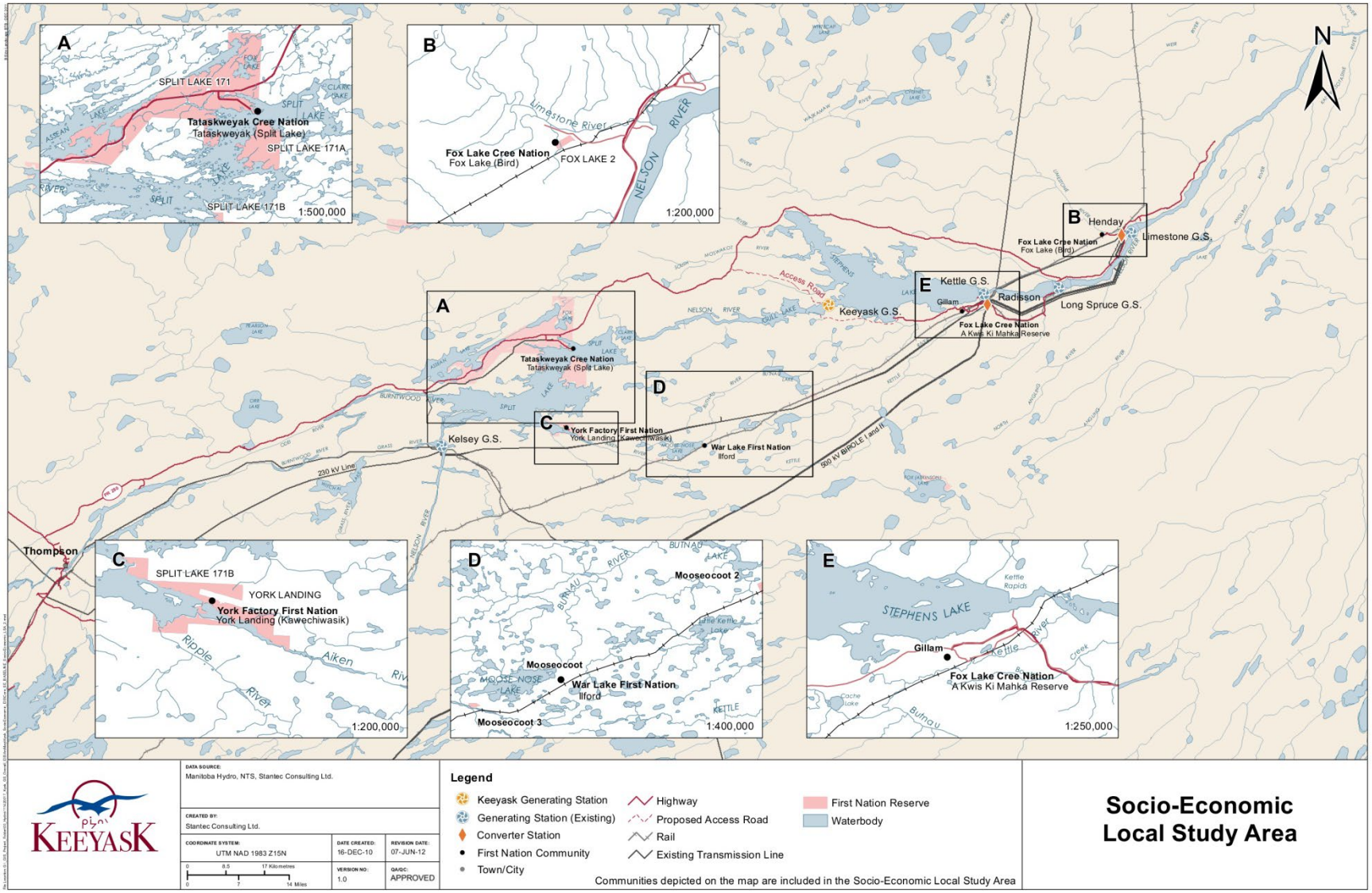
- Test predicted effects in the EIS;
- Identify unanticipated effects related to the Project;
- Monitor the effectiveness of mitigation measures;
- Determine if adaptive management is required; and
- Confirm compliance with regulatory requirements, including terms and conditions in Project approvals.

The SEMP focuses on key pathways of effect to, and components of, the socio-economic environment and builds on the assessment studies conducted for the EIS using established methods for data collection and analysis.

4.0 OVERALL SCHEDULE

Monitoring activities are outlined in SEMP (2015) as follows:

- **Construction Phase** – SEMP monitoring during construction is related to employment and training opportunities, business opportunities, income, population changes, housing, infrastructure and services, transportation infrastructure, public safety and worker interaction, travel, access and safety, and culture and spirituality. The 2021-2022 Socio-Economic Monitoring Plan Annual Report concluded the construction monitoring phase.
- **Operation Phase** – SEMP monitoring during operation assesses population change in Gillam (first five years of operation), mercury and human health risk management activities and communicates monitored water levels at Split Lake.



Map 1: Socio-Economic Local Study Area

4.1 POPULATION – TOWN OF GILLAM

The KGP EIS predicted the Project would not result in notable change in the number of people in Gillam. However, measuring levels of in- and out-migration is difficult, with limitations existing for all related data sources. The Town of Gillam is Manitoba Hydro's northern operations base and operational staff for the Project are located in Gillam. Population is being monitored to confirm the extent of Project-induced migration to Gillam to assess and help plan for impacts on housing, services and infrastructure, if any.

Population data for the Town of Gillam is based on data from Manitoba Health's annual health statistics, which were available up to 2021. As shown in the graph below, the population of Gillam experienced slight annual increases between 2008 and 2011, and, with the exception of a slight increase between 2012 and 2013, slight but continual annual decreases between 2012 and 2021. The slight decline in population does not suggest any additional pressure on housing, services and infrastructure related to in-migration for the operation of Keeyask.

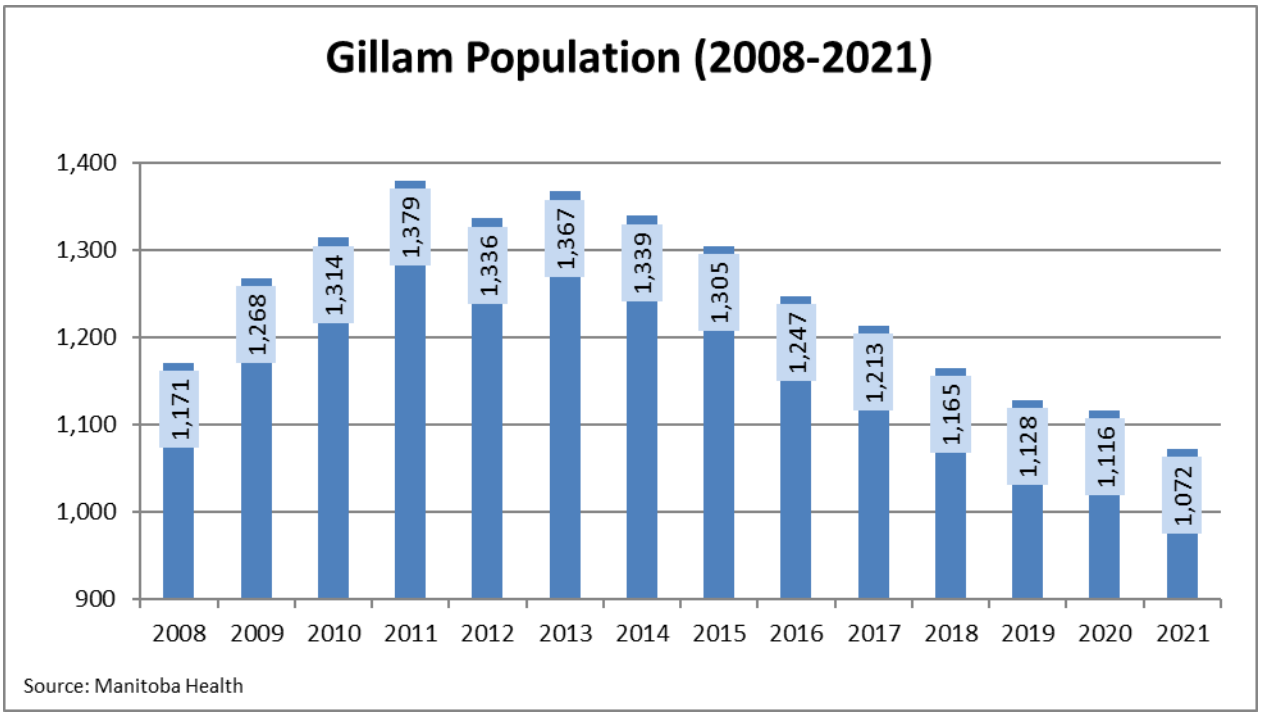


Figure 1: Gillam Population (2008-2021)

4.2 MONITORING OF WATER LEVELS ON SPLIT LAKE

The commitment to monitor water levels at Split Lake is fulfilled in the Physical Environment Monitoring Plan (PEMP). This information is reported annually to Tataskweyak Cree Nation and York Factory First Nation and included below (See figure 2).

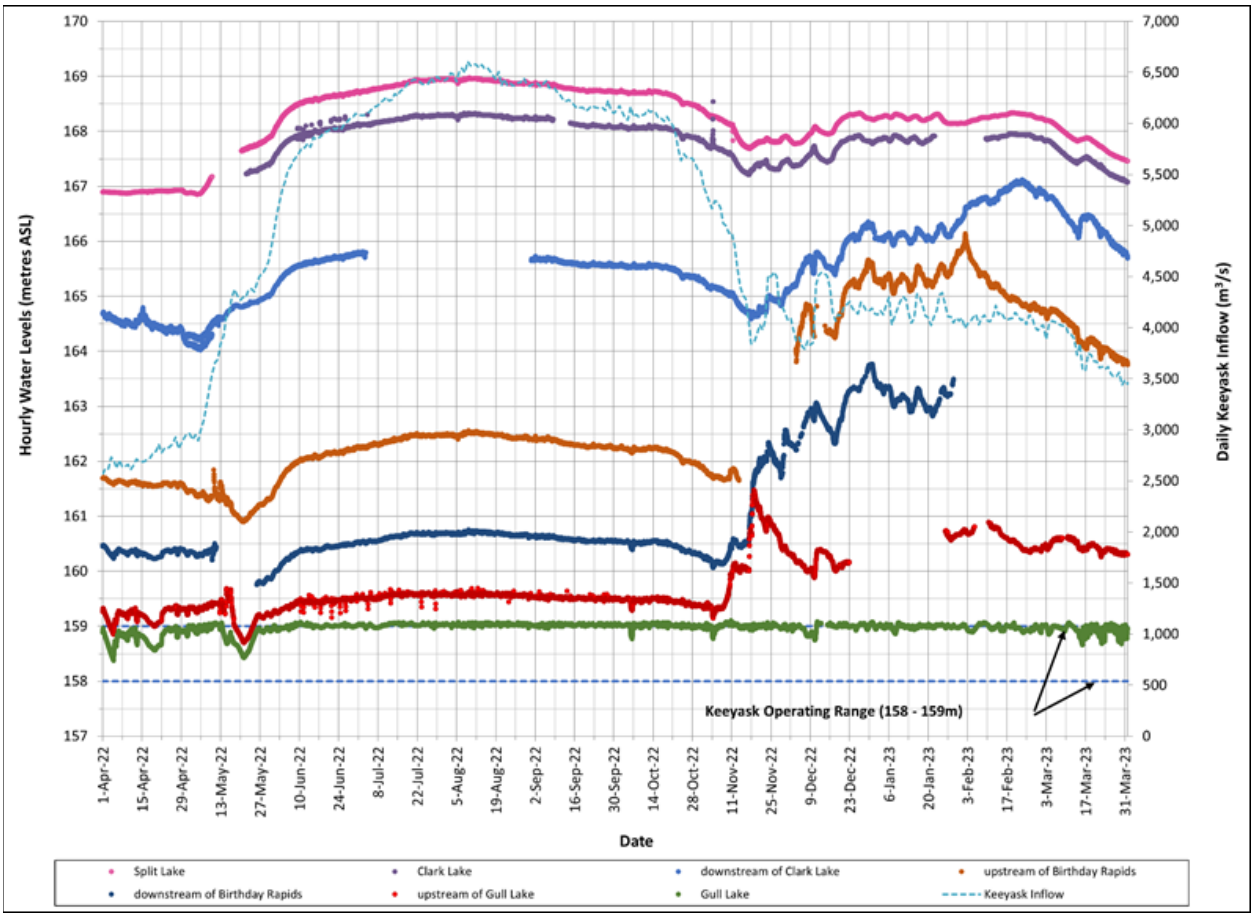


Figure 2: Split Lake Water Levels 2022-2023

4.3 MERCURY AND HUMAN HEALTH

As a result of past experiences with hydroelectric development, the partner First Nations raised the issue of mercury and human health as a primary concern in relation to the KGP. Manitoba Hydro and the partner First Nations have been working together since 2007 to study the issue and communicate information related to mercury and the Project. The KHLP, through the Mercury and Human Health Implementation Group (MHHIG), with advice from technical and health experts, developed a Mercury and Human Health Risk Management Plan. Key components of this plan include:

- a communication strategy about fish consumption for resource users in affected waterbodies;
- voluntary hair sampling;
- monitoring of mercury in fish, wildlife, and plants; and
- periodic human health risk assessments.

Local implementation of mercury and human health programing is achieved through the hiring of Mercury Community Coordinators (or delegates) in each partner community, with support from MHHIG members.

Mercury is a metal found naturally in small amounts in rock, air, soil, water, and living organisms. It can be released into the environment through natural processes, but mainly as a result of human activity related to industrial development. When organic material such as peat is broken down by bacteria, mercury is converted to a more toxic form called methylmercury. Methylmercury becomes more concentrated as it moves up the food web from bugs to smaller fish to larger predatory fish. This process occurs in the natural environment and can be accelerated by processes such as flooding. It is most affected by unnatural causes, like the larger scale flooding caused by the creation of a hydroelectric reservoir.

It was predicted that the creation of the Keeyask reservoir in 2020 will raise mercury (methylmercury) levels in fish in Gull Lake and to a lesser extent, Stephens Lake. Mercury levels will increase, mostly due to the breakdown of peat in the reservoir. Fish mercury levels are estimated to peak 3-7 years after impoundment and gradually decrease over the next 20-30 years to levels similar to non-impacted waterbodies in the region.

People can be exposed to mercury (methylmercury) through eating fish. Larger, predatory fish, like pickerel and jackfish, generally have higher mercury levels than smaller fish. Too much mercury can cause human health problems, particularly for the developing brain (e.g., babies and children); however, all age groups are susceptible to some extent if mercury intake is too high.

Mercury in surface water does not become concentrated like it does in fish. Studies show that at current levels, drinking and recreational use of water is not a threat to human health as a result of mercury.

Because fish is an important part of a healthy traditional diet and offers many important health benefits, the MHHIG has worked to build awareness and understanding in the partner First Nation communities about mercury and the risks and benefits of eating fish.

This section focuses on the key KHLP activities related to mercury and human health in 2022-2023.

4.3.1 MERCURY AND HUMAN HEALTH IMPLEMENTATION GROUP MEETINGS

Prior to the pandemic, the MHHIG normally met quarterly for in-person meetings. During the 2022-23 reporting period, the MHHIG met 5 times, in-person and virtually over the course of the year. MHHIG discussions were supported by separate meetings with Mercury Community Coordinators, subject matter experts (toxicologist, aquatic biologist, hair monitoring consultant) and provincial health representatives (Medical Officer of Health [MOH], Manitoba Health and MOHs of the Northern Health Region and First Nation Inuit Health Branch). Key topics for discussion included:

- Community-based initiatives considered or undertaken by each community intended to build understanding about mercury and promote healthy fish food consumption, including consideration of Aboriginal Traditional Knowledge, experiences, and perspectives about eating fish (see Section 4.3.3).
- Highlights from Hair Sampling and Food Survey Program (see Section 4.3.4):
    - Evaluation of pre-impoundment hair sampling program ('lessons learned') and subsequent refinements to associated program implementation and materials, including redevelopment of food survey.
    - Preparation for and implementation of post-impoundment hair sampling events, including hair sampling refresher training.
    - Review of post-impoundment hair sampling results.
- A review of preliminary human health risk interpretation of fish mercury concentrations predicted for post-impoundment conditions relative to 2022 fish monitoring results (see Sections 4.3.5 and 4.3.6), including evaluation of currency of fish consumption recommendations.
    - Consideration of contingency plan for Stephens Lake communication products in the event that mercury levels exceed predicted peak levels.
- Review of overall communication products and approach to distribution each community and other stakeholders.

These issues and outcomes are described below.

4.3.2 COMMUNICATION STRATEGY

The Mercury and Human Health Risk Management Plan (RMP) commits to communicate potential risks to human health from increased methylmercury in the environment as a result of the Keeyask Project. Over the reporting period, the MHHIG refined select post-impoundment communication products, which were developed in 2020-2021. These products are intended to support community-based activities that promote RMP goals, such as to build understanding about mercury and human health and encourage safe harvesting, sharing, and eating of healthy wild foods diet. Post-impoundment communication products include information related to predicted mercury concentrations in fish at peak levels, consumption advice for those consuming fish from the reservoir and downstream areas, and information about hair sampling and the food survey program.

Partner First Nations experiences and knowledge and scientific / regulatory agency guidance were considered to develop accurate and meaningful messaging for partner First Nation community members and people who consume fish in the Project area. This included partner First Nation members' experiences with past hydroelectric development, the cultural importance of traditional harvesting practices and consumption of local wild foods, range of communication preferences, anticipated Project effects, fish mercury concentrations and hair sampling and food survey program information.

The suite of post-impoundment communication products is shown in Appendix 1 and includes:

- "Mercury in Fish and Your Health" brochure which outlines Project effects as a results of reservoir creation, what to expect with mercury concentration in wild foods, monitoring activities and local information resources (issued in 2021).
- "Safe Catch" posters for Gull Lake and Stephens Lake which provide fish consumption recommendations for sensitive and general populations under post-impoundment period (peak conditions) (revised 2022).
    - To date, aluminium signage (Safe Catch Poster) has been installed at Stephens Lake in two public boat launch areas frequented by local resource users and Gillam area residents. This signage is accompanied by Manitoba Government Public Notice (Mercury in Fish). Additional signage will be installed at Keeyask upstream (Gull Lake) and downstream (Stephens Lake) boat launch sites in summer, 2023.
- Fish tapes for Gull Lake and Stephens Lake which visually categorizes post-impoundment (predicted peak) mercury concentrations and associated consumption categories for three fish species (i.e., very low to high mercury) (revised 2022)
- Postcard and equivalent poster which is intended to prompt interest in mercury and human health programming with an emphasis on consumers of fish in Stephens Lake (issued 2021).

All products were reviewed to make sure they were current and were and approved by the MHHIG with input from provincial and federal health representatives. Products have been distributed to each community for local distribution. Mercury Community Coordinators in each community, with the support of Manitoba Hydro staff, manage the extent and nature of distribution in their respective communities. Because of the proximity of Keeyask and Stephens Lake to Gillam, the materials noted above were provided to the Town of Gillam, as well as an offer to meet with Gillam leadership to discuss communication and engagement ideas and preferences. The Manitoba Hydro staff will follow up in summer, 2023.

Photo 2: Safe Catch Poster for Stephens Lake

4.3.3 COMMUNITY BASED ACTIVITIES

Individuals fulfilling the role of Mercury Community Coordinators assisted in the implementation of mercury and human health related activities and organized mercury and human health events in each partner First Nation community. The following activities were achieved:

- Community events such as fishing derbies, youth camps, and education opportunities at cultural events to generate interest and understanding about fish, mercury and human health. Coordinators also worked with school and Aboriginal Traditional Knowledge and cultural and land-based programs to deliver programming and share information,
- Mercury Community Coordinators continued initiatives that integrate Indigenous knowledge, experiences and perspectives about fish consumption, mercury and human health issues and those that support the goals of the RMP. With pandemic restrictions lifted, new projects have been discussed, such as the development of a joint calendar, cookbooks and Cree informed 'mercury in the food web' visual. In 2021, YFFN developed a community calendar titled, *Fish is Good for the Soul / Kinosėw Minoskákėw*, which celebrates the role of wild fish harvests to maintain good health, support cultural practices and support knowledge transfer, and may be updated given its high usage across the communities.
- Mercury Community Coordinators continue to utilize communication materials, such as the Safe Catch poster and Fish Tape in community-based activities and presentations to provide information and generate conversation about mercury and human health-related Project effects due to impoundment.
- Representatives in communities with fish replacement programming (implemented through community specific Keeyask Adverse Affects Agreement) have expressed interest in pursuing community-based fish sampling to confirm these lakes offer low mercury fish options. Discussions are ongoing with the goal to implement as soon as is practicable for relevant communities[3].

[3] During the licensing process, the KHLP committed to undertake fish sampling in newly identified offset lakes as well as monitoring of mercury levels in the catch associated with these programs on an as needed basis.

Photo 3: Youth Information Session at Fox Lake Cree Nation Cultural Camp

4.3.4 HAIR SAMPLING AND FOOD SURVEYS

The RMP provides for voluntary hair sampling and wild food surveys for partner First Nation community members, Gillam residents and other consumers of fish from Gull and Stephens Lakes.

The goals and objectives of the voluntary hair sampling and food survey program are as follows:

- For individuals who choose to participate, to characterize, with reasonable certainty, maximum monthly exposures, and in conjunction with education and/or nutritional counselling, to understand mercury levels in their bodies and manage their fish consumption.
- To understand current consumption of wild foods, in conjunction with hair mercury levels, to assess risks to human health from exposure to mercury[4]. Questions are asked about types of foods consumed, frequency of consumption and seasonal variability in diet. The food survey asks about consumption of wild and market foods but focusses on fish (as the main source of mercury exposure) to understand the primary sources and types of fish harvested from the study area.

[4] There was an initial goal to gain insight into whether wild food consumption patterns change post-impoundment, however this may be difficult to interpret based on limited data provided pre-impoundment.

In 2018, the MHHIG developed a "Know your Number" campaign to generate interest and awareness of this program in partner communities and undertook sampling in 2019 and 2020. The detailed 2019 Baseline Hair Sampling and Food Survey Community Report was included as part of 2021 SEMP report and provided pre-impoundment hair sampling and food survey results. Despite multiple attempts, the COVID-19 pandemic situation and associated lockdowns inhibited the ability to offer hair sampling events during the majority of 2020 and 2021. Hair sampling events were undertaken again in March and December 2022, and some individual samples were collected in March 2023. The detailed 2022-2023 Hair Sampling and Food Survey Report prepared by WSP Canada Inc. (WSP, formerly called Golder Associates Ltd.) provides post-impoundment hair sampling and food survey results and is contained in Appendix 2. Summary outcomes are noted below.

The hair sampling and food survey program is designed to be voluntary in nature and as such results may not be representative of (or extrapolated to) the general community population. The results should be understood as informing individual mercury levels and understandings of general trends and patterns as opposed to providing detailed statistically representative information about specific age groups or sub-populations.

The mercury hair results are compared to mercury levels that are considered acceptable by World Health Organization (WHO) and Health Canada in terms of risk to human health ("thresholds")[5]:

- 2 parts per million (ppm) for sensitive population (children and teens aged 18 or under, females who may become pregnant)
- 5 ppm for non-sensitive population (male adults, and female adults who may not become pregnant).

The results of the hair sampling and food surveys are used to assess individual risk to human health, to inform ongoing communication plans and materials and to inform the formal Human Health Risk Assessment (HHRA), which will be completed in approximately 2026.

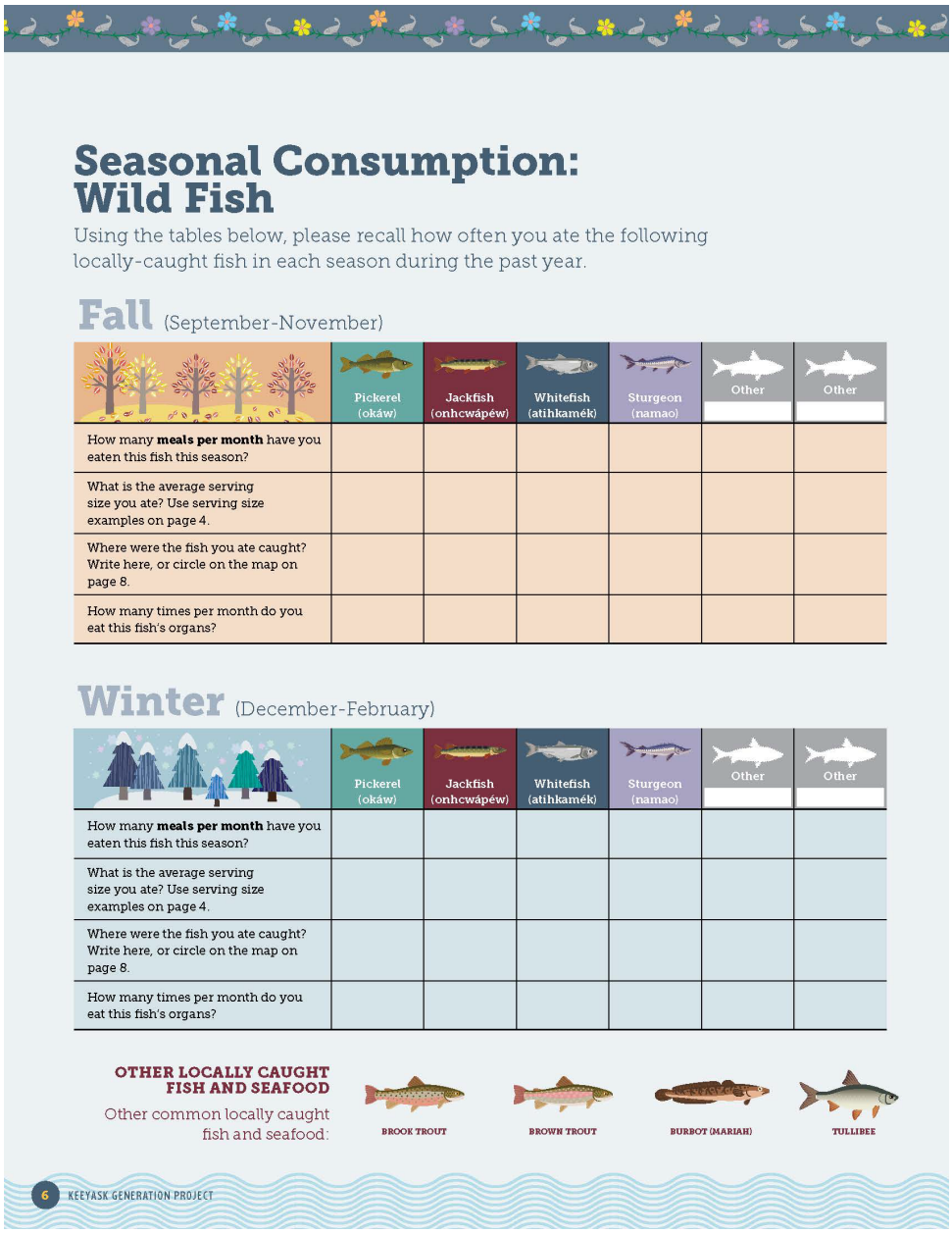
Between March 2022 and March 2023, Mercury Community Coordinators worked with the Project's Hair Sampling Consultant (WSP) to host post-impoundment hair sampling and food survey events in March and December 2022 and collect individual samples in March 2023. Participants who provided hair samples in 2022-2023 were from three of the four Partner First Nations. There was an attempt to schedule events two months following peak fish consumption periods (i.e., early summer, fall and to a lesser extent, winter), however timing did not align due to various logistical and community constraints. As a voluntary program, hair sampling did not specifically target higher risk individuals such as those who are high fish consumers or populations that are more at risk of the health effects of mercury (i.e., sensitive individuals such as children and teens 18 years and under and females of childbearing age). However, at one of the sampling events, efforts were taken to increase overall participation by offering haircuts in

[5] The guidance provided by health agencies varies on whether male teenagers should be considered sensitive or non-sensitive. This issue was re-evaluated in discussions with health regulators and MHHIG. The MHHIG adopted the approach by WHO that considers males up to 18 years of age as sensitive.

conjunction with hair sampling. This may have resulted in an increased number of higher risk individuals than may have participated otherwise.

Photo 4: Hair Sampling Training with Mercury Community Coordinators

In addition, the MHHIG reviewed the pre-impoundment experience and outcomes. A reflection of lessons learned resulted in a redesigned food survey workbook incorporating colourful graphics to make it more engaging and user-friendly. The questions were also reorganized to consider food consumption on a seasonal basis in order to help participants more easily recall their yearly food consumption. The redesigned food survey was used during the December 2022 hair sampling event and by individuals who provided hair samples in March 2023 and was well-received by participants. Based on preliminary findings, the redesigned food survey prompted more robust information compared to that provided in the previous survey format.



Seasonal Consumption: Wild Fish

Using the tables below, please recall how often you ate the following locally-caught fish in each season during the past year.

Fall (September-November)

	Pickerel (okáw)	Jackfish (onhcwápéw)	Whitefish (atihkamék)	Sturgeon (namao)	Other	Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
Where were the fish you ate caught? Write here, or circle on the map on page 8.						
How many times per month do you eat this fish's organs?						

Winter (December-February)

	Pickerel (okáw)	Jackfish (onhcwápéw)	Whitefish (atihkamék)	Sturgeon (namao)	Other	Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
Where were the fish you ate caught? Write here, or circle on the map on page 8.						
How many times per month do you eat this fish's organs?						

OTHER LOCALLY CAUGHT FISH AND SEAFOOD

Other common locally caught fish and seafood:

BROOK TROUT BROWN TROUT BURBOT (MARIAH) TULLIBEE

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Photo 5: Graphic Food Survey

A summary of outcomes from post-impoundment hair sampling and food surveys completed during this reporting period includes:

- A combined total of 82 participants volunteered for post-impoundment hair sampling and/or food surveys at hair sampling events or through individual submission of hair samples. A total of 146 hair samples were collected and 67 food surveys were completed. Multiple hair samples were analyzed for some individuals with longer hair to measure monthly (vs seasonal) mercury levels or to go back further in time in previous

seasons. Two individuals who completed the food survey also provided hair samples which could not be analysed due to insufficient hair length.

- Individual results were confidentially communicated to each participant in a personal letter, which compared their personal result with the mercury threshold that was applicable to them. The letter also included information about how to maintain a healthy fish diet and stay within an acceptable threshold as well as contact information should the participant have questions or wish to receive nutritional counselling. Sample letters are provided as an attachment to Appendix 2.

- Out of the 82 participants who provided a hair sample:
    - All participants had mercury levels in hair below their respective 'acceptable' thresholds. Three people had moderate mercury levels (greater than 1 ppm but less than their threshold) and the remainder had mercury levels that would be considered substantially below their target level of concern (less than 1 ppm). For those individuals with very low mercury levels, they were advised that consuming two to three low mercury fish meals per week is healthy and unlikely to affect their mercury exposure.
    - One of the people with a moderate mercury level was approaching their threshold during one month of the year (in summer) but was still below the threshold. The hair sample segments from other months of the year were well below the threshold., This person was provided nutritional recommendations to eat fish that were lower in mercury in their personal letter. No nutritional counselling was requested when offered.

- Results from the 67 food surveys indicated:
    - 50 individuals reported that they ate local fish in the previous year. The top species of fish consumed were pickerel (walleye) (49 respondents), jackfish (northern pike) (16), brook trout (7), whitefish (6), and sturgeon (5). The top wild birds reported to be consumed were goose (29), duck (9), grouse (7), and willow ptarmigan (3). The top wild land animals were moose (35), caribou (20), snowshoe hare (4), followed by beaver and elk. The most common berries were blueberry (13), wild raspberry (8), wild strawberry (5), and cranberry (5), followed by juniper berry, bunchberry, and gooseberry. The top wild plants were Labrador Tea (10), Northern Labrador Tea (6), wihkes (sweet flag/muskrat root) (6), followed by wild rice and jack pine needle.
    - Most individuals indicated that they generally do not consume large amounts (i.e., 4 or more meals per month) of local fish from the area. While not representative of all communities, data show that fish consumption occurs primarily during summer (e.g., June to August), followed by spring (e.g., March to May) and fall (e.g., September to November), and to a lesser extent during winter (e.g., December to February).

  - People who reported consuming fish tended to have higher mercury levels than those who did not, but as reported above, those levels were all within acceptable ranges.
  - In general, the food survey results corroborate information collected during the environmental assessment phase and subsequent MHHIG discussions about important local wild foods consumed by partner Fish Nation members. The available information also supports general understanding about harvesting patterns on Gull and Stephens lakes; currently, there is no reported fishing in Gull Lake by partner community members. Limited fishing occurs in Stephens Lake with most individuals reporting they harvest the majority of fish from non-Project impacted or off-system waterbodies. See Appendix 2 for additional aggregate information regarding location, seasonal variation, consumption frequency and amounts.

- Results of the post-impoundment hair sampling offered during 2022/2023 indicate that hair mercury levels of those who participated in the program were within acceptable ranges, and such, it can be concluded there is low overall risk from exposure to mercury for these individuals. Due to the voluntary nature of the program, there is uncertainty on whether the participants included the highest resource users (attempts to encourage participation, notwithstanding) and it is possible that other individuals may be at higher risk due to higher consumption of local fish in the Project area.

Community-level[6] and aggregate hair sampling and food survey results from 2022/2023 have been shared with all four partner First Nation communities through presentations at the MHHIG meetings (September 2022 and March 2023). In addition, a graphic poster providing the aggregate results has been developed and will be shared with the communities in spring 2023. Community-level results posters were prepared, upon request, for one of the four communities for distribution and discussion at the local level[7].

Hair sampling and food surveys will continue to be offered to all four partner First Nation communities over the next several years, which will allow individuals to monitor their mercury exposure through repeat hair sampling. There will continue to be a focused effort to encourage more frequent hair testing (e.g., seasonal) for people who consume fish from Keeyask affected lakes (Gull or Stephens lakes) and promote the participation of individuals who are higher consumers of fish in this program. Hair sampling will continue to be available upon request via the participant's local Mercury Community Coordinator, and nutritional counselling offered.

[6] With permission from Mercury Community Coordinators.
[7] A second community requested to wait to include next round of results from a planned event, which is expected to occur spring/summer 2023. Community-level results posters were not shared with KHLP or MHHIG.

4.3.5 MONITORING OF MERCURY IN FISH, WILDLIFE AND PLANTS

The Aquatic Effects Monitoring Plan (AEMP) and Terrestrial Effects Monitoring Plan (TEMP) outline pre-and post-impoundment monitoring for mercury in fish, wildlife and plants in the Project area, including a voluntary sampling component, where partner First Nations' members can submit plant, Lake Sturgeon, and wildlife samples from the Project area for mercury analysis. The overall objective of this monitoring is to provide information used to assess risks to human health from potential exposure to mercury. Because EIS predictions informed the development of post-impoundment consumption recommendations for fish, the objectives of these monitoring programs in the context of the RMP are:

- to compare current results with predictions in the EIS,
- to provide a timely communication system if levels approach or exceed predictions, and
- to provide information for individuals to make informed consumption choices (from Gull and Stephens lakes in particular).

The following provides an overview of EIS predictions, scheduled monitoring and 2022 monitoring results of fish, wildlife, plants, and water. Available data was reviewed by the Project Toxicologist to assess risk from consumption of wild foods harvested in the Project area (see Section 4.3.6).

Fish: The Keeyask reservoir (Gull Lake) was impounded in September 2020. Mercury concentrations in pickerel, jackfish, and whitefish are expected to increase by three to five times in Gull Lake and by two times in Stephens Lake, peaking between 2023 and 2027, and then gradually decline over the next thirty years. Scheduled monitoring of mercury in fish outlined in the AEMP occurs in early fall. As of 2022, annual monitoring occurs in Split Lake, the reservoir and Stephens Lake – these lakes will continue to be monitored annually until determination of peak has occurred and then every three years. Scheduled sampling also occurs every three years in the Aiken River (last year sampled was 2021).

In consideration of the monitoring objectives noted above, the MHHIG identified there is an unavoidable lag between seasonal fishing (e.g., spring/fall) and reporting of sampling results (late winter) as mercury levels rise in fish from Gull and Stephens lakes. The time lag is an issue until peak concentrations are observed and concentrations begin to decline. To address this communication lag, there was a decision in 2021 to undertake additional small-scale sampling (using non-lethal dermal punch samples) on Stephens Lake in June. This sampling may provide an additional, early warning indicator, prior to the fall fishing period, about how fast the mercury concentrations are increasing and approaching the predicted peak concentrations. Samples collected in June 2022 showed that concentrations in pickerel and jackfish remain within predictions. The MHHIG will review the need for this additional sampling on an annual basis.

The AEMP 2022/23: Mercury in Fish Flesh from Keeyask Study Area results show that mercury concentrations in jackfish, pickerel and whitefish caught in the Gull Lake are, as expected, higher than values measured historically. Average concentrations in fish from Gull Lake remain below the predicted peak values. Concentrations found in fish from Stephens Lake and Split Lake continue to fluctuate from year to year but are within historical levels.

Because there was no scheduled sampling in the Aiken River in 2022, communities were provided the opportunity to submit voluntary samples; no samples were received.

Wildlife & Plants: The scheduled sampling program for mercury in wildlife, as outlined in the TEMP was completed in winter 2022/23. No plant samples were scheduled to be collected in 2022. No wildlife or plant samples were submitted for analysis through the voluntary sampling program in the reporting period.

Post-impoundment mercury levels are expected to remain low in wildlife (moose, beaver, muskrat, snowshoe hare) and plants (blueberries and Labrador tea) consumed by people. Mercury levels in waterfowl, such as ducks, are expected to remain low with levels similar to whitefish, with even lower concentrations predicted for Canada geese. The 2022 results, outlined in the TEMP Mercury in Wildlife annual report, show beaver and muskrat concentrations remain low, consistent with EIS predictions. There was an increase in mercury levels in river otter tissue – this was expected, as river otter eat fish. To date, there is no information to suggest that people eat otter.

Monitoring for mercury in wildlife and plants will continue during the operation period. Data collected will be supplemented by any samples provided by partner First Nations through the voluntary sampling program.

Water: Mercury levels in water, post-impoundment, are expected to remain below mercury water quality guidelines as set by Manitoba and Canada for drinking and bathing. Water quality was monitored at locations upstream of the project, in Gull Lake and in Stephens Lake for a suite of parameters, including mercury. As expected, some water quality variables, including mercury, have changed since reservoir flooding. Most notably, an increase in total mercury was observed in the reservoir, under the ice, in isolated back bays that were flooded; however, all the results were well below mercury water quality guidelines and those identified in the EIS.

4.3.6 ASSESSMENT OF RISK TO HUMAN HEALTH

The Project toxicologist participates as a regular member on the MHHIG and met regularly with subject matter experts as well as with provincial health representatives to discuss issues informing the assessment of risk to human health (HHRA) from mercury exposure as a result of the Keeyask Project.

On an annual basis, the Project toxicologist interprets risk to human health risk through a review of available monitoring results of mercury in fish, wildlife, plants, and water, compared to predictions provided in the EIS. Appendix 3: Wilson Scientific: Preliminary Human Health Risk Interpretation of 2022 Environmental Data) contains more detailed information on the human health risks from the consumption of fish, wild foods, and water.

Key 2022-23 HHRA conclusions and activities are as follows:

Fish: The Project toxicologist concluded, based on 2022 fish mercury results from the Gull Lake and Stephens Lake, that post-impoundment consumption recommendations remained valid for standard length fish in these communication products.[8]

Post-impoundment consumption recommendations developed in 2021 are based on peak concentrations predicted for Gull and Stephens lakes, Health Canada, and World Health Organization guidance on acceptable rates of intake of mercury, and Manitoba Government mercury in fish guidelines. As noted in Section 7.6.2, the Safe Catch poster (2021) presents consumption recommendations based on standard length sizes for three fish species; the fish tape presents consumption and mercury level categories for pickerel and jackfish in standard length sizes, and whitefish in three class sizes.

Average mercury concentrations in Northern Pike (jackfish) and Walleye (pickerel) from Stephens Lake, while within historical values, were equal to or below predicted peak values. The MHHIG referred to the post-impoundment protocol[9] outlining a process for timely communication of monitoring results, interpretation of data, and decision-making protocol for assessing currency of safe fish consumption recommendations (see Appendix 4: Post-Impoundment Fish Mercury Communication Process) and determined to develop a contingency plan to revise consumption recommendations in the event the fish mercury concentrations exceed predicted peak values. This decision was supported by Manitoba Health. This plan will be developed in 2023 by the MHHIG, in consultation with health agencies.

Wildlife: Concentrations provided in the TEMP 2022/2023 report indicate that eating beaver and muskrat from the Project area (based on previously reported consumption rates) would not pose unacceptable risks to people. While beaver and muskrat samples were limited and samples were not available for other wild foods (e.g., moose, snowshoe hare, ducks and geese), there is no information to suggest that persons should be avoiding these foods, based on predicted peak estimates.

Efforts will continue to encourage the voluntary submissions of wildlife samples. A wild foods workshop organized through the MHHIG, in combination with review of food survey results, will be undertaken to update the findings from a pre-impoundment (2009) wild foods workshop to determine if identified foods and previously reported consumption rates (i.e., frequency and meal sizes) are still applicable.

[8]There are no anticipated increases in fish mercury concentrations in Split Lake as a result of the Project. Nonetheless, to build understanding about mercury and promote healthy fish food consumption, safe fish consumption recommendations for Gull, Stephens and Split lakes were developed in the pre-impoundment phase; the Split Lake products, last issued in 2018, were refreshed in 2021 to reflect new product design. Consistent with the pre-and post-impoundment protocol, a 20% change threshold is considered to determine whether fish consumption recommendations remain current. A review of 2022 monitoring results of fish in Split Lake indicates mercury concentrations in some fish of various sizes increased more than 20% since 2018. In consultation with the MHHIG, including health representatives, these products have been updated so that consumption recommendations reflect current monitoring results. Products will be distributed by summer 2023 and continue to be monitored on an annual basis. Results will be reviewed annually with MHHIG, including health regulators, to determine whether consumption recommendations should be revised in the future.

[9] Established by the MMHIG, in consultation with heath agencies in 2021/22.

Plants: Plants consumed by people (blueberries and Labrador tea) near the Keeyask reservoir are expected to remain low in mercury concentrations. The first post-impoundment sampling of plants is scheduled to occur in 2024 and continue into operations, which will provide more information on expected concentrations and interpretation of risk to human health. Partner First Nations are encouraged to submit plant samples from the area for mercury analysis.

Water: Mercury levels in water continue to remain below mercury water quality guidelines as set by Manitoba and Canada for drinking and bathing and below that estimated in the EIS.

A formal Human Health Risk Assessment (HHRA) will be completed upon determination of peak conditions by environment professionals (approximately 2026 - 2030) and/or discussion with MHHIG.

APPENDIX 1: POST-IMPOUNDMENT COMMUNICATION PRODUCTS

WILL MERCURY LEVELS AFFECT WILD FOODS I EAT?

FISH: After Impoundment, mercury levels in fish will gradually rise in Gull Lake, and to a lesser extent, in Stephens Lake. Within three to seven years after impoundment (~2023-2027), levels are expected to rise 3-5X in predatory fish (e.g. pickerel and jackfish) in Gull Lake and double in Stephens Lake. Levels in whitefish are expected to increase moderately. People should limit or avoid most fish from these lakes while mercury levels are high.

To help you, your family and friends make informed choices about eating fish, consumption recommendations, based on Health Canada's guidance and predicted maximum fish concentrations in Gull and Stephens lakes are available from your Mercury Community Coordinator.

WILDLIFE AND PLANTS: After impoundment, mercury levels are expected to remain low in wildlife (moose, beaver, muskrat, snowshoe hare), and plants (blueberries and Labrador Tea) consumed by people. Waterfowl, such as ducks, are expected to remain low with increases in mercury levels similar to whitefish. Evidence shows that people can expect to continue eating these wild foods as they did before impoundment. Community members are encouraged to submit wildlife samples and plants samples to test mercury levels.

WATER: Mercury levels in water, post-impoundment, will remain below mercury water quality guidelines as set by Manitoba and Canada for drinking and bathing.

HOW DO I MONITOR MERCURY LEVELS?

"Know Your Number": Free, confidential hair sampling is available to help you understand how much mercury is in your body so you can make informed decisions about eating fish.

DO YOU WANT A HAIR SAMPLE TEST?

Voluntary hair sampling (2018-2020) in partner First Nation communities has shown that average mercury levels in people are within healthy, low levels.

STICKER TO BE PLACED HERE

Monitoring for fish, wildlife and plants is ongoing. Community members are encouraged to submit wildlife samples or plant samples collected in the Keeyask Project area for mercury analysis. The Mercury Human Health Implementation Group will review available data annually to update, as required, fish consumption recommendations.

HOW CAN I LEARN MORE?

The Mercury and Human Health Implementation Group, consisting of representatives from each partner First Nation, Manitoba Hydro, technical experts and health agencies, oversees mercury and human health initiatives. Key activities include: voluntary hair sampling; community-based events to build understanding about mercury and human health, monitoring fish, wildlife, and plants; safe fish consumption guidance for specific lakes.

'Mercury Community Coordinators' in your area provide information about mercury and coordinate activities.

Look for the following in your community:

- "Know your Number": Free, confidential hair sampling
- Community information sessions about mercury and human health
- Information about safe fish consumption for Keeyask area lakes

Information provided in 2021 in collaboration with Manitoba Government.

MERCURY IN FISH AND YOUR HEALTH

Understanding mercury in fish resulting from the impoundment of the Keeyask reservoir

FOR GULL LAKE AND STEPHENS LAKE

KEEYASK

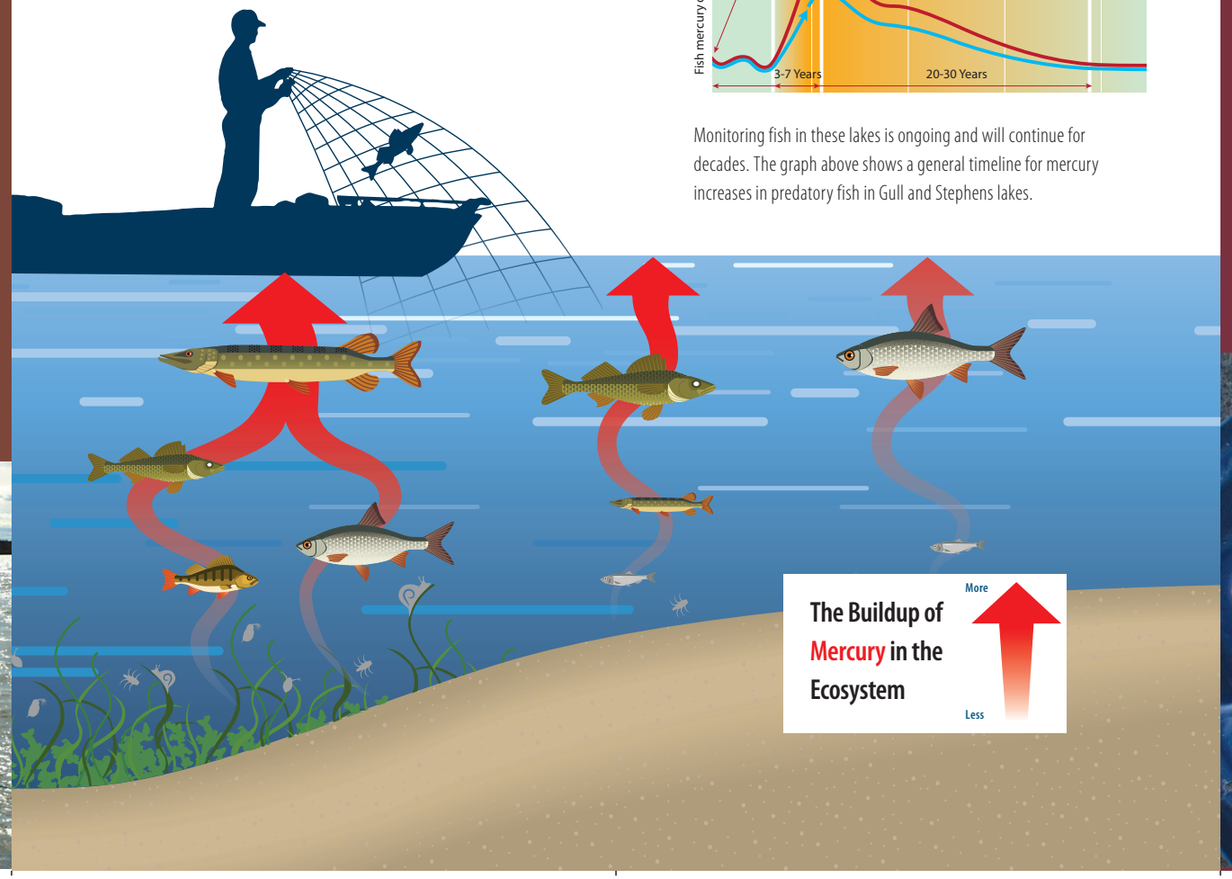
RESPECTING THE LAND AND UNDERSTANDING THE EFFECTS OF MERCURY

Development of the Keeyask Project is a collaborative effort between Manitoba Hydro and four Manitoba First Nations – Tataskweyak Cree Nation and War Lake First Nation (acting as the Cree Nation Partners), York Factory First Nation, and Fox Lake Cree Nation – working together as the Keeyask Hydropower Limited Partnership (KHLP).

As a result of past experience with hydroelectric development, the partner First Nations raised concerns about mercury and human health. **The Partnership has been working together on this issue since 2007 to study mercury** and develop strategies to build understanding about mercury and the risks and benefits of eating fish. The work is influenced by the teachings of Cree culture, spirituality and wellbeing, which is grounded in the relationship and balance between people, land, water and all other living beings. Discussions about 'mercury' cannot be separated from the larger environment and all of the connected world.

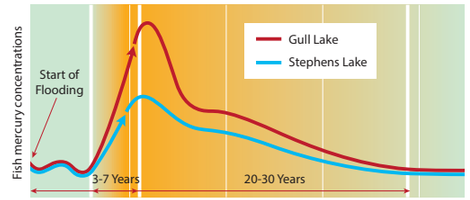
CAN MERCURY AFFECT MY HEALTH?

Mercury can get into your body by eating fish, particularly large predatory fish (such as pickerel and jackfish). High levels of mercury can cause health problems in humans, particularly for the developing brain. For this reason, children and females of childbearing age are advised to keep their mercury levels lower than adult males or post-menopausal females or Elders.



WHY ARE MERCURY LEVELS A CONCERN?

Impoundment of the Keeyask reservoir was completed in September of 2020. Mercury levels will increase in fish in Gull Lake, and to a lesser extent Stephens Lake. It will take about 3-7 years for mercury levels in fish to reach maximum levels. Levels will decrease over 20-30 years.



Monitoring fish in these lakes is ongoing and will continue for decades. The graph above shows a general timeline for mercury increases in predatory fish in Gull and Stephens lakes.

WHAT IS MERCURY?

Mercury is a metal that has always been found in small amounts naturally in the environment and in fish. Flooding of soil or wetlands creates conditions where mercury is converted into methylmercury by bacteria living in the soil. This methylmercury then makes its way through the food web into the fish.

Eating fish and other wild foods is more than just nutritious – it is part of mino pimatisiwin or "living the good life." Fish provides people with important nutrients for overall good health. In general, fish such as whitefish or small pickerel and jackfish are lower in mercury than large predatory fish.

SAFE CATCH

A Mercury-Level Guide to eating fish from Stephens Lake

KEEYASK

As a result of Keeyask reservoir impoundment, fish mercury concentrations are expected to rise 2x in predatory fish in Stephens Lake. Recommendations are based on the estimated maximum (average) concentrations for standardized lengths in each fish species shown below. Fish concentrations will gradually decline after reaching peak conditions (expected to occur between 2023-2027).

Recommendations in effect until approximately 2030.

VERY GOOD CHOICE | OCCASIONAL CONSUMPTION | RESTRICTED CONSUMPTION

Larger fish than shown are expected to be higher in mercury concentrations and not recommended for consumption. Smaller fish than shown are expected to have lower mercury concentrations.

Pickerel greater than 16 inches not recommended for consumption.

Jackfish greater than 21 inches are not recommended for consumption.

Fish are Good for You!

Remember to eat fish that are low in mercury.

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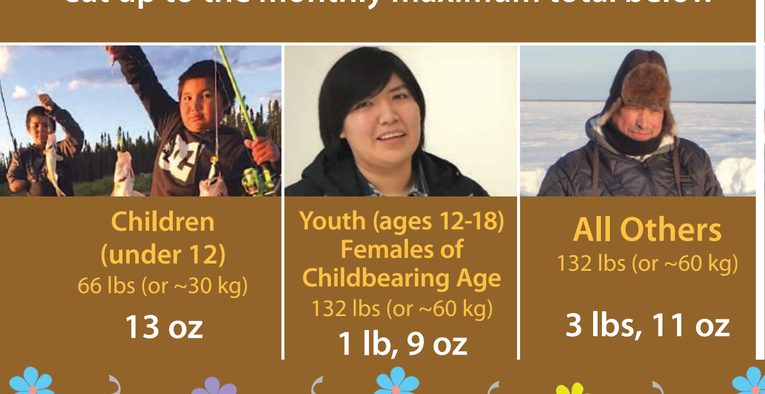
Pickerel

For fish up to 16 inches, eat up to the monthly maximum total below



Children (under 12)	Youth (ages 12-18) Females of Childbearing Age	All Others
66 lbs (or ~30 kg)	132 lbs (or ~60 kg)	132 lbs (or ~60 kg)
13 oz	1 lb, 9 oz	3 lbs, 11 oz

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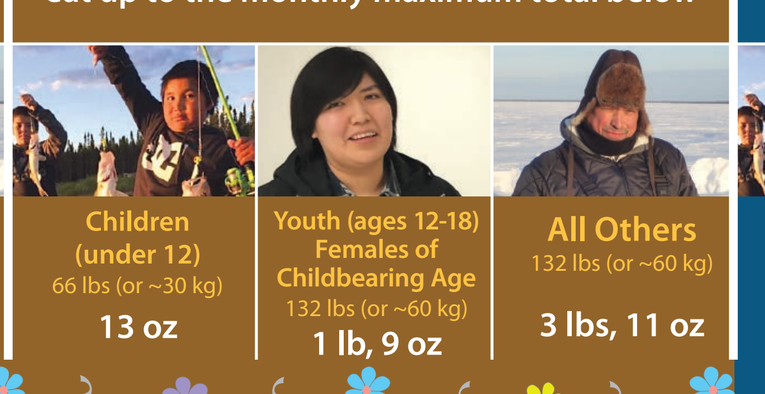
Jackfish

For fish up to 21 inches, eat up to the monthly maximum total below



Children (under 12)	Youth (ages 12-18) Females of Childbearing Age	All Others
66 lbs (or ~30 kg)	132 lbs (or ~60 kg)	132 lbs (or ~60 kg)
13 oz	1 lb, 9 oz	3 lbs, 11 oz

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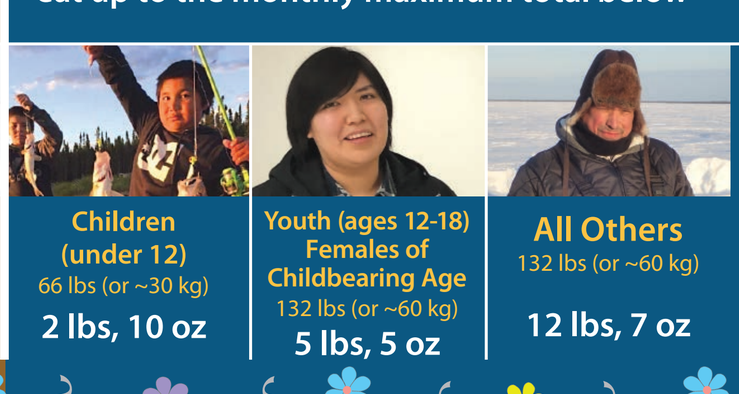
atihkamék
Whitefish

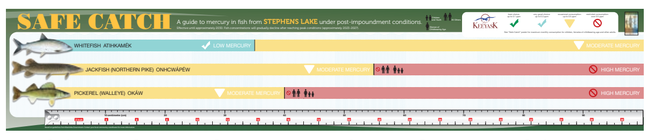
For fish up to 14 inches, eat up to the monthly maximum total below

Get your hair tested to KNOW YOUR NUMBER!
The best indicator of mercury exposure



Children (under 12)	Youth (ages 12-18) Females of Childbearing Age	All Others
66 lbs (or ~30 kg)	132 lbs (or ~60 kg)	132 lbs (or ~60 kg)
2 lbs, 10 oz	5 lbs, 5 oz	12 lbs, 7 oz

The chart shows maximum monthly fish consumption during peak conditions. Recommendations apply to total fish consumed. For example, if you eat half of the maximum monthly intake of whitefish, you can have half the recommended amount of pickerel or jackfish. Intake should be adjusted if people weigh more or less than noted here. For example, if an individual child weighs 33 lbs rather than the assumed 66 lbs, divide the maximum monthly intake by 2. Standardized lengths in each fish species are rounded to the nearest inch.



See fish tape for specific recommendations for various fish sizes.

Information provided in 2021 in collaboration with Manitoba Government.

To test your mercury levels through a hair sample contact:

STICKER TO BE PLACED HERE

SAFE CATCH

A Mercury-Level Guide to eating fish from Gull Lake

KEEYASK

As a result of Keeyask reservoir impoundment, fish mercury concentrations are expected to rise 3-5x in predatory fish in Gull Lake. Recommendations are based on the estimated maximum (average) concentrations for standardized lengths in each fish species shown below. Fish concentrations will gradually decline after reaching peak conditions (expected to occur between 2023-2027).

Recommendations in effect until approximately 2030.

VERY GOOD CHOICE | OCCASIONAL CONSUMPTION | RESTRICTED CONSUMPTION

Larger fish than shown are expected to be higher in mercury concentrations and not recommended for consumption. Smaller fish than shown are expected to have lower mercury concentrations.

Pickerel greater than 16 inches not recommended for consumption.

Jackfish greater than 21 inches are not recommended for consumption.

Fish are Good for You!

Remember to eat fish that are low in mercury.

Whitefish greater than 14 inches are not recommended for consumption.

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okáw
Pickerel

For fish up to 16 inches, eat up to the monthly maximum total below

Children (under 12) 66 lbs (or ~30 kg)	Youth (ages 12-18) Females of Childbearing Age 132 lbs (or ~60 kg)	All Others 132 lbs (or ~60 kg)
Avoid	Avoid	1 lb, 14 oz

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onhcwápéw
Jackfish

For fish up to 21 inches, eat up to the monthly maximum total below

Children (under 12) 66 lbs (or ~30 kg)	Youth (ages 12-18) Females of Childbearing Age 132 lbs (or ~60 kg)	All Others 132 lbs (or ~60 kg)
Avoid	Avoid	1 lb, 14 oz

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atihkamék
Whitefish

Get your hair tested to **KNOW YOUR NUMBER!** The best indicator of mercury exposure

For fish up to 14 inches, eat up to the monthly maximum total below

Children (under 12) 66 lbs (or ~30 kg)	Youth (ages 12-18) Females of Childbearing Age 132 lbs (or ~60 kg)	All Others 132 lbs (or ~60 kg)
2 lbs, 1 oz	4 lbs, 3 oz	9 lbs, 13 oz

The chart shows maximum monthly fish consumption during peak conditions. Recommendations apply to total fish consumed. For example, if you eat half of the maximum monthly intake of whitefish, you can have half the recommended amount of pickerel or jackfish. Intake should be adjusted if people weigh more or less than noted here. For example, if an individual child weighs 33 lbs rather than the assumed 66 lbs, divide the maximum monthly intake by 2. Standardized lengths in each fish species are rounded to the nearest inch.

See fish tape for specific recommendations for various fish sizes.

Information provided in 2021 in collaboration with Manitoba Government.

To test your mercury levels through a hair sample contact:

STICKER TO BE PLACED HERE

SAFE CATCH

A guide to mercury in fish from **GULL LAKE** under post-impoundment conditions.

Effective until approximately 2030. Fish concentrations will gradually decline after reaching peak conditions (approximately 2023-2027).

Children and Youth
All Others
Women of Childbearing Age

KEEYASK

best choice: up to 0.1 ppm
very good choice: up to 0.2 ppm
occasional consumption: up to 0.5 ppm
restricted consumption: over 0.5 ppm

See "Safe Catch" poster for maximum monthly consumption for children, females of childbearing age and other adults.

WHITEFISH ATIHKAMÉK — LOW MERCURY | HIGH MERCURY

JACKFISH (NORTHERN PIKE) ONHCWÁPÉW — HIGH MERCURY

PICKEREL (WALLEYE) OKÁW — HIGH MERCURY

Based on guidelines from Manitoba Government. Contact your local community coordinator for more information.

SAFE CATCH

A guide to mercury in fish from STEPHENS LAKE under post-impoundment conditions.

Effective until approximately 2030. Fish concentrations will gradually decline after reaching peak conditions (approximately 2023-2027).

Children and Youth
All Others
Women of Childbearing Age

KEEYASK

best choice: up to 0.1 ppm
very good choice: up to 0.2 ppm
occasional consumption: up to 0.5 ppm
restricted consumption: over 0.5 ppm

See "Safe Catch" poster for maximum monthly consumption for children, females of childbearing age and other adults.

WHITEFISH ATIHKAMÉK — LOW MERCURY — MODERATE MERCURY

JACKFISH (NORTHERN PIKE) ONHCWÁPÉW — MODERATE MERCURY — HIGH MERCURY

PICKEREL (WALLEYE) OKÁW — MODERATE MERCURY — HIGH MERCURY

Based on guidelines from Manitoba Government. Contact your local community coordinator for more information.

MERCURY & HEALTH

DO YOU EAT LOCAL FISH?

Fish monitoring is ongoing to assess mercury levels in fish over time.

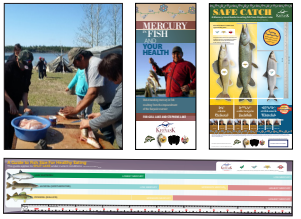
What can you do to help you and your family make informed choices about eating fish from lakes affected by the Keeyask Project?

1

LEARN ABOUT MERCURY IN FISH

Learn from local knowledge holders, and check out these resources:

- Mercury in Fish and Your Health
- Safe Catch Poster
- Fish Tape



2

"KNOW YOUR NUMBER"

Get your hair tested for mercury, especially if you eat fish from Gull Lake or Stephens Lake.

KNOW YOUR NUMBER

3

CONTACT YOUR LOCAL MERCURY COMMUNITY COORDINATOR

Place sticker here of current coordinator

Tataskweyak Cree Nation

KEEYASK

APPENDIX 2: WSP POST-IMPOUNDMENT BASELINE HAIR SAMPLING AND FOOD SURVEY COMMUNITY REPORT, 2023

REPORT

2022-2023 Hair Sampling and Food Survey Program

Keeyask Generation Project

Submitted to:

Manitoba Hydro

14-360 Portage Avenue
Winnipeg, MB R3C 0G8

Submitted by:

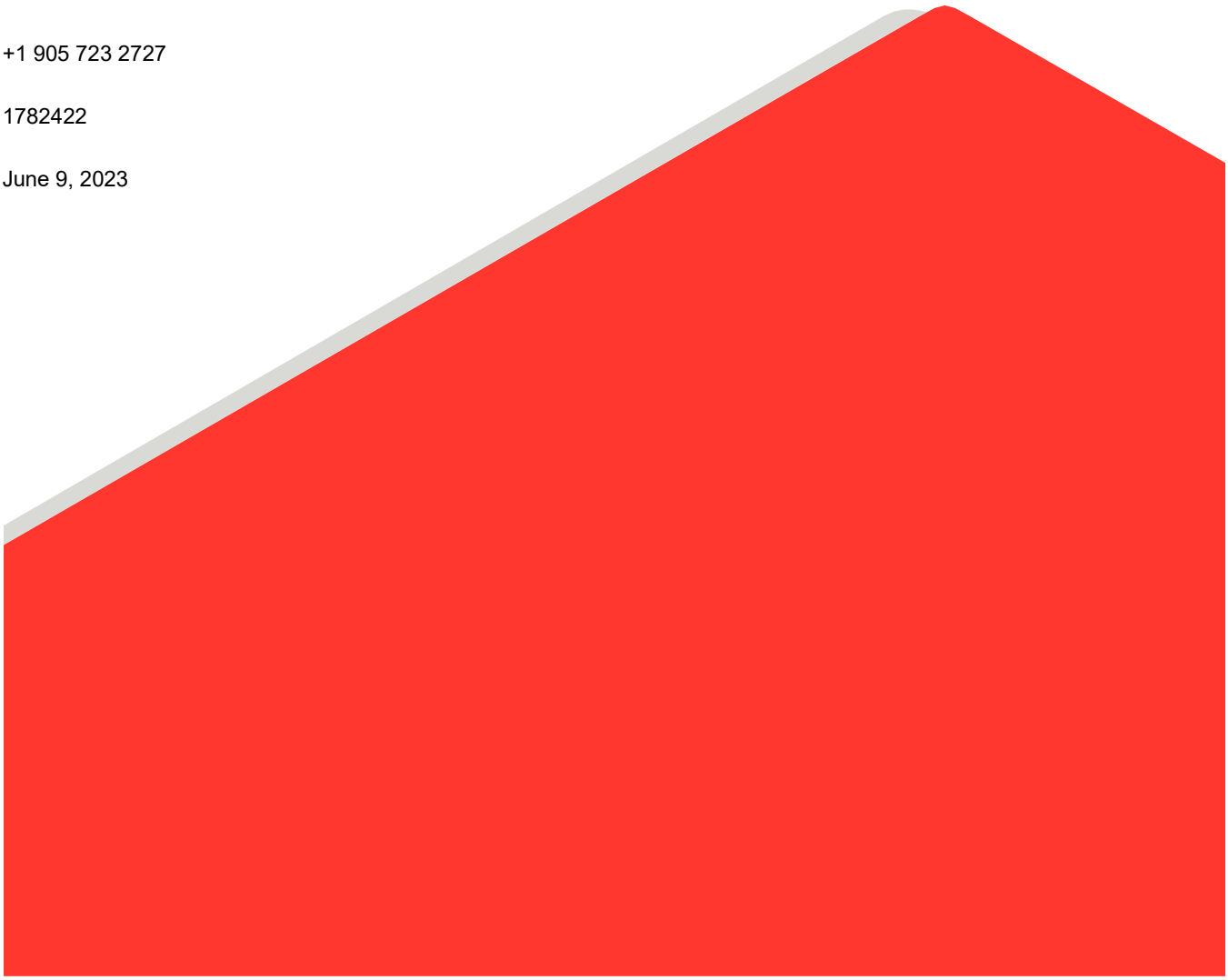
WSP Canada Inc.

100 Scotia Court, Whitby, Ontario, L1N 8Y6, Canada

+1 905 723 2727

1782422

June 9, 2023



Distribution List

1 electronic copy: Manitoba Hydro

1 electronic copy: WSP Canada Inc.

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APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

cm	centimetre
CVAF	Cold vapour atomic fluorescence
FLCN	Fox Lake Cree Nation
FNFNES	First Nations Food, Nutrition and Environment Study
Golder	Golder Associates Ltd.
Hg	Mercury
KHLP	Keeyask Hydropower Limited Partnership
MHHIG	Mercury and Human Health Implementation Group
mm	millimetre
MW	megawatt
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
SEMP	Socio-Economic Monitoring Plan
TCN	Tataskweyak Cree Nation
WHO	World Health Organization
WLFN	War Lake First Nation
WSP	WSP Canada Inc.
YFFN	York Factory First Nation

1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is the development of a 695 megawatt (MW) hydroelectric power generating station and the associated infrastructure on the lower Nelson River. The Project is a collaborative undertaking between Manitoba Hydro and four Manitoba First Nations – Tataskweyak Cree Nation (TCN), War Lake First Nation (WLFN), York Factory First Nation (YFFN) and Fox Lake Cree Nation (FLCN) – working together as the Keeyask Hydropower Limited Partnership (KHLP).

As a consequence of impoundment, which began on August 31, 2020 and was completed over the course of 5 days, and the creation of the Keeyask reservoir, flooding of approximately 45 square kilometers is anticipated and will result in an increase in methylmercury levels in the environment. These increased methylmercury levels will primarily affect human health through the consumption of locally caught fish. The Mercury and Human Health Risk Management Plan, developed as part of the Project, includes specific mitigation and monitoring commitments to address the effects of increasing mercury levels in the environment on human health. The Keeyask Mercury and Human Health Implementation Group (MHHIG) is responsible for the implementation of the Risk Management Plan, which includes the development and implementation of a hair sampling and a food survey program, with an emphasis on wild foods. WSP Canada Inc. (WSP, formerly called Golder Associates Ltd.) has been retained by Manitoba Hydro, on behalf of the KHLP, to work with the MHHIG to design and undertake the hair sampling and food survey program.

This report provides a description of the hair sampling and food survey program and key findings for the 2022-2023 reporting period (i.e., post-impoundment). It is noted that this report has been prepared to maintain the confidentiality of individual-level and community-level results; as such, the results and key findings are provided as pooled data for all participants during the 2022-2023 reporting period.

1.1 Background

In 2018, the MHHIG developed a “Know your Number” campaign to generate interest and awareness of this program in partner communities and undertook sampling in 2019 and 2020. The detailed 2019 Baseline Hair Sampling and Food Survey Community Report (“Baseline Report”; Golder, 2021) was included as part of the 2021 Socio-Economic Monitoring Plan Report (“SEMP Report”; Manitoba Hydro, 2022) and provided pre-impoundment hair sampling and food survey results. Despite multiple attempts, the COVID-19 pandemic situation and associated lockdowns inhibited the ability to offer hair sampling events during the majority of 2020 and 2021. Hair sampling events were undertaken again in March and December 2022, and some individual samples were collected in March 2023.

1.2 Goals and Objectives

The goals and objectives of the voluntary hair sampling and food survey program are generally consistent with those listed in the Baseline Report, but have focussed on the following objectives during post-impoundment:

- For individuals who choose to participate, to characterize, with reasonable certainty, maximum monthly exposures, and in conjunction with education and/or nutritional counselling, to understand mercury levels in their bodies and manage their fish consumption.

- To understand current consumption of wild foods, in conjunction with hair mercury levels, to assess risks to human health from exposure to mercury[1]. Questions are asked about types of foods consumed, frequency of consumption and seasonal variability in diet. The food survey asks about consumption of wild and market foods, but focusses on fish, as the main source of mercury exposure, to understand the primary sources and types of fish harvested from the study area.

The intent of this program is not to sample a representative population for the purpose of conducting a detailed statistical analysis of trends or correlations, or to draw conclusions about specific age groups or sub-populations. The primary goal of the study is to offer hair sampling to community members who wish to take part on a completely voluntary basis in order to help them manage their fish consumption, with the additional goals of fulfilling the commitments made as part of the Mercury Human Health Risk Management Plan for the Project and to help inform future human health risk assessments.

1.3 Project Team

Table 1 details the project team, including what organization they are affiliated with and their role on the Project.

Table 1: Project Team

Name / Organization	Role
Sharon Guin / WSP Canada Inc.	Principal Investigator, Project Manager and Technical Lead
Ruwan Jayasinghe / WSP Canada Inc.	Senior Technical Advisor
Audrey Wagenaar / WSP Canada Inc.	Senior Technical Advisor
Amica Ferras / WSP Canada Inc.	Intermediate Technical Support
Nik Davos / WSP Canada Inc.	Junior Technical Support
Dr. Eric Liberda / Toronto Metropolitan University (formerly Ryerson University)	Academic Subject Matter Expert
Mercury and Human Health Implementation Group (MHHIG) / Mercury Community Coordinators	Local subject matter experts and program implementation support

1.4 Definitions

The definitions of technical terminology used frequently throughout the report are provided below:

Food Survey: A questionnaire-based program to solicit information on community members' demographic information, as well as their food consumption habits and patterns for both locally caught wild and market foods in relation to the types of food items consumed, harvesting locations, the amounts consumed, the consumption frequency, and other aspects of food consumption habits and patterns that can provide useful study area-specific data that leads to developing reasonably accurate and realistic mercury/methylmercury exposure estimates.

[1] There was an initial goal in the Baseline Report to gain insight into whether wild food consumption patterns change post-impoundment, however this may be difficult to interpret based on limited data provided pre-impoundment.

Hair Sampling: For individuals who wish to participate, to characterize, with reasonable certainty, maximum monthly or seasonal exposures; and to understand and be able to confidently respond to mercury levels in their bodies, before and after impoundment, in conjunction with education and nutritional counselling. In addition to the food surveys, it will be used to supplement inputs in future human health risk assessments completed for the Project.

Participant: An individual who participated in a hair sampling event and provided a hair sample to understand their mercury levels in their body.

Respondent: An individual who responded to a food survey and filled out the questionnaire about their food consumption.

Human Health Risk Assessment: A study that estimates or determines whether or not people working at, living at, or visiting a given location or area are being exposed, or are likely to be exposed, to concentrations of chemicals in environmental media and/or food items that have the potential to result in adverse human health effects (i.e., toxicity).

2.0 STUDY DESIGN AND METHODOLOGY

For the 2022-2023 reporting period, the hair sampling and food survey program followed the general study design outlined in the Baseline Report (Golder, 2021). The full details are provided in the Baseline Report and are briefly summarized below:

- The communities of interest were four partner First Nation communities in northern Manitoba: FLCN, TCN, YFFN and WLFN. Residents living near these communities, such as Gillam and Ilford, or consumers for fish from Project affected lakes were invited to participate in this program. To encourage understanding about mercury hair levels and fish consumption, no individual who expressed interest in the program was turned away.
- There were no restrictions on the number of or types of participants, who may include capable adults, minors, children, pregnant women, ethnic groups, and any other vulnerable populations.
- There was no obligation for any individual to participate in this study; it was and will continue to be completely voluntary and participants may opt out at any time.
- The overall approach to recruiting participants was initiated by the Mercury Community Coordinators through in-community information sessions and posters/pamphlets posted around the community.

During 2022-2023, the hair sampling methods generally followed those outlined in the Hair Sampling Methodology memorandum (Appendix A) and summarized in the Baseline Report, which was developed based on the First Nations Food, Nutrition and Environment Study (FNFNES; UNBC, 2020). A 5 to 10 mm bundle of hair (approximately 100 strands) was cut close to the scalp from the occipital region of the head. The hair sample bag was labelled with the date, community name, and unique participant ID number. A consent form was completed by all participants who provided a hair sample. The consent forms were reviewed for currency and updated in 2022 to reflect changes in principal investigator contact information (see Appendix B). In addition to submitting a hair sample and completed consent form, the participants were encouraged to complete a food survey, intended to provide information about their demographics and food consumption patterns, with a focus on locally caught fish. The current food survey is provided in Appendix C.

In conjunction with the food survey information, participants were assigned to one of the three groups outlined in Table 2, which are based upon Health Canada's fish consumption guidelines (Environment Canada, Health Canada, 2010). The groups are based on the amount of fish that the participants consume per week. It is possible that consumption practices may exist that are not accounted for in the groupings outlined below. Professional judgement was used to assess the appropriate hair sampling methodology (specifically, peak season and 3 cm or 1 cm) for these extenuating circumstances. While the frequency of hair sample collection outlined in Table 2 was used as a guide, during 2022-2023 all participants submitted one hair sample from which multiple segments, if hair length permitted, were analysed to represent monthly or seasonal exposure.

Table 2: Proposed frequency of Hair Collection for Participant Groupings

Rate of Fish Consumption [(a)]	Length of Hair Analysed	Proposed Frequency of Hair Sample Collection
Low (≤1)	3 cm	Seasonal
Moderate (2-3)	1 cm (up to 3 segments)	Monthly / Seasonal [(b)]
High (>3)	1 cm	Monthly

Notes: ≤ = less than or equal to; > = greater than; cm = centimetre.

(a) Rate of fish consumption during the peak season in terms of meals per week for the general population, and meals per month for sensitive subpopulations (i.e., toddlers 4 years of age and younger, children 12 years of age and younger, adolescents 18 years of age and younger, and women of child-bearing age (15-49 years).

(b) While seasonal has been proposed at a minimum, if there are no logistical constraints, monthly sampling for the moderate group may be completed if possible.

The hair samples were then analysed for total mercury as follows:

- For participants who indicated they do not generally consume a lot of fish (i.e., consume fish ≤1 time per week), a 3 cm length of hair was sectioned and analysed for mercury.
- For participants who consume a moderate amount of fish (i.e., consume fish 2-3 times a week), one or more 1 cm lengths of hair were submitted corresponding to the month or month(s) when exposure is expected to be the highest.
- For participants who consume a high amount of fish (i.e., ≥4 times a week), multiple 1 cm lengths of hair were submitted for analysis corresponding to the multiple months that they may be exposed and that is expected to represent a peak of exposure. The objective of multiple samples was to minimize the chance of missing the true peak of exposure.

The hair samples were sent to Bureau Veritas Laboratories in Mississauga, Ontario, which were forwarded to its Burnaby, British Columbia location for mercury analysis. The samples were analysed for total mercury using the cold vapour atomic fluorescence (CVAF) method. Once the analytical information was received from the laboratory, WSP provided each participant with a personal letter that includes what sensitivity group they fall into, whether their mercury in hair concentration was below or above the acceptable threshold, and recommendations related to future consumption of fish. Example personal letters are provided in Appendix D.

As the program was implemented during post-impoundment, there were some updates to the methodology and food survey as described below:

- In 2021, the definition of sensitive groups were updated to include male adolescents based on discussions with health regulators and the MHHIG. The MHHIG adopted the approach by World Health Organization (WHO) that considers males up to 18 years as sensitive. As such, the sensitive group is defined as females of child-bearing age (15 to 49 years), adolescents (males and females 12 to 18 years), children (5 to 11 years), and toddlers (0 to 4 years). Non-sensitive groups were considered to be adult men and adult females that are not of child-bearing age.
- The MHHIG reviewed the pre-impoundment experience and outcomes from the hair sampling and food survey program. A reflection of lessons learned resulted in a redesigned food survey workbook incorporating colourful graphics to make it more engaging and user-friendly. The questions were also reorganized to consider food consumption on a seasonal basis in order to help participants more easily recall their yearly food consumption. The redesigned food survey was used during the December 2022 hair sampling events and by individuals who provided hair samples in March 2023 and was well-received by participants. Based on preliminary findings, the redesigned food survey prompted more robust information compared to that provided in the previous survey format. The redesigned food survey is provided in Appendix C.

There was an attempt to schedule events six to eight weeks following peak fish consumption periods (i.e., early summer, fall and to a lesser extent, winter), however timing did not align due to various logistical and community constraints. As a voluntary program, hair sampling did not specifically target higher risk individuals such as those who are high fish consumers or populations that are more at risk of the health effects of mercury (i.e., sensitive individuals such as toddlers, children and adolescents 18 years and under and females of childbearing age). However, at one of the sampling events, efforts were taken to increase overall participation by offering haircuts in conjunction with hair sampling. This may have resulted in an increased number of higher risk individuals than may have participated otherwise.

3.0 RESULTS FOR 2022-2023 POST-IMPOUNDMENT PERIOD

A summary of the post-impoundment hair sampling and food survey events that have taken place to date (March 2022 to March 2023) are shown in Table 3, below. The results from these sampling events are detailed in Section 3.1 (Hair Sampling) and Section 3.2 (Food Survey).

Table 3: Summary of Completed Sampling Events in Each Community

Community	Dates of Sampling Event(s) or Sample Submission (individuals)	Number of Participants in Hair Sampling	Number of Respondents to Food Survey
FLCN	March 2022	36	31
TCN	March 2023	2	2
YFFN	December 2023	44	34
WLFN	No events were held	0	0
Total	March 2022 - March 2023	82	67

A total of 82 individuals took part in the hair sampling and/or food survey program. There were 82 participants who provided hair samples; 17 of whom had multiple segments analyzed due to sufficient length and two with samples which could not be analyzed due to insufficient hair volume, for a total of 146 hair samples. Of the 82 participants, 67 participants filled out the food survey. The food surveys provide pooled demographic information from the 67 respondents, as summarized in Table 4 below. Therefore, demographic information was not available for 15 participants who provided a hair sample.

There were more females (38) who responded to the food survey compared to males (24), however five respondents did not indicate their sex on the food survey. The majority of respondents (52) were adults (i.e., ≥19 years old), along with 9 adolescents (i.e., 12 to 18 years old), 5 children (i.e., 5 to 11 years old), and 1 toddler (i.e., 0 to 4 years old). Out of the 67 respondents, 59 stated that they live in the community full-time, and/or belong to a First Nation.

Table 4: Study Participant Information

Category	Total Number of Study Participants
Total Number of Participants	82
Total Hair Sample Participants	82
Total Food Survey Respondents	67
Males	24[(a)]
Females	38[(a)]
Toddlers (0-4 years old)	1
Children (5-11 years old)	5
Adolescents (12-18 years old)	9
Adults (≥19 years old)	52
Live in the community full-time	59[(b)]
Belong to a First Nation	59[(c)]

Notes: ≥ = greater or equal to

(a) Five respondents did not indicate their sex.

(b) Three respondents did not indicate if they live in the community full-time.

(c) Seven respondents did not indicate if they belong to an Indigenous Organization.

3.1 Hair Sampling

As described in Section 2.0, each participant was assigned to a sensitivity group (i.e., sensitive or non-sensitive). As discussed above, not all participants who provided a hair sample completed a food survey; 67 participants filled out the food survey. Given that the required demographic information, such as age, sex, and pregnancy status, to assign participants to a sensitivity group was gathered from the food survey, assumptions were made for those participants who did not fill out a food survey (i.e., assumptions on age based on minor or general consent form, and sex based on name). As shown in Table 5, the acceptable threshold of mercury in hair for the sensitive group is 2 parts per million (ppm) and 5 ppm for the non-sensitive group. Table 6 provides a summary of the number of participants in each sensitivity group and age category and the statistics for mercury concentrations measured in hair.

Table 5: Description of Sensitive and Non-Sensitive Characteristics and Resultant Dietary Recommendations

Group	Characteristics	Acceptable Threshold of Hg in Hair (ppm)	Recommendation	
			If < acceptable threshold	If > acceptable threshold
Sensitive	■ Toddler (age 0 to 4) ■ Child (age 5 to 11) ■ Adolescent (age 12 to 18) ■ Female of childbearing age who is pregnant, is breastfeeding, or could become pregnant.	2	Eating low mercury fish up to 2 or 3 times per week is healthy.	Encouraged to eat less fish (or different species or smaller sizes of fish) to help mercury levels come back down into the acceptable threshold.
Non-sensitive	■ Male adult ■ Female over childbearing age (50+)	5		

Notes: Hg = mercury; ppm = parts per million; < = less than; > = greater than.

Table 6: Summary Statistics of Total Mercury Concentrations in Hair for All Study Participants

Parameter	Pooled Group of Participants
Number of Non-Sensitive Adults	39[(a)]
Number of Sensitive Adults	27[(b)]
Number of adolescents (12-18 years old)	9[(c)]
Number of children (5-11 years old)	4
Number of toddlers (0-4 years old)	1
Number of minors (unknown age)	2[(d)]
Total number of Participants providing a Hair Sample	82
Number of Participants that consume locally caught fish	50[(e)]
Number hair samples analyzed	146
Minimum concentration of Hg in hair (ppm)	0.0022
Maximum concentration of Hg in hair (ppm)	1.97
Average concentration of Hg in hair (ppm)	0.22

Notes: Hg = mercury; ppm = parts per million.

(a) Six participants were assumed to be non-sensitive adults based on general consent form and/or commonly male name.

(b) Eleven participants were assumed to be sensitive adults based on general consent form and commonly female name.

(c) Two participants were assumed to be adolescents based on comparison of consent form and food survey response to age group.

(d) Two participants were assumed to be minors based on minor consent form.

(e) Numbers are based on information provided in the 67 food surveys.

A combined total of 82 individuals submitted hair samples, voluntarily, either at community based hair sampling events or through individual submissions to a Mercury Community Coordinator or principal investigator. A total of 146 hair samples were collected. Multiple hair samples were analyzed for 17 individuals with longer hair to measure monthly (vs seasonal) mercury levels or to go back further in time in previous seasons. Two individuals provided hair samples which could not be analyzed due to insufficient hair volume.

The mercury hair results were compared to mercury levels that are considered acceptable by World Health Organization (WHO; 2007) and Health Canada (2007; Environment Canada, Health Canada 2010) in terms of risk to human health ("thresholds"):

- 2 ppm for the sensitive group (i.e., toddlers, children, adolescents, and females of childbearing age) (Environment Canada, Health Canada 2010, Legrand et al. 2010)
- 5 ppm for the non-sensitive group (i.e., male adults and females over childbearing age) (Health Canada 2007, Environment Canada, Health Canada 2010)

Individual results were confidentially communicated to each participant in a sealed personal letter, in which their personal mercury result was compared to the applicable mercury threshold. The confidential letter also included information about how to maintain a healthy fish diet and stay within an acceptable threshold as well as contact information should the participant have questions or wish to receive nutritional counselling (see Appendix D for example personal letters).

Out of the 82 participants who provided a hair sample, no participant had mercury levels that exceeded their acceptable threshold. There were three participants that had moderate mercury levels (i.e., greater than 1 ppm but less than their acceptable threshold), and the remainder (77 participants) had mercury levels that would be considered very low (i.e., less than 1 ppm). There were two participants who provided a hair sample, but the samples could not be analyzed due to insufficient volume. For those people with very low mercury levels, they were advised that consuming two to three low mercury fish meals per week is healthy and unlikely to adversely affect their mercury exposure.

One participant with a moderate mercury level was approaching their threshold during one month of the year (in summer) but was still below the threshold. The participant reported eating the most locally caught fish in the spring and summer. Their hair samples from other months of the year were all well below the threshold. This person was provided nutritional recommendations to eat fish that were lower in mercury in their personal letter. No nutritional counselling was requested when offered.

Two participants that provided a hair sample and filled out a food survey could not have their hair analyzed due to insufficient volume. Because their food surveys indicated that they had low to moderate consumption of locally caught fish (mostly from non-Project or off-system lakes), they were encouraged to submit a hair sample when their hair was longer than 1 cm and after a high fish-consuming season (i.e., to collect a sample 30-60 days after high fish consumption has decreased).

Because of increased risk of mercury exposure from eating fish from Gull and Stephens lakes, the food survey attempted to understand important sources of local fish. At this time, there is no reported fishing in Gull Lake by partner community members. Some individuals reported fishing in Stephens Lake, with most individuals reporting they harvest the majority of fish from non-Project area lakes or off-system waterbodies.

Seasonal variability in hair mercury levels was observed in the limited number of participants for whom a year's worth of data was available and was generally consistent with fish consumption patterns reported in the food survey. For those who ate more fish in one season compared to other times of the year, hair mercury levels changed up to 14x between seasons (e.g., 0.061 ppm in spring to 0.83 ppm in the fall). For those who ate a similar number of meals throughout the year, hair mercury levels only changed up to 2.5x between seasons (e.g., 0.083 ppm in spring to 0.21 ppm in winter).

Based on the food surveys, most individuals indicated that they generally do not consume large amounts (i.e., 4 or more meals per month or greater than one pound of fish per meal) of local fish from the area. The participants that reported consuming fish tended to have higher mercury levels than those who did not; however, those mercury levels were all below acceptable thresholds.

There was an attempt to schedule hair sampling events two months following peak fish consumption periods (i.e., early summer, fall and to a lesser extent, winter), however timing did not align due to various logistical and community constraints. As discussed in Section 3.2.1, the highest number of respondents reported consuming fish during summer, however the sampling events during 2022-2023 occurred in the winter. Therefore, there is uncertainty whether the peak exposure was captured for all individuals due to the length of hair available at the time of sampling. Timing of future sampling events will continue to be encouraged to take place in summer and fall to align with periods six to eight weeks following peak fish consumption.

Results of the post-impoundment hair sampling offered during 2022-2023 indicate that hair mercury levels of those who participated in the program were within acceptable ranges, and such, it can be concluded there is low overall risk from exposure to mercury for these individuals. Due to the voluntary nature of the program, there is uncertainty on whether the participants included the highest resource users (attempts to encourage participation, notwithstanding) and it is possible that other individuals may be at higher risk due to higher consumption of local fish in the Project area.

Community-level[2] and aggregate hair sampling and food survey results from 2022-2023 have been shared with all four partner First Nation communities through presentations at the MHHIG meetings (September 2022 and March 2023). In addition, a graphic poster providing the aggregate results has been developed and will be shared with the communities in spring 2023. Community-level results posters were prepared, upon request, for one of the four communities for distribution and discussion at the local level[3].

3.2 Food Survey

Food surveys were completed by 67 out of the 82 participants; herein referred to as respondents. Respondents were encouraged to fill out the local fish (and wild foods) sections to understand the potential of mercury exposure from local fish, in particular. Respondents were encouraged to fill out other sections if interest and time allowed, but incompletion of these sections may suggest lower consumption of other foods than in reality. Not all respondents filled out all portions of the food survey, and so the results presented herein indicate only the results of "eaters" and not of "non-eaters" or "non-respondents".

[2] With permission from Mercury Community Coordinators.

[3] A second community requested to wait to include next round of results from a planned event, which is expected to occur spring/summer 2023. Community-level results posters were not shared with KHLP or MHHIG.

The food survey collected information regarding type of food (i.e., species), frequency, portion size and location (wild fish only). Given that the food survey was voluntary, and primarily self-directed, there were some limitations to the data provided. For example, the results provided robust information on frequency of meals but provided limited information on portion sizes, particularly for the hair sampling event using the original food survey (March 2022). In addition, some sections were incomplete or incorrectly filled out, therefore these were not included in the dataset. Only the most commonly reported species or foods are presented herein to protect the confidentiality of individual participants, as there is a risk in inadvertently identifying individuals who report consuming less common foods.

3.2.1 Local Wild Foods

A total of 50 respondents (~75%) indicated that they consume local fish as part of their diet. As indicated in Table 7, the most frequently consumed locally caught fish noted by survey respondents are pickerel and jackfish, followed by brook trout, whitefish, and sturgeon, while a few respondents reported that they also eat fish organs. Seasonally, of the respondents who consumed local fish, more ate in the summer (80%), than any other season, spring (62%), fall (56%), and winter (46%). Fish were largely caught from lakes and rivers outside of the Project area (including off-system); no fishing was reported in Gull Lake, however some respondents reported fishing in Stephens Lake.

Table 7: Respondents' Consumption of Locally Caught Fish

Category	Total Number of Survey Respondents				
	Fall (Sept. - Nov.)	Winter (Dec. - Feb.)	Spring (Mar. - May)	Summer (Jun. - Aug.)	Full Year[(a)]
Pickerel (Walleye)	26	21	30	39	49[(b)]
Jackfish (Northern Pike)	10	9	9	11	16[(c)]
Brook Trout	5	1	2	5	7
Whitefish	5	4	4	3	6
Sturgeon	4	1	2	3	5
Seasonal Totals[(d)]	28	23	31	40	

Notes:

(a) Number of respondents for the full year may not equal the sum of seasons as respondents may consume fish in more than one season.

(b) Two respondents did not indicate which season the fish was consumed.

(c) One respondent did not indicate which season fish was consumed.

(d) Number of respondents for seasonal totals may not equal the sum of fish categories as respondents may consume more than one type of fish in a season.

A total of 30 respondents (~45%) indicated that they consume local birds as part of their diet. As indicated in Table 8, the most frequently consumed locally caught wild bird noted by survey respondents was goose (e.g., Canada or snow), followed by duck (e.g., black, canvasback, eider, mallard, pintail, greenwing teal or scoter), grouse (e.g., spruce, sharp-tailed, or partridge ruffed) and willow ptarmigan. A few respondents also reported that they eat organs from wild birds. Seasonally, of the respondents who consumed local birds, more ate in the spring (80%), than any other season, fall (50%), summer (33%), and winter (27%).

Table 8: Respondents' Consumption of Wild Birds

Category	Total Number of Survey Respondents				
	Fall (Sept. - Nov.)	Winter (Dec. - Feb.)	Spring (Mar. - May)	Summer (Jun. - Aug.)	Full Year[a]
Goose	14	8	24	10	29[b]
Duck	6	0	7	4	9
Grouse	3	1	4	2	7[c]
Willow Ptarmigan	1	1	1	0	3[c]
Seasonal Totals[d]	15	8	24	10	

Notes:

Goose = Canada or snow

Duck = black, canvasback, eider, mallard, pintail, greenwing teal or scoter

Grouse = spruce, sharp-tailed, partridge ruffed

(a) Number of respondents for the full year may not equal the sum of seasons as respondents may consume wild birds in more than one season.

(b) Two respondents did not indicate which season the wild bird was consumed.

(c) One respondent did not indicate which season the wild bird was consumed.

(d) Number of respondents for seasonal totals may not equal the sum of wild bird categories as respondents may consume more than one type of wild bird in a season.

A total of 35 respondents (~52%) indicated that they consume local wild land animals as part of their diet. As indicated in Table 9, moose and caribou stand out as the most frequently consumed, followed by snowshoe hare. A few respondents reported eating beaver, elk or organs from wild land animals. Seasonally, of the respondents who consumed local wild land animals, more ate in the fall (80%), than any other season, winter (66%), spring (43%), and summer (31%).

Table 9: Respondents' Consumption of Wild Land Animals

Category	Total Number of Survey Respondents				
	Fall (Sept. - Nov.)	Winter (Dec. - Feb.)	Spring (Mar. - May)	Summer (Jun. - Aug.)	Full Year[a]
Moose	28	21	15	11	35[b]
Caribou	13	14	8	5	20[b]
Snowshoe Hare	4	3	2	1	4
Seasonal Totals[c]	28	23	15	11	

Notes:

(a) Number of respondents for the full year may not equal the sum of seasons as respondents may consume wild land animals in more than one season.

(b) Two respondents did not indicate which season the wild land animals was consumed.

(c) Number of respondents for seasonal totals may not equal the sum of wild land animal categories as respondents may consume more than one type of wild land animal in a season.

A total of 15 respondents (~22%) indicated that they consume local berries and 12 respondents (~18%) indicated that they consume local terrestrial vegetation as part of their diet. As indicated in Table 10, the most frequently consumed wild berry was blueberry, followed by wild raspberry, wild strawberry and cranberry; juniper berry, bunchberry and gooseberry were rarely consumed. The most frequently consumed terrestrial vegetation was Labrador tea, followed by Northern Labrador tea, and wihkes; wild rice and jack pine needle were rarely consumed. Seasonally, of the respondents who consumed local berries, more ate in the summer (67%), followed by fall (53%), winter (47%), and spring (33%). Of the respondents who consumed local terrestrial vegetation, more ate in the winter (92%), followed by spring and summer (75%), and fall (67%).

Table 10: Respondents' Consumption of Wild Berries and Terrestrial Vegetation

Category	Total Number of Survey Respondents				
	Fall (Sept. - Nov.)	Winter (Dec. - Feb.)	Spring (Mar. - May)	Summer (Jun. - Aug.)	Full Year[a]
Wild Berries					
Blueberry	6	7	5	8	13[b]
Wild Raspberry	5	5	5	7	8[c]
Wild Strawberry	1	1	1	3	5[c]
Cranberry	5	4	3	3	5
Seasonal Totals[d]	8	7	5	10	
Wild Terrestrial Vegetation					
Labrador Tea	7	7	7	8	10[c]
Northern Labrador Tea	6	6	5	5	6
Wihkes (sweet flag/muskrat root)	5	6	5	5	6
Seasonal Totals[d]	8	11	9	9	

Notes:

(a) Number of respondents for the full year may not equal the sum of seasons as respondents may consume berries and terrestrial vegetation in more than one season.

(b) Two respondents did not indicate which season the berries were consumed.

(c) One respondent did not indicate which season the berries or terrestrial vegetation was consumed.

(d) Number of respondents for seasonal totals may not equal the sum of wild berry or wild terrestrial vegetation categories as respondents may consume more than one type of wild berry or wild terrestrial vegetation in a season.

3.2.2 Market Foods

In addition to, or instead of consuming local wild fish, 24 respondents (~36%) indicated they consume market fish (i.e., fish from their local supermarkets). As shown in Table 11, the most commonly consumed market fish are salmon and canned tuna, followed by shrimp, arctic char, breaded fish, canned salmon, and cod; lobster, crab and pickerel were rarely consumed. Seasonally, of the respondents who consumed market fish, more ate in the fall (71%), followed by winter (63%), spring (54%), and summer (46%).

Table 11: Respondents' Consumption of Fish from Local Supermarkets

Category	Total Number of Survey Respondents				
	Fall (Sept. - Nov.)	Winter (Dec. - Feb.)	Spring (Mar. - May)	Summer (Jun. - Aug.)	Full Year[a]
Salmon	8	7	6	5	10
Canned Tuna	8	7	7	5	10
Shrimp	5	5	4	3	6
Arctic Char	1	2	1	3	4
Breaded Fish	2	2	2	2	4
Canned Salmon	2	3	4	2	4
Cod	1	2	0	1	4[b]
Seasonal Totals[c]	17	15	13	11	

Notes:

(a) Number of respondents for the full year may not equal the sum of seasons as respondents may consume market fish in more than one season.

(b) One respondent did not indicate which season the market fish was consumed.

(c) Number of respondents for seasonal totals may not equal the sum of market fish as respondents may consume more than one type of market fish in a season.

Separate from market fish consumption, 30 respondents (~45%) indicated that they consume market livestock and poultry. As shown in Table 12, the most commonly consumed market livestock and poultry is chicken, turkey and beef (including beef, steak and ground beef), followed by chicken eggs, pork (including pork, pork chops, roast), and processed meat; lamb chops/roast and livestock/poultry organs were rarely consumed. Seasonally, of the respondents who consumed market livestock and poultry, more ate in the fall (77%), followed by winter (67%), spring (63%), and summer (60%).

Table 12: Respondents' Consumption of Livestock and Poultry from Local Supermarkets

Category	Total Number of Survey Respondents				
	Fall (Sept. - Nov.)	Winter (Dec. - Feb.)	Spring (Mar. - May)	Summer (Jun. - Aug.)	Full Year[a]
Chicken	20	19	17	17	27[b]
Turkey	18	17	10	10	26[c]
Beef (beef, steak, ground beef)	19	19	17	17	26[b]
Chicken Eggs	16	14	14	13	21[c]
Pork (pork, pork chops, roast)	14	13	12	13	20[b]
Processed Meat	1	2	1	1	7[b]

Category	Total Number of Survey Respondents				
	Fall (Sept. - Nov.)	Winter (Dec. - Feb.)	Spring (Mar. - May)	Summer (Jun. - Aug.)	Full Year[(a)]
Lamb Chops/Roast	0	1	0	0	2[(d)]
Seasonal Totals[(e)]	23	20	19	18	

Notes:

(a) Number of respondents for the full year may not equal the sum of seasons as respondents may consume market livestock and poultry in more than one season.

(b) Five respondents did not indicate which season the market livestock or poultry was consumed.

(c) Four respondents did not indicate which season the market livestock or poultry was consumed.

(d) One respondent did not indicate which season the market livestock or poultry was consumed.

(e) Number of respondents for seasonal totals may not equal the sum of market livestock and poultry as respondents may consume more than one type of market livestock and poultry in a season.

3.3 Quality Assurance / Quality Control

Quality assurance and quality control (QA/QC) was carried out by the laboratory on each batch of hair samples submitted. The laboratory QA/QC protocol included the analysis of QC standard (i.e., a sample of known concentration), spiked blank (i.e., a blank matrix sample to which a known amount of mercury has been added) and method blank samples (i.e., a blank matrix containing all reagents used in the analytical method). No QA/QC deficiencies were reported. Based on this, it is assumed that all data (i.e., 146 hair samples) met the laboratory quality control and method performance criteria.

4.0 CONCLUSIONS

The primary goal of the hair sampling and food survey program is to offer hair sampling to community members who wish to take part on a completely voluntary basis in order to help them manage their fish consumption, with the additional goals of fulfilling the commitments made as part of the Mercury Human Health Risk Management Plan for the Project and to help inform future human health risk assessments.

Results of the post-impoundment hair sampling offered during 2022-2023 indicate that hair mercury levels of those who participated in the program were within acceptable ranges, and such, it can be concluded there is low overall risk from exposure to mercury for these individuals. Due to the voluntary nature of the program, there is uncertainty on whether the participants included the highest resource users (attempts to encourage participation, notwithstanding) and it is possible that other individuals may be at higher risk due to higher consumption of local fish in the Project area.

Based on preliminary findings, the redesigned food survey used in the December 2022 hair sampling event, prompted more robust information compared to that provided in the previous survey format. As the redesigned food survey is used in future hair sampling events, general information regarding wild food consumption patterns (e.g., food consumption rates) at the community or aggregate level will be summarized for internal use by the MHHIG and to support the human health risk assessment.

Individuals were provided with their personal letters indicating their personal result and providing general advice on whether continued fish consumption would be encouraged. The hair sampling program is part of the broader Risk Management Plan, which also includes the preparation of consumption recommendations for the Project

affected lakes under peak concentrations, and annual monitoring of fish, wildlife and plants. Adjustments to hair sampling materials will be considered in the context of the broader Risk Management Plan activities and outcomes. Hair sampling and food surveys will continue to be offered to all four Partner First Nation communities over the next several years, which will allow individuals to monitor their mercury exposure through repeat hair sampling. There will continue to be a focused effort to encourage more frequent hair testing (e.g., seasonal) for people who consume fish from Keeyask affected lakes (Gull or Stephens lakes) and promote the participation of individuals who are higher consumers of fish in this program. Hair sampling will continue to be available anytime upon request via the participant's local Mercury Community Coordinator, and nutritional counselling offered.

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6.0 CLOSURE

We trust that this report meets your current requirements. If you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

WSP Canada Inc.

Sharon Guin, M.Sc.
Senior, Risk Assessor

Ruwan Jayasinghe, M.Sc. DABT, QPRA
Senior Principal, Risk Assessor

ND/SG/RJ

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APPENDIX A

Hair Sampling Methodology Memo

TECHNICAL MEMORANDUM

DATE January 23, 2020 **Project No.** 1782422-004-L-Rev0

TO Monica Wiest
Manitoba Hydro

CC Ruwan Jayasinghe

FROM Andrea Amendola, Cameron Ollson **EMAIL Andrea_Amendola@golder.com**

KEEYASK GENERATION PROJECT – HAIR SAMPLING METHODOLOGY

Background

The Keeyask Generation Project (the project) is the development of a 695 MW hydroelectric power generating station and the associated infrastructure on the lower Nelson River. The Keeyask Generation Project is a collaborative undertaking between Manitoba Hydro and four Manitoba First Nations – Tataskweyak Cree Nation, War Lake First Nation, York Factory First Nation and Fox Lake Cree Nation – working together as the Keeyask Hydropower Limited Partnership.

As a consequence of impoundment, anticipated to begin in 2020, and the creation of the Keeyask reservoir, flooding of approximately 45 square kilometers is anticipated and will result in an increase in methylmercury levels in the environment. These increased methylmercury levels will primarily affect human health through the consumption of locally caught fish. The Mercury and Human Health Risk Management Plan developed as part of the project includes specific mitigation and monitoring commitments to address the effects of increasing mercury levels in the environment on human health, including the development and implementation of a hair sampling and a food survey study with an emphasis on wild foods.

Golder Associates Ltd. has been retained by Manitoba Hydro to undertake the hair sampling and food survey study. The purpose of this document is to provide the objectives and methodology for the hair sampling program, as well as provide justification for the methodology (via a brief literature review completed to November, 2019).

Objectives

The objectives of the hair sampling program are as follows:

- To offer hair mercury analysis to First Nation communities and Gilliam as part of the Mercury Human Health Risk Management Plan for the project. Three scheduled events (one pre-impoundment, two post-impoundment) are currently being proposed, although hair sampling will be offered in interim years, upon individual request.

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- For individuals who wish to participate, to characterize, with reasonable certainty, maximum monthly exposures; and to understand and be able to confidently respond to mercury levels in their bodies, now and after impoundment, in conjunction with education and nutritional counselling.
- In conjunction with the food surveys, to understand the primary sources and types of fish harvested from the study area and how the hair mercury results may influence the fish consumption guidance and/or advisories.
- To use the hair sampling results and results of the food surveys as supplemental information in future human health risk assessments completed for the area.

As noted, a food survey will be conducted in tandem with the hair sampling program. Briefly the objectives for that program are:

- To understand the current consumption of wild foods (i.e. what types of foods, frequency of consumption and seasonal variability in diet).
- To contribute to the planning of communication that encourages harvesting and use of wild foods, which in turn strengthens health and culture (part of living *mino pimatisiwin* or “the good life”).
- To understand how consumption patterns may change post-impoundment.

It is noted that the intent of this program is not to sample a representative population for the purpose of conducting a detailed statistical analysis of trends or correlations, or to draw conclusions about specific age groups or sub-populations. The primary goal of the study is to offer hair sampling to community members who wish to take part on a completely voluntary basis in order to help them manage their fish consumption, with the additional goals of fulfilling the commitments made as part of the Mercury Human Health Risk Management Plan for the project and to help inform future human health risk assessments.

Literature Review

Hair Sampling as a Biomarker for Mercury Exposure in Fish-Eating Populations

In fish-eating human populations, fish consumption rates are well-correlated to the concentrations of mercury in hair (often measured as total mercury) and blood (as methylmercury) (e.g. Berglund et al. 2005; Björnberg et al. 2005).

Following consumption of fish containing methylmercury, absorption of methylmercury from the gastrointestinal tract is nearly complete (95%, as cited in Berglund et al. 2005; ATSDR 1999). Once in the blood, greater than 90% of methylmercury binds to hemoglobin in red blood cells, while inorganic mercury is equally distributed between red blood cells and plasma (as cited in Berglund et al. 2005). Absorption of inorganic mercury from the gastrointestinal tract is relatively poor (7% for divalent inorganic mercury and less than 1% for metallic mercury; as cited in Berglund et al. 2005).

From the blood, methylmercury is then distributed to the various target organs, particularly the brain (methylmercury has the ability to cross the blood-brain and placental barriers) (as cited in Berglund et al. 2005). It is also distributed and incorporated into the developing hair follicle, resulting in methylmercury accumulation in hair tissue. For people who eat fish, it is estimated that approximately 80% of total mercury in hair is present as methylmercury (Cernichiari et al. 1995). In populations or individuals with no or low fish consumption, mercury in

hair would then be present as inorganic mercury rather than methylmercury (Berglund et al. 2005). As a result, measuring total mercury in hair for fish-eaters will provide a good representation of methylmercury in those individuals. Additionally, total mercury measurement in hair is the typical approach used when assessing methylmercury exposure in fish-eating human populations (e.g. Berglund et al. 2005).

Accumulation of methylmercury in hair tissue is directly proportional to methylmercury content in blood and does not appear to require a threshold blood level for hair accumulation to occur (ATSDR 1999). The World Health Organization (WHO) has cited a concentration ratio of 250 (range of 250 to 300), which translates into a mercury concentration in a segment of hair of 250 times the concentration in blood over the course of that hair segment's growth period (WHO 2008; and as cited in Bartell et al. 2004). Additionally, once mercury has been incorporated into hair, its accumulation is irreversible: no metabolism or reduction in hair mercury content occurs over time (ATSDR 1999; WHO 2008). As a result, mercury exposure can be traced back as far as the length of hair allows. Although a typical hair growth rate is approximately 1 cm/month (WHO 2008), given that hair growth rates may vary somewhat not just between individuals, but within individuals, precision in associating a given hair length to a specific time period of exposure deteriorates when the segment of hair is further from the scalp (Bartell et al. 2004).

It is noted that neither the WHO (2008) nor First Nations Food, Nutrition and Environment Study (FNFNES; UNBC 2020) have indicated that a lag time should be considered when collecting hair samples; that is, these sources indicate that the 1 cm closest to the scalp represents the previous month's exposure. However, literature related to hair sampling indicates that it takes approximately 7-10 days for hair to emerge from the follicle and reach the scalp (Kintz et al. 2015). This lag time was accounted for when interpreting exposure periods corresponding to the volunteers' hair segment(s). The preferred biomarker for chronic mercury exposure is hair sampling, given that other biomarkers such as blood sampling are more appropriately used when assessing acute exposures. For example, a study by Tsuchiya et al. (2012) investigated whether instantaneous blood samples collected 3 times over the course of one year correlated with fish consumption. While the blood concentrations collected over the three events correlated well when averaged over the entire study population, the authors reported that the instantaneous blood samples did not adequately account for individual variability in exposure, given that fish consumption varied for each person over the course of the year of study and the blood mercury levels varied largely over the three sampling events. That is, blood sampling does not accurately represent chronic mercury exposure for individuals that do not have a consistent diet over the long-term.

These conclusions were also reached by Bartell et al. (2004) and Bartell and Johnson (2011) in their investigations into errors associated with steady-state exposure assumptions where consumption rates are variable. The authors found that using instantaneous blood levels to represent a 30-day steady-state blood concentration when examining total exposures of 500 days had relatively wide 95% confidence intervals for error. For example, for a mean daily intake of 2 µg/day, the 95% confidence intervals ranged from -1.06 to 1.08 µg/day, suggesting that using the instantaneous blood levels could result in an estimated daily average ranging from 50% to 200% of the actual daily average. However, for longer-term exposures (e.g. greater than 250 days), error is close to zero when using hair as a biomarker (Bartell et al. 2004).

Recent literature (Bartell et al. 2004; Bartell and Johnson 2011) has also examined the shortcomings in conducting risk assessments when non-steady-state exposure conditions are valid. Risk assessments typically assume a continuous daily consumption rate (e.g., grams per day) when exposure may in fact vary over time, from day-to-day, week-to-week, and over the longer-term. For example, if one fish meal per week is assumed,

this fish meal may occur on a different day each week, and may occur two days in a row on occasion, both of which affect the magnitude of exposure to methylmercury. The use of statistical models to better estimate variable exposure using biomarkers have been developed and this type of analysis can be included in the uncertainty assessment of the HHRA to better understand the uncertainties surrounding the exposure and risk estimates.

Hair Sampling Methodology

The methodology used for collecting hair samples is based on that utilised by the First Nations Food, Nutrition and Environment Study (FNFNES). In brief, a 5 to 10 mm bundle of hair (approximately 100 strands) will be cut close to the scalp from the occipital region of the head. The hair bundle will then be placed into a zip closable bag (e.g. Ziploc ®) and a few staples will be used to fasten the scalp end of the hair to the bag. The hair sample bag will be labelled with the date, community name, and unique participant ID number. The hair samples will then be analysed for total mercury. Any unused sample will be handled as per individual and community preferences.

Whilst the FNFNES serves as the basis for this sampling methodology, modifications have been made in order to tailor the program to be specific to the project. The key differences are as follows:

- Based upon the literature regarding a lag time of 7-10 days between the time a hair begins to grow (i.e., incorporates mercury into the growing hair at its root within the follicle) to the time the hair emerges from the scalp), it has been assumed that the hair at the scalp end represents hair that began to grow approximately 2 weeks prior. Although hair is clipped from the scalp as closely as possible, there is typically a small amount (1 mm or thereabouts) that remains. If hair samples are collected in the first week of December from the 0-1 cm closest to the scalp, this hair is considered to represent exposure that occurred from mid-October to mid-November.
- Following the completion of the food survey, participants will be assigned to one of the three groups outlined in Table 1 which are based upon Health Canada's fish consumption guidelines. The groups are based on the amount of fish that the participants consume per week.

Table 1: Hair Sampling Methodology Participant Groupings

Rate of Fish Consumption*	Length of Hair Analysed	Frequency of Hair Sample Collection
Low (≤1)	3 cm	Seasonal
Moderate (2-3)	1 cm (up to 3 segments)	Monthly / Seasonal**
High (>3)	1 cm	Monthly

* Rate of fish consumption during the peak season in terms of meals per *week* for the general population, and meals per *month* for sensitive subpopulations (i.e., children under 12 years of age and women of child-bearing age (15-49)).

** While seasonal has been proposed at a minimum, if there are no logistical constraints, monthly sampling for the moderate group may be completed if possible.

For participants that generally indicate they do not consume a lot of fish (i.e., consume fish ≤1 time per week), a 3 cm length of hair will be sectioned and analysed for mercury. The sample collection period will correspond with the season when they are most likely to be exposed (e.g. summer). It is considered that a 3 cm length of hair is representative of this groups' exposure to mercury as the variability associated with their consumption is low and their exposure to mercury (via consumption of fish) is anticipated to be negligible.

For participants that consume a moderate amount of fish (i.e., consume fish 2-3 times a week), one or more 1 cm lengths of hair will be submitted corresponding to the month or month(s) when exposure is expected to be the highest. It is noted that the Toxicity Reference Value (TRV) for methylmercury is based on monthly exposure, and therefore submitting a 3 cm length of hair for a moderate consumer could potentially result in a false negative. In this case, the purpose of decreasing the length analyzed from 3 cm to 1 cm is to provide more certainty that maximum monthly levels are captured and to avoid potentially analysing a hair sample that is not representative of a period of moderate consumption..

For participants that consume a high amount of fish (i.e., ≥4 times a week), multiple 1 cm lengths of hair would be submitted for analysis corresponding to the multiple months that they may be exposed and that is expected to represent a peak of exposure. The objective of multiple samples is to minimize the chance of missing the true peak of exposure.

Some individuals may have very long hair where one year or more of consumption can be determined. Although the accuracy of hair segments corresponding to months of exposure deteriorates the further the hair is from the scalp (Bartell et al. 2004), those individuals with long hair and who may also have some variability in fish consumption throughout the year could be candidates for having multiple seasons analyzed to gain an understanding of seasonal variability in hair mercury concentrations. For example, if an individual with long hair tends to eat the most fish during the spring and fall, but less during the winter and summer, 12 1-cm hair lengths corresponding to the previous year's exposure could be collected and analyzed to observe the corresponding changes in mercury levels over the course of that time. Decisions on which individuals may be candidates for this type of analysis will be discussed and determined in consideration of logistical constraints in combination with food survey results.

It is noted that it is possible that consumption practices may exist that are not accounted for in the groupings outlined above. Professional judgement will be used to assess the appropriate hair sampling methodology (specifically, peak season and 3-cm or 1-cm) for these extenuating circumstances. For example, the type of fish consumed may affect when the expected peak season would occur for that individual. It is understood that there are differences in mercury concentration between different fish species (e.g. the concentrations of mercury in pike tend to be approximately 4 times greater than the mercury concentrations in whitefish in some lakes[1]). Therefore, for the same consumption rate, a participant may be exposed to 4 times more mercury if the participant is consuming pickerel or northern pike rather than lake whitefish For example, f a hypothetical individual is consuming approximately 1 fish meal of pike per week during the spring (i.e., 1 meal x 4 units of mercury exposure = 4 units of mercury exposure per week) and 3 fish meals of whitefish during the summer (i.e., 3 meals x 1 unit of mercury exposure = 3 units of mercury exposure per week), the

[1] Fish ratios of mercury levels will be based on fish tissue mercury data from lakes in the Project area. The 4:1 ratio shown for pike and whitefish was assumed for demonstration purposes only.

exposure to mercury via pike would be greater than for whitefish. As a result, the spring season would be considered the peak exposure season even though the strict number of meals per week is lower in the spring than in the summer. Consideration of known variability in mercury concentrations in fish tissue will be taken into account when selecting the hair sample interval for analysis such that it correlates with the expected exposure peak. Additionally, for this same individual, the difference in mercury exposure between the spring and summer may not be very high, since they only differ slightly in terms of the estimated units of mercury exposure (i.e., 3 vs. 4). The number of fish meals per week would fall into the "high" category considering 4 fish meals per week of whitefish during the summer, which would correspond to several 1-cm hair lengths for submissions for the peak exposure season. However, since the peak exposure may occur over the spring and summer, , hair lengths corresponding to both the spring and summer months from individuals with a sufficient length of hair available will be submitted for analysis to ensure that the true peak is not missed.

Consultation with community members indicated that peak fish consumption typically occurs during the late spring, summer and fall months (June – October). For this reason, hair sampling events are scheduled based on the most opportune times to collect data with a bias towards being most representative of peak fish consumption for most community members. It is acknowledged that the length of a participant's hair varies throughout the year and does not always line up with the timing of these collection events. For scenarios where a participant's hair is too short (i.e., < 3 cm) or the length of hair available for sampling does not align with their expected peak exposure, there is opportunity for that participant to provide hair samples during an off-cycle event. The logistics of these opportunities are explained to participants during the sampling events.

- The hair samples will be sent to Maxxam Analytics in Mississauga, ON rather than the FNIHB laboratory.
  - The analysis of hair samples will be carried out by Maxxam Analytics (Maxxam) which has been independently audited by the Standards Council of Canada (SCC) under ISO guide 17025. Details of Maxxam's accreditation can be viewed through the following link: http://maxxam.ca/about-maxxam/quality/accreditation-certification/. Maxxam is accredited for mercury analysis via cold vapour atomic absorption spectroscopy (CVAAS) on a tissue matrix by SCC.
- The hair samples will not be pre-washed with acetone and water to avoid potential removal of endogenous mercury in the sample which has been suspected in some studies as summarized by Esteban et al. (2014).

The selected analytical method for analyzing total mercury in hair is CVAAS. Based upon a review by WHO (2008), CVAAS is one of the more commonly used analytical methods which allows for comparison to other studies. Additionally, it has sufficient sensitivity with Maxxam achieving detection limits on the order of 0.005 ppm (the health effect threshold considered is 2 ppm (Legrand et al. 2010) for sensitive subgroups such as women of childbearing age and children and 5 ppm (Environment Canada, Health Canada 2010) for non-sensitive subgroups such as adult men).

Disclaimer

Due to the pandemic situation, this document could not be reviewed with the MHHIG and involved health agencies prior to submitting to meet the Project's annual reporting requirements. These parties have discussed

the contents within and while no substantive changes are anticipated, the finalization of this document is subject to review and input from MHHIG and health agencies.

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AA/CO/RJ/co/cg

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APPENDIX B

Consent Forms

GOLDER

PARTICIPANT ID

Consent to Take Part in Hair Sampling/Food Survey

(General – Age 18 years and older)

TITLE:	Keeyask Generation Project Hair Sampling and Food Survey
PRINCIPAL RESEARCHER:	Sharon Guin (Phone Number: (905) 723-2727)
SPONSOR:	Keeyask Hydropower Limited Partnership (The Partnership)

You have been invited to participate in mercury hair sampling and a food survey being offered in your community. **Participation in this activity is voluntary. If you choose to participate in this activity you can withdraw from the activity at any time.** Before you decide, you need to understand what this activity is for, what risks you might take and what benefits you might receive. This consent form explains the activity being proposed.

Please read this carefully. Take as much time as you like. If you prefer, you may take this form home to think about for a while. Mark anything you do not understand, or want explained better. After you have read it, please ask questions about anything that is not clear.

The researchers will:

- Discuss the activity with you
- Answer your questions
- Keep confidential any information which could identify you personally
- Be available during the sampling and survey to deal with problems and answer questions

This consent form only applies to the current food survey and hair sampling program. If future sampling is undertaken, you will be asked again to provide your consent at that time.

1. Introduction/Background

Mercury is a metal that is “naturally” present in the environment and in fish. Since industrial times (1800s), mercury levels have risen in the environment due to industries like coal-fired power generation, incinerators, metal refining, and chemical manufacturing. All of these processes release mercury into the atmosphere from where it is deposited, onto land and water. Flooding of soil or wetlands commonly results in a temporary increase in mercury and its organic form, methylmercury. Methylmercury is taken up by the organisms that live in and use those environments. Bacteria living, for example, in soils and water change inorganic mercury to ‘methylmercury’. This type of mercury builds up and becomes more concentrated at higher levels in the food web, such as in predatory fish.

The Keeyask Project will flood some forest and wetland areas through the creation of a reservoir which will increase mercury levels in fish from Gull Lake, and to a lesser extent in Stephens Lake. Mercury concentrations in fish are expected to peak three to seven years after the creation of the Keeyask reservoir, and then slowly decline over time. We want to know whether eating fish from the reservoir will increase people’s exposure to mercury and if people’s health might be affected.

2. Purpose of this Activity

To collect information on baseline mercury levels from people who live or fish in the Keeyask Generation Project area.

3. Description of Activity Procedures

The food survey will include questions about the number of people in your home and their ages, if anyone is pregnant or breastfeeding, the type of work and hobbies you have, and the food you and your family eat, with a focus on wild foods. After the survey, a small section of hair less than the width of a pencil eraser (about 0.75 cm) will be cut. The hair will be cut from near the base of your scalp. The hair samples will be collected by Mercury Community Coordinators and research assistants selected by your community who have been trained in this procedure. The hair samples will be tested for mercury only, at a certified laboratory, and any leftover hair will be returned to your community at a central location in case you would like it back.

4. Length of Time

The hair sampling takes about 5 minutes, and the first part of the food survey focusing on fish will take about 10 minutes. There are some portions of the food survey that are not critical to understanding mercury exposure but would be of interest to the research team; if you decide to answer those additional questions the food survey will take between 30 and 40 minutes, depending on how much wild food is eaten.

5. Possible Risks and Discomforts

There are no risks or discomforts to those individuals who take part in this activity. However, there is the possibility of finding out that your baseline mercury levels are above regulatory guidelines set by health agencies. Golder will directly contact any individual whose levels exceed the regulatory guidelines (note that all participants will receive a letter will their personal results a few weeks after the samples are collected).

6. Benefits

Knowing your mercury levels lets you know whether the exposure you have today to mercury is safe, and whether you should continue to eat wild foods (including fish) the same way you are now. It will also let you know whether you should make any changes to the amount of fish or types of fish you are eating for optimal health.

Having data on mercury levels in people before reservoir flooding could also be used in future human health risk assessments that the Keeyask Partnership has committed to doing. The food and hair study, along with the future human health risk assessments, will provide valuable information on mercury exposure in the communities near the project, and provide a point of comparison should there be increases in mercury exposure after flooding and after the project has begun operating. All of this information will be essential for deciding, whether changes to fish consumption recommendations are needed to protect people's health in the future.

7. Liability Statement

Signing this form gives us your consent to take part in this activity. It tells us that you understand the information about the activity and how the information will be used. When you sign this form, you do not give up your legal rights. Researchers or agencies involved in this activity still have their legal and professional responsibilities.

8. What about my privacy and confidentiality?

Protecting your privacy is an important part of this activity. Every effort to protect your privacy will be made. However, it cannot be guaranteed. For example, we may be required by law to allow access to your records as part of this activity.

When you sign this consent form you give us permission to:

- Collect information from you
- Share information with the people conducting this activity
- Share information with the people responsible for protecting your safety

<u>Access to your records</u>

Some members of the research team will see records that identify you by name. Other people may need to look at the records that identify you by name. This might include the research ethics board. You may ask to see the list of these people. They can look at your records only when supervised by a member of the research team.

You may ask the researcher to see the information that has been collected about you at any time.

Use of your information

The research team will collect and use only the information they need for this activity and to support future human health risk assessments for the Keeyask Generation Project.

- This information will include your:
  - age
  - gender
  - the results of your mercury hair sampling
  - information from dietary survey questionnaires, including some personal information such as how many people live with you and whether you are pregnant
- Your name and contact information will be kept secure by the Golder research team. You will be assigned a unique participant ID number. The participant ID number will be used on the food survey and hair sample results, not your name or contact information. It will not be shared with others without your permission except as indicated above. Your name will not appear in any report or article published as a result of this activity.
- Information collected for this activity will be kept for an undetermined period because baseline data could be used for the future human health risk assessments, as well as in monitoring programs post-flooding and during operations.
- If you decide to withdraw from this activity, the information collected up to that time will continue to be used by the research team. It will not be removed. This information will only be used for the purposes of this activity.
- Information collected and used by the research team will be stored within the Golder team's secure and password-protected database. Sharon Guin (Principal Researcher) is the person responsible for keeping it secure.

9. Questions or Problems

If you have any questions about taking part in this activity, you can speak with the principal researcher who is in charge of this activity. That person is Sharon Guin: 905-723-2727. Collect calls will be accepted.

Or, you can talk to someone who is not involved with this activity at all, but can advise you on your rights as a participant in this activity. You may contact:

Manager, Research Ethics Board Secretariat
70 Colombine Driveway
9th Floor, Room 941C
Brooke Claxton Building, Postal Locator: 0909C
Tunney's Pasture
Ottawa, Ontario, K1A 0K9
Phone number (613) 941-5199
Fax (613) 941-9093
Email: REB-CER@hc-sc.gc.ca

GOLDER

PARTICIPANT ID

Signature Page

To be filled out and signed by the participant or an authorized third party:

By signing this form, I agree that:

- The activity has been explained to me. Yes ☐ No ☐
- All my questions were answered. Yes ☐ No ☐
- The possible discomforts and the possible benefits (if any) of this activity have been explained to me. Yes ☐ No ☐
- I understand that I have the right not to participate and the right to stop my participation at any time, for any reason. Yes ☐ No ☐
- I understand that I may refuse to participate without consequence. Yes ☐ No ☐
- I have a choice of not answering any specific questions. Yes ☐ No ☐
- I am free now, and in the future, to ask any questions about this activity. Yes ☐ No ☐
- I have been told that my personal records will be kept confidential. Yes ☐ No ☐
- I understand that should I choose to withdraw from this activity my data will remain part of the data used in this activity. Yes ☐ No ☐
- I understand that no information that would identify me will be released or printed without asking me first. Yes ☐ No ☐
- I understand that I will receive a signed copy of the consent form. Yes ☐ No ☐
- I agree that my doctor/health care provider can receive the results of this activity. Yes ☐ No ☐ N/A ☐

Would you like to be contacted to take part in future food surveys/hair sampling? Yes ☐ No ☐

I hereby consent to participate in this activity:

_____ _____

Signature of Participant or Authorized Third Party | Date

_____

Name of Participant (please print)

_____

Name of Authorized Third Party, if applicable (please print)

To be signed by the researcher or person obtaining consent:

I have explained this activity to the best of my ability. I invited questions and gave answers. I believe that the participant/authorized third party fully understands what is involved in taking part in this activity, any potential risks associated with taking part in this activity and that he or she has freely chosen to take part in this activity.

Name of person who obtained consent: _____

_____ _____

Signature | Date

GOLDER

PARTICIPANT ID

Consent to Take Part in Hair Sampling/Food Survey

(Minor – Under 18 years of age)

TITLE: Keeyask Generation Project Hair Sampling and Food Survey

PRINCIPAL RESEARCHER: Sharon Guin (Phone Number: (905) 723-2727)

SPONSOR: Keeyask Hydropower Limited Partnership

Your child/ward has been invited to participate in mercury hair sampling and a food survey being offered in your community. **Participation in this activity is voluntary. If you choose on behalf of your child/ward to participate you can withdraw your child/ward from the activity at any time.** Before you decide, you need to understand what the activity is for, what risks your child/ward might take and what benefits your child/ward might receive. This consent form explains the activity being proposed.

Please read this carefully. Take as much time as you like. If you prefer, you may take this form home to think about for a while. Mark anything you do not understand, or want explained better. After you have read it, please ask questions about anything that is not clear.

The researchers will:

- Discuss the activity with you and your child/ward
- Answer questions from you and your child/ward
- Keep confidential any information which could identify your child/ward personally
- Be available during the hair sampling and food survey to deal with problems and answer questions

If your child/ward is aged 7 to 13, please let the Mercury Community Coordinator know whether you would like to explain the activity to your child/ward yourself or if you would like the Mercury Community Coordinator to explain instead. Once the activity is explained, please have the child read and sign the attached Assent Form.

1. Introduction/Background

Mercury is a metal that is “naturally” present in the environment and in fish. Since industrial times (1800s), mercury levels have risen in the environment due to industries like coal-fired power generation, incinerators, metal refining, and chemical manufacturing. All of these processes release mercury into the atmosphere from where it is deposited, onto land and water. Flooding of soil or wetlands commonly results in a temporary increase in mercury and its organic form, methylmercury. Methylmercury is taken up by the organisms that live in and use those environments. Bacteria living, for example, in soils and water change inorganic mercury to ‘methylmercury’. This type of mercury builds up and becomes more concentrated at higher levels in the food web, such as in predatory fish.

The Keeyask Project will flood some forest and wetland areas through the creation of a reservoir which will increase mercury levels in fish from Gull Lake, and to a lesser extent in Stephens Lake. Mercury concentrations in fish are expected to peak three to seven years after the creation of the Keeyask reservoir, and then slowly decline over time. We want to know whether eating fish from the reservoir will increase people’s exposure to mercury and if people’s health might be affected.

2. Purpose of this Activity

To collect information on baseline mercury levels from people who live or fish in the Keeyask Generation Project area.

3. Description of Activity Procedures

The food survey will include questions about the number of people in your child/ward's home and their ages, if anyone is pregnant or breastfeeding, the type of hobbies your child/ward has, and the food your child/ward and your family eat, with a focus on wild foods. After the survey, a small section of hair less than the width of a pencil eraser (about 0.75 cm) will be cut. The hair will be cut from near the base of your child/ward's scalp. The hair samples will be collected from Mercury Community Coordinators and research assistants selected by your community who have been trained in this procedure. The hair samples will be tested for mercury only, at a certified laboratory, and any leftover hair will be returned to your community at a central location in case your child's/ward would like it back.

4. Length of Time

The hair sampling takes about 5 minutes, and the first part of the food survey focusing on fish will take about 10 minutes. There are some portions of the food survey that are not critical to understanding mercury exposure but would be of interest to the research team; if your child/ward decides to answer those additional questions the food survey will take between 30 and 40 minutes, depending on how much wild food is eaten.

5. Possible Risks and Discomforts

There are no risks or discomforts to those individuals who take part in this activity. However, there is the possibility of finding out that your child's/ward's baseline mercury levels are above regulatory guidelines set by health agencies. Golder will directly contact any individual whose levels exceed the regulatory guidelines (note that all participants will receive a letter will their personal results a few weeks after the samples are collected).

6. Benefits

Knowing your mercury levels lets you know whether the exposure your child/ward has today to mercury is safe, and whether your child/ward should continue to eat wild foods (including fish) the same way they are now. It will also let you know whether your child/ward should make any changes to the amount of fish or types of fish they are eating for optimal health.

Having data on mercury levels in people before reservoir flooding could also be used in future human health risk assessments that the Keeyask Partnership has committed to doing. The food and hair activity, along with the future human health risk assessments, will provide valuable information on mercury exposure in the communities near the project, and provide a point of comparison should there be increases in mercury exposure after flooding and after the project has begun operating. All of this information will be essential for deciding whether changes to fish consumption guidelines or advisories are needed to protect people's health in the future.

7. Liability Statement

Signing this form gives us your consent for your child/ward to take part in this activity. It tells us that you understand the information about the activity and how the information will be used. A separate assent form is available if your child/ward is able to understand the activity, which gives us their permission to participate in the activity. When you sign this form, you do not give up your legal rights or those of your child/ward. Researchers or agencies involved in this activity still have their legal and professional responsibilities.

8. What about my privacy and confidentiality?

Protecting the privacy of your child/ward is an important part of this activity. Every effort to protect your child's/ward's privacy will be made. However, it cannot be guaranteed. For example we may be required by law to allow access to your records as part of this activity.

When you sign this consent form you give us permission to:

- Collect information from your child/ward
- Share information with the people conducting this activity
- Share information with the people responsible for protecting your safety

<u>Use of your information</u>

The research team will collect and use only the information they need for this activity and to support future human health risk assessments for the Keeyask Generation Project.

- This information will include your child's/ward's:
  - age
  - gender
  - the results of your child's/ward's mercury hair sampling
  - information from dietary survey questionnaires, including some personal information such as how many people live with your child/ward and whether your child/ward is pregnant
- Your child's/ward's name and contact information will be kept secure by the Golder research team. Your child/ward will be assigned a unique participant ID number. The participant ID number will be used on the food survey and hair sample results, not your child's/ward's name or contact information. It will not be shared with others without your permission except as indicated above. Your child's/ward's name will not appear in any report or article published as a result of this activity.
- Information collected for this activity will be kept for an undetermined period because baseline data will be used for the future human health risk assessments, as well as in monitoring programs post-flooding and during operations.
- If your child/ward decides to withdraw from this activity, the information collected up to that time will continue to be used by the research team. It will not be removed. This information will only be used for the purposes of this activity.
- Information collected and used by the research team will be stored within the Golder team's secure and password-protected database. Sharon Guin (Principal Researcher) is the person responsible for keeping it secure.

Access to your child's/ward's records

Some members of the research team will see records that identify your child/ward by name. Other people may need to look at the records that identify your child/ward by name. This might include the research ethics board. You and your child/ward may ask to see the list of these people. They can look at your child's/ward's records only when supervised by a member of the research team.

You may ask the researcher to see the information that has been collected about your child/ward at any time.

9. Questions or Problems

If you have any questions about taking part in this activity, you can speak with the principal researcher who is in charge of the activity. That person is Sharon Guin: 905-723-2727. Collect calls will be accepted.

Or, you can talk to someone who is not involved with this activity at all, but can advise you on your rights and your child's/ward's rights as a participant in this activity. You may contact:

Manager, Research Ethics Board Secretariat
70 Colombine Driveway
9th Floor, Room 941C
Brooke Claxton Building, Postal Locator: 0909C
Tunney's Pasture
Ottawa, Ontario, K1A 0K9
Phone number (613) 941-5199
Fax (613) 941-9093
Email: REB-CER@hc-sc.gc.ca

GOLDER

PARTICIPANT ID

Signature Page

To be filled out and signed by the parent/guardian:

By signing this form, I agree that:

- The activity has been explained to me and my child/ward. Yes ☐ No ☐
- All our questions were answered. Yes ☐ No ☐
- The possible discomforts and the possible benefits (if any) of this activity have been explained to me and my child/ward. Yes ☐ No ☐
- I understand that I have the right not to have my child/ward participate and the right to stop his/her participation at any time, for any reason. Yes ☐ No ☐
- I understand that I may refuse to have my child/ward participate without consequence. Yes ☐ No ☐
- I have a choice of having my child/ward not answer any specific questions. Yes ☐ No ☐
- I and my child/ward are free now, and in the future, to ask any questions about the activity. Yes ☐ No ☐
- I have been told that my child's/ward's personal records will be kept confidential. Yes ☐ No ☐
- I understand that should I choose to withdraw my child/ward from this activity my child's/ward's data will remain part of the data used in this activity. Yes ☐ No ☐
- I understand that no information that would identify my child/ward will be released or printed without asking me first. Yes ☐ No ☐
- I understand that I and my child/ward will receive a signed copy of the consent form. Yes ☐ No ☐
- I agree that my child's/ward's doctor/health care provider can receive the results of this activity. Yes ☐ No ☐ N/A ☐

Would you like to be contacted for my child/ward to take part in future food surveys/hair sampling? Yes ☐ No ☐

I hereby consent to have my child/ward _____ participate in this activity:

_____ _____

Signature of Parent/Guardian Date

_____

Name of Parent/Guardian (please print)

Assent Form is attached: Yes ☐ N/A ☐

To be signed by the researcher or person obtaining consent:

I have explained this activity to the best of my ability. I invited questions and gave answers. I believe that the parent/guardian fully understands what is involved in taking part in this activity, any potential risks associated with taking part in this activity and that he or she has freely chosen for the child/ward to take part in this activity.

Name of person who obtained consent: _____

_____ _____

Signature Date

GOLDER

PARTICIPANT ID

Consent to Take Part in the Hair Sampling/Food Survey Activity

(Minor Assent Form – 7 to 13 years of age)

TITLE:	Keeyask Generation Project Hair Sampling and Food Survey
PRINCIPAL RESEARCHER:	Sharon Guin (Phone Number: (905) 723-2727)
SPONSOR:	Keeyask Hydropower Limited Partnership

Why are you here?

We want to tell you about some hair sampling that we're doing for children living in this area. We want to see if you would like to participate in this sampling. This form tells you about the sampling. If there is anything you do not understand, please ask your parent, your guardian or the staff.

Why are they doing this sampling?

Eating fish is very healthy, but you can overdo it. A scientist can measure how much mercury is in your hair. We are doing the mercury hair sampling to see how much fish you're eating.

What will happen to you?

If you want to participate in the sampling, these things will happen:

- You will be asked to have a little bit of your hair taken, and you will be asked some questions about the things that you eat.
- The hair sampling will take about 5 to 10 minutes to complete.
- The questions about the foods you eat will take about another 10 to 30 minutes.
- Your parent or guardian will be with you at all times.

Will the sampling hurt?

No, it will not hurt. It is like getting a haircut.

What if you have any questions?

You can ask questions any time, now or later. You can talk to the staff, your family or someone else.

Who will know that I did the sampling?

Anything that you tell or give to the staff will be kept private (or secret). Your name will not be on any reports and no one but the staff and your family doctor will know that it was you who was in the sampling.

GOLDER

PARTICIPANT ID

Do I have to have my hair sampled?

No, you do not have to have your hair sampled if you don't want to.

If you don't want to have your hair sampled, just say so. We will also ask your parents if they would like you to have your hair sampled.

Even if you say yes now you can change your mind later. It's up to you.

Do you have any questions? What questions do you have?

You can also ask your questions to the sampling leader (Sharon Guin) or to someone not involved with the sampling (Research Ethics Board). Their telephone numbers are shown on the main consent form.

When you have no more questions, please print your name and sign below.

ASSENT

I want to take part in the mercury hair sampling. I know I can change my mind at any time.

_____ Verbal assent given Yes ☐

Print name of child

OR

Written assent if the child chooses to sign the assent.

_____	_____	_____
Signature of Child	Age	Date

This section must be completed:

I confirm that I have explained the mercury hair sampling to the participant to the extent compatible with the participants understanding, and that the participant has agreed to be in the mercury hair sampling.

_____	_____	_____
Printed name of Person obtaining assent	Signature of Person obtaining assent	Date

APPENDIX C

Food Survey

FOOD SURVEY

KEEYASK

AND MERCURY EXPOSURE WORKBOOK

PARTICIPANT ID

INTERVIEW DATE

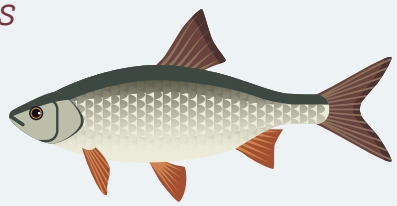
Get your hair tested to **KNOW YOUR NUMBER!** The best indicator of mercury exposure

wsp

Tansi – Hello!

Thank you for participating in the Keeyask Food Survey. This survey will ask you about your food intake and other ways you may be exposed to mercury. All your answers from this survey are confidential.

Thank you – Ekosi



Participant Information

COMMUNITY/FIRST NATION

GENDER

Do you live in the community full-time? ☐ YES ☐ NO

If no, how many months per year do you live in the community?

How long have you lived in this community?

YOUR AGE CATEGORY

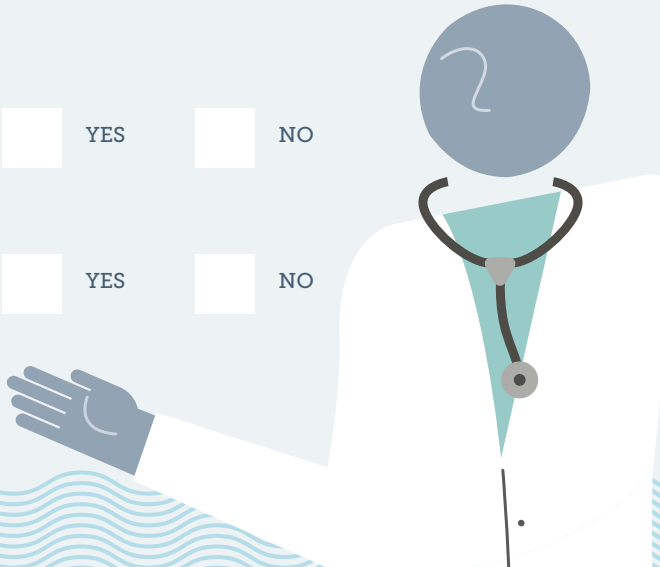
☐ 0-4 YEARS ☐ 5-11 YEARS ☐ 12-18 YEARS ☐ 19-49 YEARS ☐ 50 YEARS +

MEDICAL RECORDS

Do you want a second copy of your personal results that you can provide to your health care practitioner? ☐ YES ☐ NO

Do you want your hair sample returned to you? ☐ YES ☐ NO

Note: It may not be possible to return the hair sample if the full length was required for analysis.



Additional Information

The questions in this section are optional, but the information will help in the interpretation of your mercury hair results, especially if you are a moderate or high consumer of fish (e.g., more than 2 meals of fish per week).

BODY WEIGHT?

Body weight can affect how much mercury is stored in your body.

WHAT IS YOUR CURRENT WEIGHT? OR ENTER A WEIGHT RANGE BELOW:

- ☐ 60 LBS OR LESS
- ☐ 61-90 LBS
- ☐ 91-130 LBS
- ☐ 131-160 LBS
- ☐ 161-200 LBS
- ☐ 200 LBS OR MORE

POTENTIAL MERCURY EXPOSURE

Some jobs and hobbies have a higher exposure to mercury than others. In the past year what type of work have you done? (for example, commercial fishing, forestry, building construction, water treatment)

In your current job(s) or hobby(ies) are you exposed to any chemicals?

☐ YES ☐ NO ☐ NOT SURE

If yes, which ones? (check all that apply)

- ☐ METALS (e.g., solders, welding, wires, greases, sheet metal, arts/crafts involving carving/grinding/etching of rocks)
- ☐ PESTICIDES, INSECTICIDES, HERBICIDES, FUNGICIDES
- ☐ DYES
- ☐ PAINTS, STAINS, CAULKS, SEALANTS
- ☐ GLUES OR OTHER ADHESIVES
- ☐ FUELS, OILS, GREASES
- ☐ OFFICE PRODUCTS (E.G., INKS, TONERS, ETC.)
- ☐ CLEANING PRODUCTS
- ☐ CEMENTS, LANDSCAPING MATERIALS
- ☐ OTHER _____

Do you have any silver dental fillings?

☐ YES ☐ NO ☐ NOT SURE

Do you colour your hair?

☐ YES ☐ NO

If yes, how many times per year?

Core Questions: Wild Foods Survey

The core questions section will ask you about how often and how much you consumed of the following food in each season of the past year:

- Locally caught fish and seafood
- Market fish, seafood and other

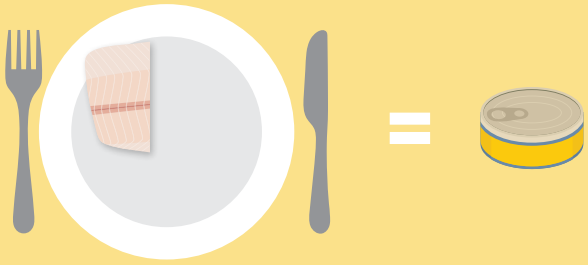
This questionnaire covers wild (or harvested/traditional) food and also market food. Wild food comes from the local land and environment (fish, birds, other animals and plants/berries). Market food comes from the supermarket or grocery store.

SERVING SIZES:

Please use the examples below to estimate the typical serving size of fish you ate at each meal.

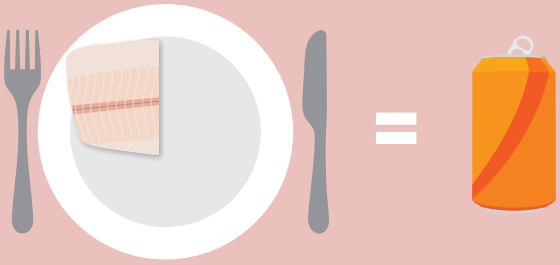
A

up to ¼ lb (3.5 oz)



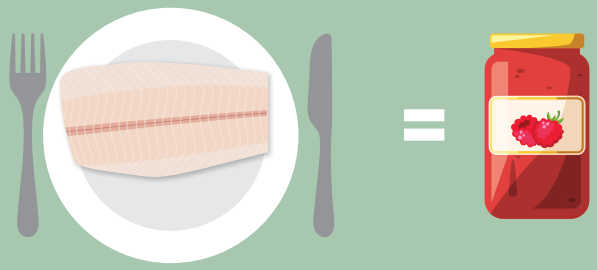
B

¼ lb to ½ lb (3.5-8 oz)



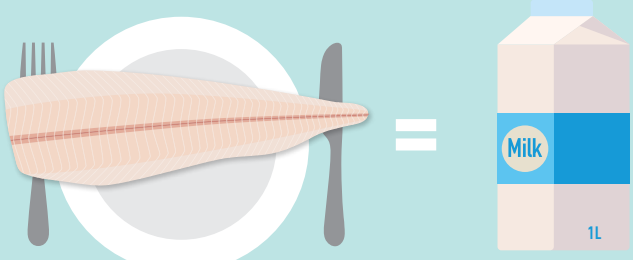
C

½ lb to 1 lb (8-16 oz)



D

more than 1 lb (16 oz)



Section 1: Fish

Have you eaten locally caught fish in the last year? ☐ YES ☐ NO

If yes, please complete pages 6-9, if no proceed to page 10.

Have you eaten market fish or seafood in the last year? ☐ YES ☐ NO

If yes, please complete pages 10-11, if no proceed to page 12.

In the last year, what month did you eat the most fish? _____

Seasonal Consumption: Wild Fish

Using the tables below, please recall how often you ate the following locally-caught fish in each season during the past year.

Fall (September-November)

	Pickerel (okáw)	Jackfish (onhcwápéw)	Whitefish (atihkamék)	Sturgeon (namao)	Other	Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
Where were the fish you ate caught? Write here, or circle on the map on page 8.						
How many times per month do you eat this fish's organs?						

Winter (December-February)

	Pickerel (okáw)	Jackfish (onhcwápéw)	Whitefish (atihkamék)	Sturgeon (namao)	Other	Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
Where were the fish you ate caught? Write here, or circle on the map on page 8.						
How many times per month do you eat this fish's organs?						

OTHER LOCALLY CAUGHT FISH AND SEAFOOD

Other common locally caught fish and seafood:

BROOK TROUT

BROWN TROUT

BURBOT (MARIAH)

TULLIBEE

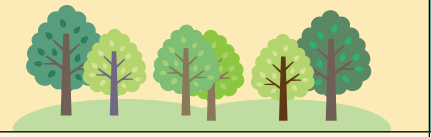
FAST FACT

Fish are healthy traditional food filled with lots of nutrients.

Spring (March-May)

	 Pickerel (okáw)	 Jackfish (onhcwápéw)	 Whitefish (atihkamék)	 Sturgeon (namao)	 Other	 Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
Where were the fish you ate caught? Write here, or circle on the map on page 8.						
How many times per month do you eat this fish's organs?						

Summer (June-August)

	 Pickerel (okáw)	 Jackfish (onhcwápéw)	 Whitefish (atihkamék)	 Sturgeon (namao)	 Other	 Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
Where were the fish you ate caught? Write here, or circle on the map on page 8.						
How many times per month do you eat this fish's organs?						


LAKE TROUT


LONGNOSE SUCKER

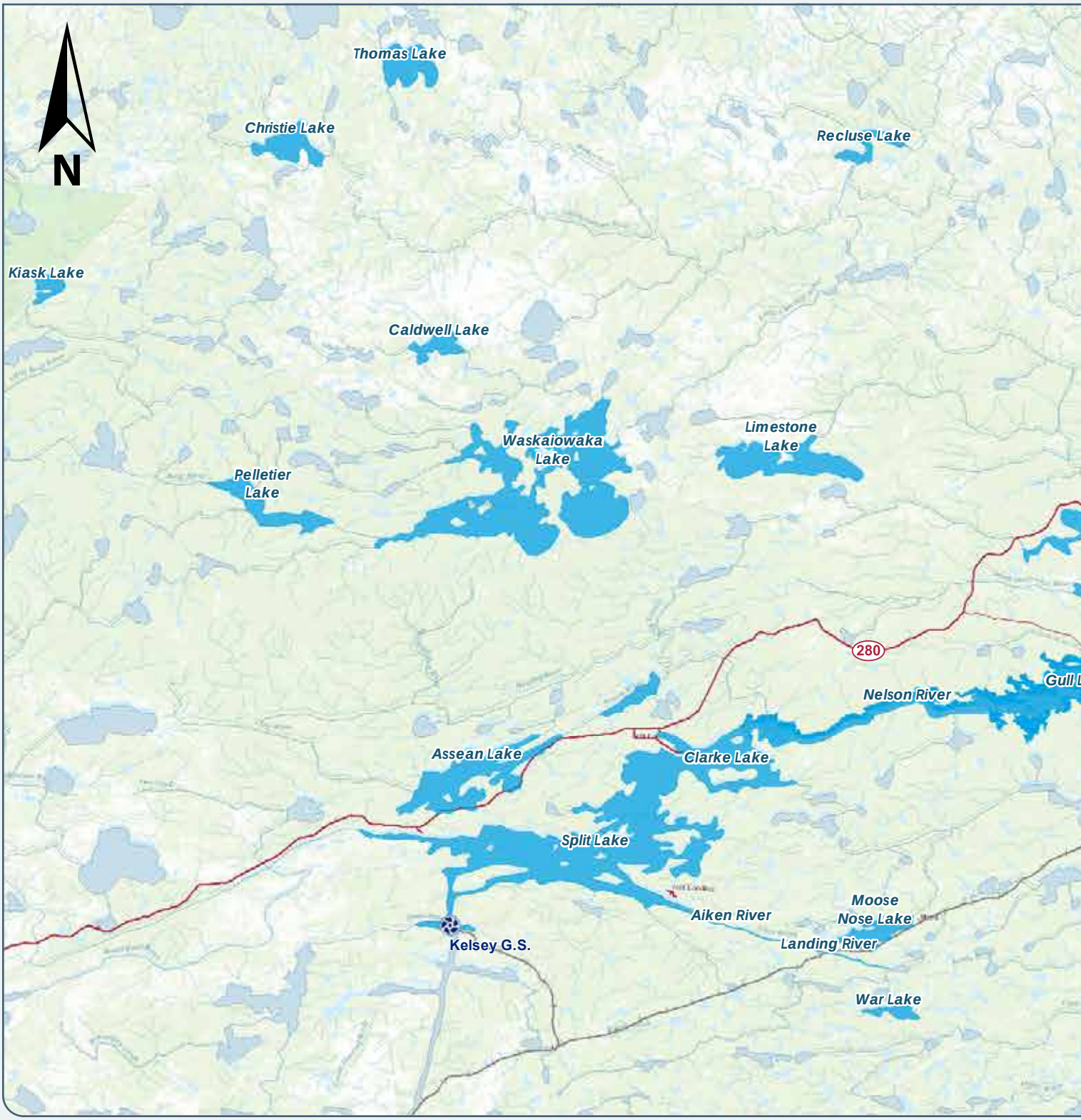

WHITE SUCKER

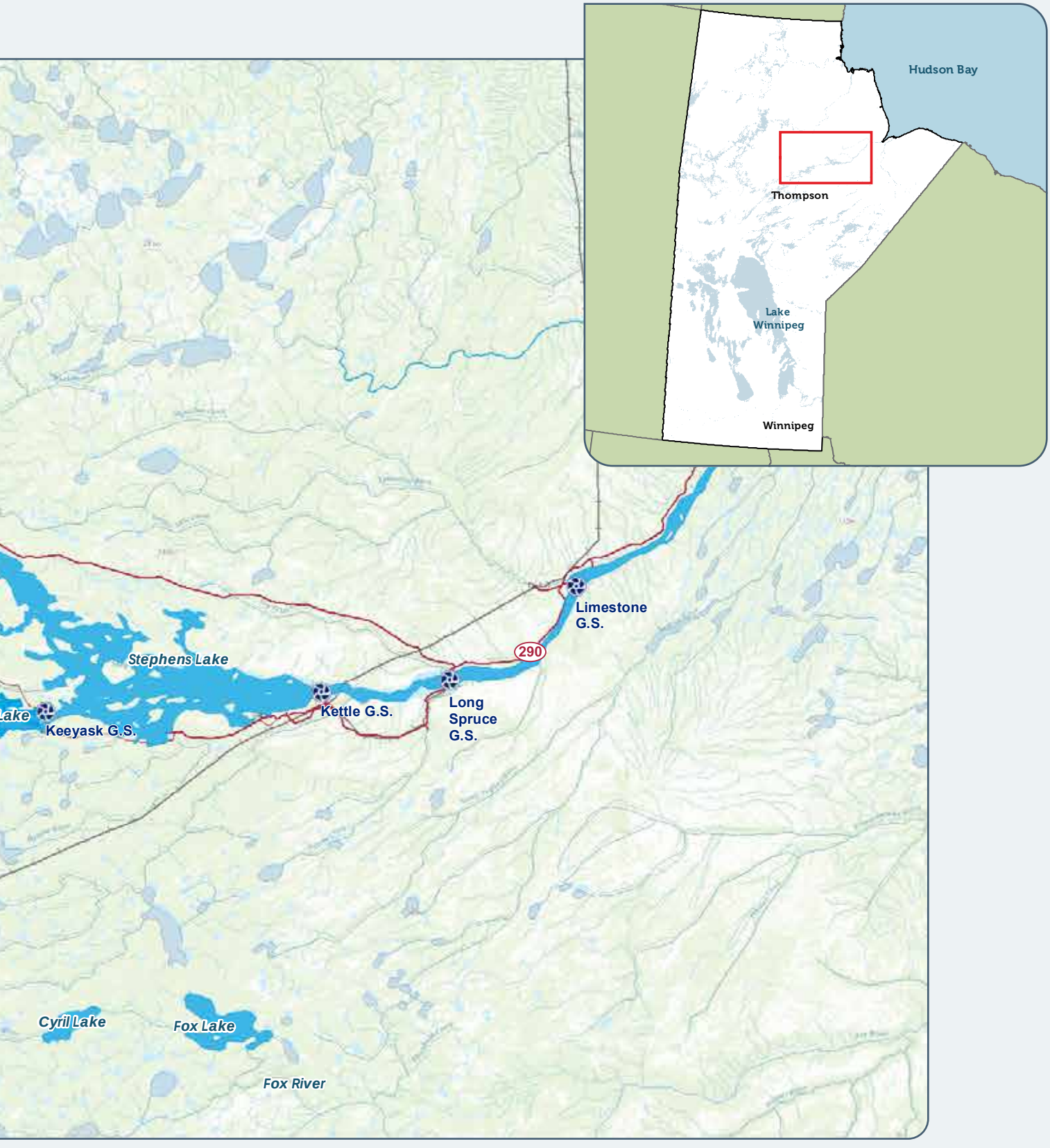

CLAMS


CRAYFISH

LOCATION MAP OF FISH CAUGHT AND CONSUMED

Circle on the map near the lake where you caught fish to eat and indicate the type of fish and the season it was caught.

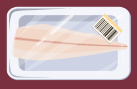
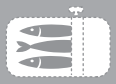



Hudson Bay
Thompson
Lake
Winnipeg
Winnipeg
Limestone
G.S.
290
Stephens Lake
Kettle G.S.
Long
Spruce
G.S.
Keeyask G.S.
Cyril Lake
Fox Lake
Fox River

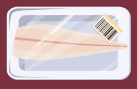
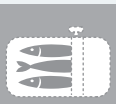
Seasonal Consumption: Market Fish and Seafood (fresh and frozen)

Using the tables below, please recall how often you ate the following market/store bought fish and seafood in each season during the past year.

Fall (September-November)

	 Arctic Char	 Cod	 Canned Tuna	 Salmon	 Breaded Fish	 Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
How many times per month do you eat this fish's organs?						

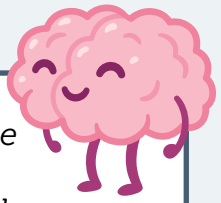
Winter (December-February)

	 Arctic Char	 Cod	 Canned Tuna	 Salmon	 Breaded Fish	 Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
How many times per month do you eat this fish's organs?						

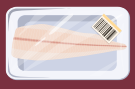
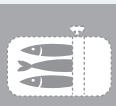
OTHER COMMON MARKET FISH AND SEAFOOD: Flounder/Turbot, Halibut, Rainbow Trout, Canned Salmon, Canned Sardines, Crab, Shrimp, Lobster, Swordfish, Tilapia, other.

FAST FACT

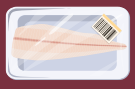
Fish is good for the brain in both the young and the old.



Spring (March-May)

	 Arctic Char	 Cod	 Canned Tuna	 Salmon	 Breaded Fish	 Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
How many times per month do you eat this fish's organs?						

Summer (June-August)

	 Arctic Char	 Cod	 Canned Tuna	 Salmon	 Breaded Fish	 Other
How many **meals per month** have you eaten this fish this season?						
What is the average serving size you ate? Use serving size examples on page 4.						
How many times per month do you eat this fish's organs?						

Optional Questions: Wild Foods Survey

The optional questions section will ask you about how often and how much you consumed of the following food in each season of the past year:

- Wild Foods – Birds
- Wild Foods – Mammals
- Market Foods – Livestock/Poultry
- Wild Foods – Wild Berries
- Wild Foods – Wild Plants

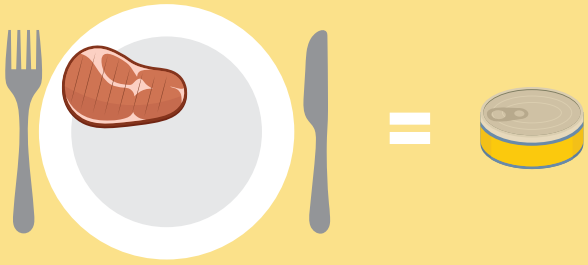
This questionnaire covers wild (or harvested/traditional) food and also market food. Wild food comes from the local land and environment (fish, birds, other animals and plants/berries). Market food comes from the supermarket or grocery store.

SERVING SIZES:

Please use the examples below to estimate the typical serving size of fish you ate at each meal.

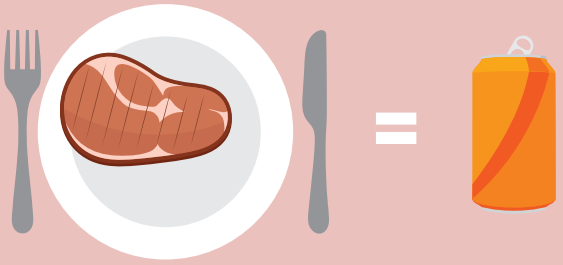
A

up to ¼ lb (3.5 oz)



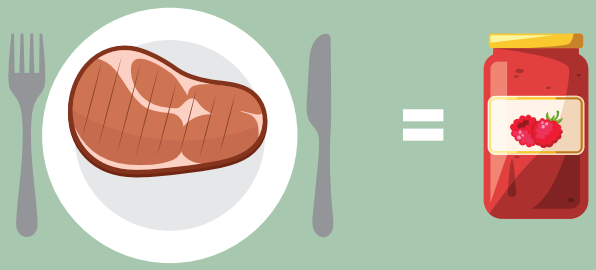
B

¼ lb to ½ lb (3.5-8 oz)



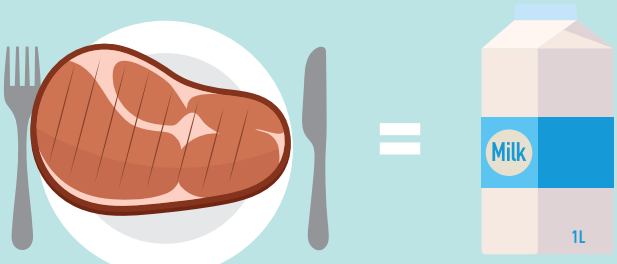
C

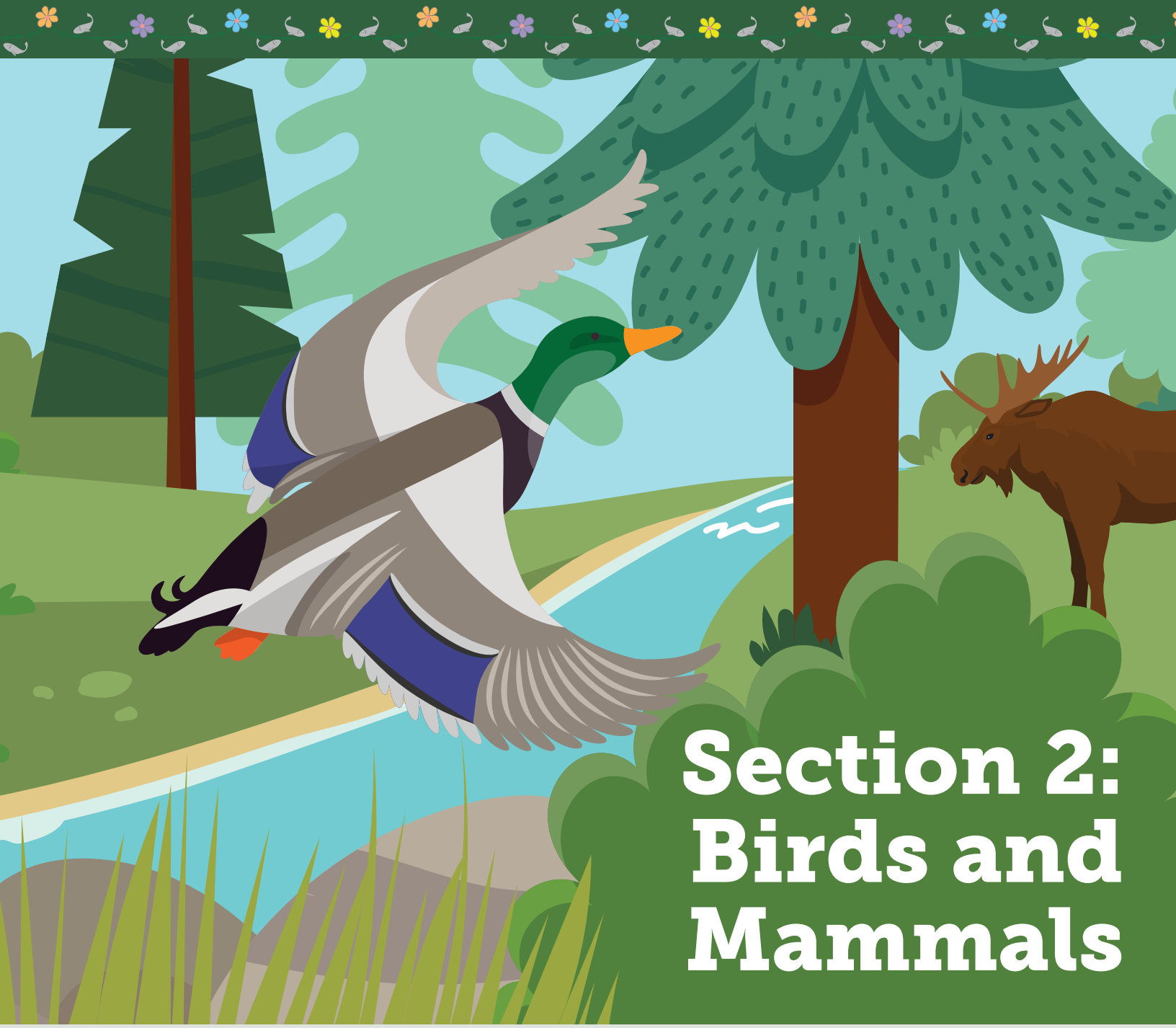
½ lb to 1 lb (8-16 oz)



D

more than 1 lb (16 oz)





Section 2: Birds and Mammals

Have you eaten locally hunted birds or mammals in the last year? ☐ YES ☐ NO

If yes, please complete pages 14-17, if no proceed to page 18.

Have you eaten market livestock and poultry in the last year? ☐ YES ☐ NO

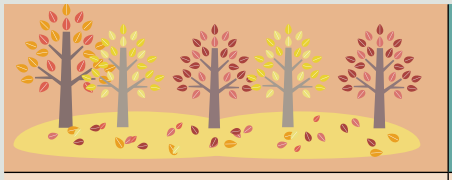
If yes, please complete pages 18-19, if no proceed to page 21.

In the last year, what month did you eat the most birds and mammals? _____

Seasonal Consumption: Wild Foods – Birds

Using the tables below, please recall how often you ate the following food in each season during the last year.

Fall (September-November)

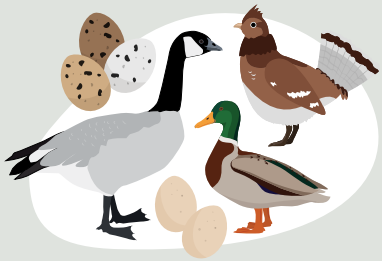
	 Duck	 Goose	 Grouse	 Willow Ptarmigan	 Other	 Other
How many **meals per month** have you eaten this bird this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this bird's organs						

Winter (December-February)

	 Duck	 Goose	 Grouse	 Willow Ptarmigan	 Other	 Other
How many **meals per month** have you eaten this bird this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this bird's organs?						

OTHER COMMON WILD BIRDS: Goose (Snow, Canada), Duck (Black, Canvasback, Eider, Mallard, Pintail, Greenwing Teal, Scoter), Grouse (Spruce, Sharp-Tailed, Partridge Ruffed), Duck Eggs*, Gull Eggs*, Tern Eggs*

** If bird eggs are consumed, indicate the number of eggs per serving*



FAST FACT

Fish that eat other fish (pickerel, jackfish) tend to be higher in mercury than fish that mainly feed on bugs.

Spring (March-May)

	 Duck	 Goose	 Grouse	 Willow Ptarmigan	 Other	 Other
How many **meals per month** have you eaten this bird this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this bird's organs?						

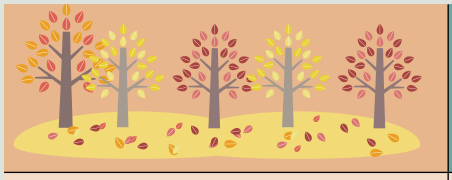
Summer (June-August)

	 Duck	 Goose	 Grouse	 Willow Ptarmigan	 Other	 Other
How many **meals per month** have you eaten this bird this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this bird's organs?						

Seasonal Consumption: Wild Foods – Mammals

Using the tables below, please recall how often you ate the following food in each season during the last year.

Fall (September-November)

	 Moose	 Caribou	 Snowshoe Hare	 Beaver	 Other	 Other
How many **meals per month** have you eaten this meat this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this mammal's organs						

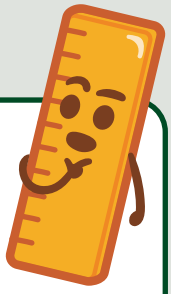
Winter (December-February)

	 Moose	 Caribou	 Snowshoe Hare	 Beaver	 Other	 Other
How many **meals per month** have you eaten this meat this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this mammal's organs?						

OTHER COMMON WILD MAMMALS: Black Bear, Muskrat, other

FAST FACT

Did you know that the hair on your head grows about 1 cm per month?



Spring (March-May)

	 Moose	 Caribou	 Snowshoe Hare	 Beaver	 Other	 Other
How many **meals per month** have you eaten this meat this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this mammal's organs?						

Summer (June-August)

	 Moose	 Caribou	 Snowshoe Hare	 Beaver	 Other	 Other
How many **meals per month** have you eaten this meat this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this mammal's organs?						

Seasonal Consumption: Market Foods – Livestock, Poultry and Other

Using the tables below, please recall how often you ate the following food in each season during the last year.

Fall (September-November)

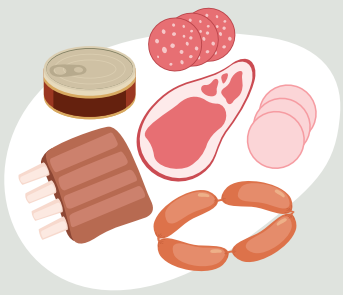
	Beef	Chicken	Pork	Turkey	Chicken Eggs*	Other
How many **meals per month** have you eaten this food this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this animal's organs						

Winter (December-February)

	Beef	Chicken	Pork	Turkey	Chicken Eggs*	Other
How many **meals per month** have you eaten this food this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this animal's organs?						

OTHER COMMON MARKET FOODS: Lamb, Veal, Processed Meat (e.g., Sandwich Meat, Canned Meat), Market Rice**, other.

** If bird eggs are consumed, indicate the number of eggs per serving*



FAST FACT

The mercury level in your hair is a good estimate of the mercury level in your body.

Spring (March-May)

	 Beef	 Chicken	 Pork	 Turkey	 Chicken Eggs*	 Other
How many **meals per month** have you eaten this food this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this animal's organs?						

Summer (June-August)

	 Beef	 Chicken	 Pork	 Turkey	 Chicken Eggs*	 Other
How many **meals per month** have you eaten this food this season?						
What is the average serving size you ate? Use serving size examples on page 12.						
How many times per month do you eat this animal's organs?						

**The proper portion size for one serving of rice is 1/2-cup cooked, which is about the size of a cupcake wrapper.

Optional Questions: Wild Foods Survey

The optional questions section will ask you about how often and how much wild berries and plants you consumed in each season of the past year.

SERVING SIZES:
Please use the examples below to estimate the typical serving size of berries/plants you ate at each meal.

A

½ cup (75 grams)

B

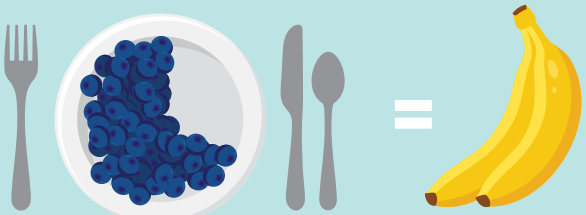
¾ cup (110 grams)

C

1 cup (150 grams)

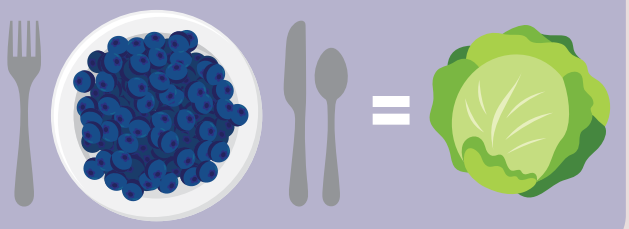
D

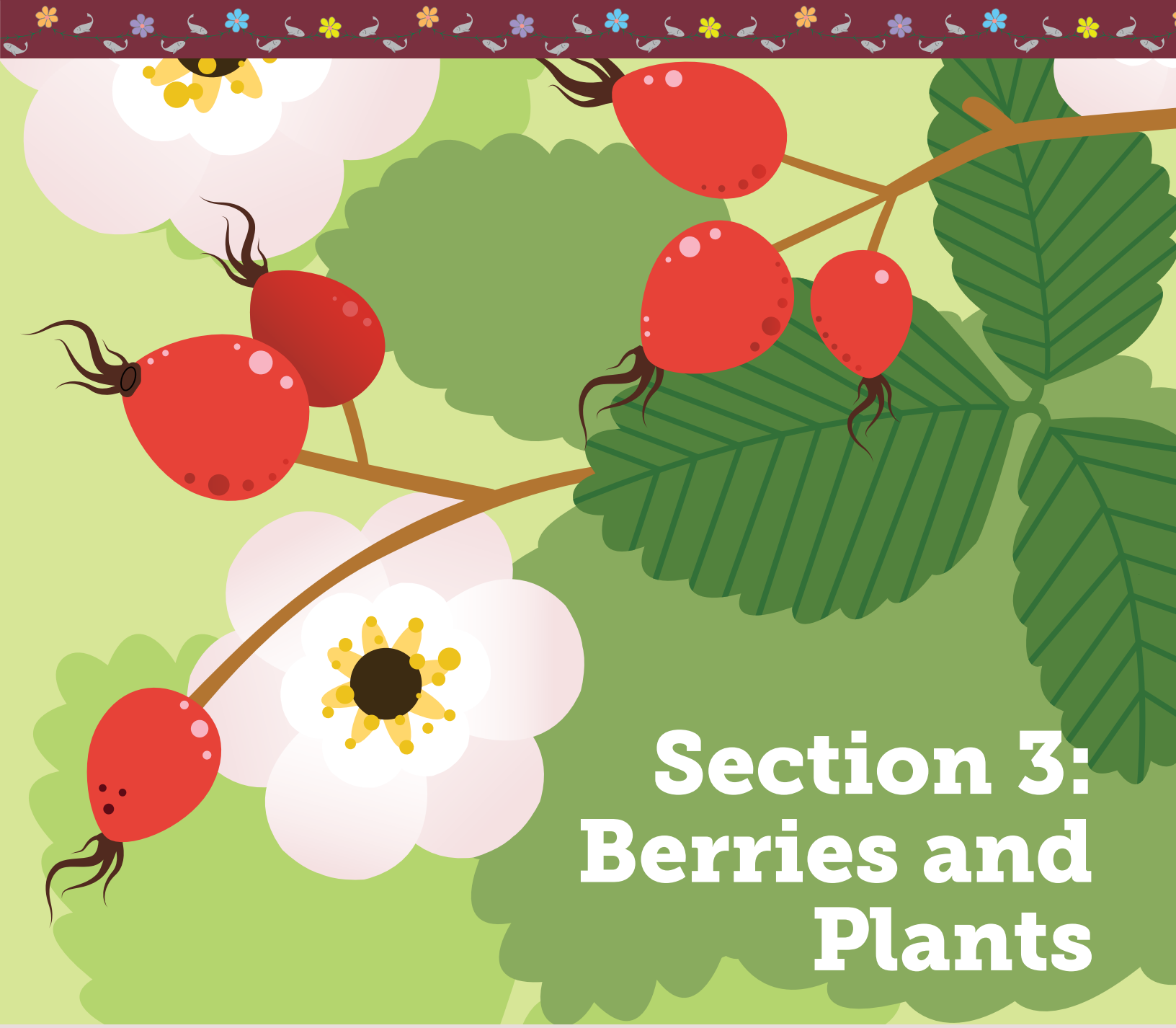
1-1/2 cup (225 grams)



E

2 cups (300 grams)





Section 3: Berries and Plants

Have you eaten locally picked berries or plants in the last year? ☐ YES ☐ NO

If yes, please complete pages 22-25.

In the last year, what month did you eat the most locally picked berries or plants?

Seasonal Consumption: Wild Foods – Wild Berries

Using the tables below, please recall how often you ate the following food in each season during the last year.

Fall (September-November)

	 Blueberry	 Cranberry	 Raspberry	 Rosehip Berry	 Juniper Berry	 Other
How many **meals per month** have you eaten this berry this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

Winter (December-February)

	 Blueberry	 Cranberry	 Raspberry	 Rosehip Berry	 Juniper Berry	 Other
How many **meals per month** have you eaten this berry this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

OTHER COMMON WILD BERRIES: Bunchberry, Crowberry, Teaberry (wintergreen), Bearberry, Wild Strawberry, Cloudberry, Gooseberry, Hawthorn Berry, other.

FAST FACT

The section of hair closest to your scalp is the newest hair growth and represents your most recent mercury exposure.

Spring (March-May)

	 Blueberry	 Cranberry	 Raspberry	 Rosehip Berry	 Juniper Berry	 Other
How many **meals per month** have you eaten this berry this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

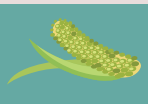
Summer (June-August)

	 Blueberry	 Cranberry	 Raspberry	 Rosehip Berry	 Juniper Berry	 Other
How many **meals per month** have you eaten this berry this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

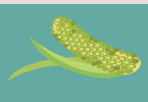
Seasonal Consumption: Wild Foods – Wild Plants

Using the tables below, please recall how often you ate the following food in each season during the last year.

Fall (September-November)

	 Wihkes (Sweetflag)	 Labrador Tea	 Northern Labrador Tea	 Jack Pine Needle	 Other	 Other
How many **meals per month** have you eaten this plant this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

Winter (December-February)

	 Wihkes (Sweetflag)	 Labrador Tea	 Northern Labrador Tea	 Jack Pine Needle	 Other	 Other
How many **meals per month** have you eaten this plant this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

OTHER COMMON WILD PLANTS wild plants: Arrowhead, Fiddleheads, Cattail, Bulrush, Fireweed, Dandelions, Dock, Raspberry Leaves, Nettle Leaves, Pine Pitch, Balsam poplar (bark, buds), Spruce (pitch, inner bark), Aspen (bark, twigs), Chanterelle, wild rice*

* Indicate serving Size of Cooked Rice

FAST FACT

Mercury binds with protein, so plants like blueberries and Labrador Tea are low mercury.

Spring (March-May)

	 Wihkes (Sweetflag)	 Labrador Tea	 Northern Labrador Tea	 Jack Pine Needle	 Other	 Other
How many **meals per month** have you eaten this plant this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

Summer (June-August)

	 Wihkes (Sweetflag)	 Labrador Tea	 Northern Labrador Tea	 Jack Pine Needle	 Other	 Other
How many **meals per month** have you eaten this plant this season?						
What is the average serving size you ate? Use serving size examples on page 20.						

Notes:

FAST FACT

Whitefish broth is a traditional meal supplement for infants.

Notes:

What did you think of this survey?

We'd love to hear your feedback. Talk to your Mercury Community Coordinator or write your comments here.

wsp

KEEYASK

V2.04.2023

APPENDIX D

Personal Letter Template

February 7, 2023 Project No. 1782422

Participant's Name
Participant's First Nation

KEEYASK HAIR SAMPLING RESULTS: YOUR MERCURY LEVEL IN HAIR

Dear Participant's Name

Thank you for participating in the mercury hair sampling process. A copy of your signed consent form is attached. A second copy of this letter is included for you to provide to your health care practitioner, if desired.

Your hair mercury level is **6 ppm** (parts per million), which is above the recommended range for you (0-2 ppm) because you are part of a Sensitive Group. A member of our study team will contact you soon to talk about your mercury level with you and offer some recommendations about how to manage it. We would also encourage you to speak with your health care provider (like a doctor or nurse) about your mercury level. Please look at **the white box in the table below** for some advice for you about eating fish.

PLEASE NOTE: The best type of fish to eat that is low in mercury is **whitefish of any size**. Jackfish (Northern Pike) and Walleye are still fine to eat, but be sure to choose Jackfish and Walleye that are smaller in size because they are lower in mercury than larger-sized fish.

Sensitive Groups If you are a… - **Child** (age 12 and under) - **Teenager** (age 13 to 18 years) - **Female of childbearing age** who is pregnant, is breastfeeding, or could become pregnant…	**Non-Sensitive Groups** If you are a… - **Male adult** - **Female over childbearing age**
*And if your level is **less than 2 ppm**…* Eating fish up to 2 or 3 times per week is healthy.	*And if your level is **less than 5 ppm**…* Eating fish 2 or 3 times per week is healthy if you are not already doing so.
*And your level is **more than 2 ppm**…* You are encouraged to eat less fish (or different species or smaller sizes of fish) to help your mercury levels come back down into the healthy range.	*And if your level is **more than 5 ppm**…* You are encouraged to eat less fish (or different species or smaller sizes of fish) to help your mercury levels come back down into the healthy range.

WSP Canada Inc.
100 Scotia Court, Whitby, Ontario, L1N 8Y6, Canada
T: +1 905 723 2727 F: +1 905 723 2182

Your hair sample was taken on (*hair sample date*) and it shows your average mercury exposure / how much fish you ate from around (*date range the hair sample represents*). If you eat more fish in other seasons, we encourage you to contact me or work with your mercury community coordinator (*name of coordinator*) to figure out the best time of year to collect another sample.

Hair sampling and food surveys will continue to happen over the next few years. A community event to collect more hair samples and food surveys will be held sometime in 2023, but you can contact your mercury community coordinator anytime if you would like to get another hair sample before then.

If you have any questions or wish to talk about your results with a member of the project team or someone who can offer more detailed advice about eating fish, please contact the project's lead researcher Sharon Guin at 905-723-2727 or sharon.guin@wsp.com. You can also contact your mercury community coordinator (*name and email of coordinator*) or your local health provider, your local (*title*) is (*name*) and their contact info is (*phone or email*).

To learn more about mercury and health, please visit:

General information about mercury and health: https://www.canada.ca/en/health-canada/services/healthy-living/your-health/environment/mercury-human-health.html

Information about mercury and fish: https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/environmental-contaminants/mercury/mercury-fish.html

Sincerely,

WSP Canada Inc.

DRAFT

Sharon Guin, MSc
Principal Researcher, Risk Assessor

SG/

Attachments: Signed Consent Form

February 7, 2023 Project No. 1782422

Participant's Name
York Factory First Nation

KEEYASK HAIR SAMPLING RESULTS: YOUR MERCURY LEVEL IN HAIR

Dear Participant's Name

Thank you for participating in the mercury hair sampling process. A copy of your signed consent form is attached. A second copy of this letter is included for you to provide to your health care practitioner, if desired.

Your hair mercury level is **1 ppm** (parts per million), which is within the recommended range for you (0-2 ppm) because you are part of a Sensitive Group. Please look at **the white box in the table below** for some advice about eating fish.

PLEASE NOTE: The best type of fish to eat that is low in mercury is **whitefish of any size**. Jackfish (Northern Pike) and Walleye are still fine to eat but be sure to choose Jackfish and Walleye that are smaller in size because they are lower in mercury than larger-sized fish.

Sensitive Groups If you are a… - **Child** (age 12 and under) - **Teenager** (age 13 to 18 years) - **Female of childbearing age** who is pregnant, is breastfeeding, or could become pregnant…	**Non-Sensitive Groups** If you are a… - **Male adult** - **Female over childbearing age**
*And if your level is **less than 2 ppm**…* Eating fish up to 2 or 3 times per week is healthy.	*And if your level is **less than 5 ppm**…* Eating fish 2 or 3 times per week is healthy if you are not already doing so.
*And your level is **more than 2 ppm**…* You are encouraged to eat less fish (or different species or smaller sizes of fish) to help your mercury levels come back down into the healthy range.	*And if your level is **more than 5 ppm**…* You are encouraged to eat less fish (or different species or smaller sizes of fish) to help your mercury levels come back down into the healthy range.

WSP Canada Inc.
100 Scotia Court, Whitby, Ontario, L1N 8Y6, Canada
T: +1 905 723 2727 F: +1 905 723 2182

Your hair sample was taken on *(hair sample date),* and it shows your average mercury exposure / how much fish you ate from around (*date range the hair sample represents*). If you eat more fish in other seasons, we encourage you to contact me (Sharon Guin) or work with your mercury community coordinator (*name of coordinator*) to figure out the best time of year to collect another sample.

Hair sampling and food surveys will continue to happen over the next few years. A community event to collect more hair samples and food surveys will be held sometime in 2023, but you can contact your mercury community coordinator anytime if you would like to get another hair sample before then.

If you have any questions or wish to talk about your results with a member of the project team or someone who can offer more detailed advice about eating fish, please contact the project's lead researcher Sharon Guin at 905-723-2727 or sharon.guin@wsp.com. You can also contact your mercury community coordinator (*name and email of coordinator*) or your local health provider.

To learn more about mercury and health, please visit:

General information about mercury and health: https://www.canada.ca/en/health-canada/services/healthy-living/your-health/environment/mercury-human-health.html

Information about mercury and fish: https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/environmental-contaminants/mercury/mercury-fish.html

Sincerely,
WSP Canada Inc.

DRAFT

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Attachments: Signed Consent Form

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APPENDIX 3: PRELIMINARY HUMAN HEALTH RISK ASSESSMENT - INTERPRETATION OF 2022 ENVIRONMENTAL DATA BY WILSON SCIENTIFIC, 2023

Attachment 3a: North/South Consultants: Predictions of Post-Impoundment Fish Mercury Concentrations for Application in the Mercury and Human Health Risk Management Plan Products, 2021

Attachment 3b: North/South Consultants: Preliminary Results of 2022 Spring Mercury Sampling in Stephens Lake

Technical Memorandum

To: Manitoba Hydro, on behalf of the Keeyask Hydropower Limited Partnership

From: Ross Wilson, M.Sc., DABT, Wilson Scientific Consulting Inc.

Date: June 14, 2023

Re: Preliminary Human Health Risk Interpretation of 2022 Environmental Data

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1.0 Introduction

This memorandum is to inform Manitoba Hydro on behalf of the Keeyask Hydropower Limited Partnership (KHLP) and the Mercury and Human Health Implementation Group (MHHIG) of the preliminary interpretation of human health risks from reported concentrations of fish and wildlife sampled in 2022. This memorandum contributes to the Socio-Economic Monitoring Plan (SEMP) report, submitted in fulfillment of annual regulatory requirements.

The Keeyask Mercury and Human Health Risk Management Plan (RMP) was prepared to fulfill the requirements of The Environment Act (Manitoba) Licence No. 3107 and outlines a range of commitments to monitor and mitigate the risks associated from increased methylmercury in the environment as a result of the operation of the Keeyask Generation Project (the Project). Key components of the RMP include the monitoring of fish, wildlife, plants; a communication strategy regarding safe fish consumption; periodic human health risk assessments (HHRA); and voluntary hair sampling. As part of this effort, Wilson Scientific Consulting Inc. (Wilson Scientific) has been retained by Manitoba Hydro (on behalf of the KHLP) as a subject matter expert (toxicology) in meeting Keeyask monitoring and licence commitments relating to mercury and human health. This includes conducting a preliminary human health risk interpretation of available environmental data. This report considers the predicted peak concentrations of mercury in fish from Gull and Stephens lakes and other environmental data on mercury from the Project-affected area.

Aquatic and terrestrial environment monitoring plans were also submitted by the KHLP in fulfillment of the licence requirements. On behalf of the KHLP, Manitoba Hydro contracted various environmental professionals to estimate peak mean mercury concentrations (as a modelling effort) during the licensing phase. Later, these same professionals were contracted to undertake monitoring to determine if predicted concentrations identified in the Keeyask Environmental Impact Statement (EIS) are exceeded. The modelled peak mercury concentrations form the basis of interpretation of risk to human health from the consumption of wild foods and, in the case of fish, maximum consumption recommendations.

Wilson Scientific has assumed all concentrations and predictions provided by the various disciplines are accurate and representative in the Keeyask Project Area, and persist, unless otherwise informed, until concentrations are in decline.

As of the date of this memorandum and since impoundment, the following environmental monitoring reports have been received which have key relevancy to the estimation of human health risks:

- fish mercury concentrations: predicted peak average fish concentrations in Gull and Stephens lakes (North/South, 2021); mercury concentrations in fish sampled from Stephens Lake in June 2022 (NSC, 2022); mercury concentrations in fish sampled from Gull (the Keeyask Reservoir) and Stephens lakes in August/September 2022 (Holm and Aiken, 2023 – component of the Aquatic Environment Monitoring Plan); and
- wildlife mercury concentrations: mercury concentrations in aquatic furbearers as both predictions and sampled from the Keeyask reservoir area in the winter of 2022/2023 (Wildlife Resource Consulting Services MB Inc. [WRCS], 2023 – component of the Terrestrial Environment Monitoring Plan).

2.0 Interim Assessment of Human Health Risks

A preliminary assessment of human health risks is presented below based on the fish and wildlife data received up until the date of this memorandum. Fish and wildlife sampling programs are ongoing during operations, and future risk interpretations will consider results, and may change, as data becomes available. While newer data are presented below, the general approach and results have been part of previous presentations with health agencies and partner First Nations and their representatives. It is recommended that Manitoba Hydro and/or the MHHIG, on behalf of KHLP, continue to engage with and follow up with health agencies to discuss contents within these documents to ensure concurrence with risk interpretation prior to making final conclusions about health risks. A consistent message from all experts, including health agencies, will likely reduce confusion and skepticism regarding the safety of consuming fish, wild game and waterfowl.

Wilson Scientific has engaged in conversations with the environment professionals to clarify our interpretation of the information provided on mercury concentrations in fish and other wildlife; however, a critical analysis of their methodologies, dataset and conclusions in the cited reports is beyond the scope of the preliminary risk interpretation[1]. As such, all concentrations and predictions provided by North/South and WRCS have been assumed to be accurate and representative in the Keeyask Project Area. It is recommended that dialogue continues with communities and regulators on any issues, concerns or ideas for the environmental datasets.

[1] The contents of the Keeyask EIS and all Environment Protection Plans (e.g., AEMP, SEMP, TEMP) underwent critical peer and regulatory review as part of the planning and licensing process. It is understood that the 2023 AEMP, SEMP and TEMP reports will also undergo regulatory agency review and if issues are identified it is important that these are communicated and considered for human health risk interpretation.

2.1 Fish

The environment professionals have indicated that the annual monitoring results have been compared to the peak EIS estimates to confirm they are not exceeded and are still valid for the purpose of the preliminary human health risk interpretation. The data are compared to the peak estimates annually and will continue to be until concentrations reach peak (approximately 2023-2027) which can only be determined once the concentrations are in decline. The results of the 2022 monitoring are used by Wilson Scientific in this memo to assess risk to human health and to determine whether the current consumption recommendations remain valid. Future monitoring data will be considered in a fulsome Human Health Risk Assessment (HHRA) in approximately 2026 to 2030 (exact year will be subject to MHHIG input and timing of decline).

Fish consumption recommendations as maximum monthly intakes were previously developed in Wilson Scientific (2021; revised 2022) using the predicted peak length-standardized average concentration for the various fish species noted below, and calculating the consumption rate that would result in exposures to mercury equal to Health Canada's Tolerable Daily Intakes (TDIs) for the various age groups that may consume fish from these lakes. As a result, the primary approach to interpreting human health risks from fish consumption involved: 1) verifying that the environmental professionals considered the predicted peak length-standardized average concentrations remains the best estimate of peak fish concentrations; and 2) verifying that risk assessment guidance provided by the key regulatory agencies remains valid.

<u>Summary of the Comparison of Measured Fish Data to Predicted Peak Average Concentrations</u>

In development of the fish consumption recommendations, the following mercury concentrations for length-standardized for three fish species from Gull and Stephens lakes predicted in the EIS and re-iterated in North/South (2021) and the Holm and Aiken (2023) AEMP 2022 were assumed to be the peak average concentration:

- Gull Lake jackfish at 550 mm: 1.0 ppm
- Gull Lake pickerel at 400 mm: 1.0 ppm
- Gull Lake whitefish at 350 mm: 0.19 ppm
- Stephens Lake jackfish at 550 mm: 0.5 ppm
- Stephens Lake pickerel at 400 mm: 0.5 ppm
- Stephens Lake whitefish at 350 mm: 0.15 ppm

Holm and Aiken (2023) indicate that the average concentrations found in jackfish, pickerel and whitefish for the specified standardized lengths did not surpass the plus 20% value for triggering a change in communication products. The Holm and Aiken (2023) report also contains some unique aspects which were considered in determining the currency of fish consumption recommendations:

- Stephens Lake pickerel of standardized size is equal to the predicted peak mercury concentration (i.e., 0.503 ppm) and the upper 95th percent confidence limit of 0.574 ppm. These concentrations equal or exceed the peak average concentration prediction; however, the 95% confidence limit is less than 0.6 ppm which is the plus 20% value for triggering a change in communication products.
- Holm and Aiken (2023) calculated the mean mercury concentration for standardized size whitefish in Gull Lake (using only the larger fish dataset); however, they could not calculate the mean mercury concentration for standardized size whitefish from Stephens Lake. Nevertheless,

they do not consider the mean concentrations for standardized size whitefish of 350 mm to be exceeded in either Gull or Stephens lakes.

- Holm and Aiken (2023) presented ridgeline plots to illustrate changes in mercury concentrations in fish over time. Of potential importance to interpreting human health risks, these plots provide an estimate of the relative frequency of mercury concentrations in fish of standardized size. The results from the author's analysis show the estimated likelihood that individual fish may exceed EIS estimates even though mean concentrations do not exceed these estimates. This information is discussed below from a risk interpretation perspective.

North/South and Manitoba Hydro re-affirmed that sampling and monitoring efforts are scientifically sound and attempt to balance detection of an exceedance of predicted mercury concentrations with the conservation of fish. Both parties are aware of the importance that an exceedance of the EIS estimates is detected as soon as reasonably possible (should an exceedance occur) and have indicated they remain confident that the methods, analysis and program to measure mercury in fish tissue are reliable and accurate.

In their report, Holm and Aiken (2023) concluded that peak mercury concentrations after two years of post-impoundment monitoring have not exceeded the predicted peaks identified in the EIS based on the most recent sampling. As a result, there is no concentration data triggering a change at this point for consumption recommendations for jackfish, pickerel and whitefish from Gull and Stephens lakes[2].

Risk Interpretation for those Following Consumption Recommendations

The key parameters used in Wilson Scientific (2021; revised 2022) to estimate consumption recommendations have not changed including: 1) verification that the EIS estimates of peak average mercury concentrations in Gull and Stephens lakes fish (jackfish, pickerel and whitefish) remain valid; and 2) the toxicity reference values, body weights and the dose-averaging factor of a month also remain valid and reasonable. The Health Canada Tolerable Daily Intakes for methylmercury remain applicable for the sensitive age groups (TDI = 0.2 µg/kg bw/day) and non-sensitive groups (TDI = 0.5 µg/kg bw/day). In the case of body weight, the values used in the consumption recommendations match those used in Health Canada (2021) and/or are similar to those used in Province of Manitoba (2007). In addition, the communication materials provide information that individual body weight can and should be used to adjust these estimates on a personal basis. In the case of the dose-averaging factor of a month, fish consumption advice from Health Canada and Province of Manitoba have relied on this period and we are not aware of current information to deviate from this approach for fish consumption. Although it could be suggested that the methylmercury TDI should be dose-averaged over a week (i.e., based on the World Health Organization provisional tolerable weekly intake of 1.6 µg/kg bw/week), the use of monthly dose-

[2] North/South (2022) reported slight exceedances of the EIS estimates for Stephens Lake jackfish and pickerel based on punch biopsies taken from 16 fish of each species in June 2022 sampling (i.e., mean concentrations of 0.54 ppm for jackfish at 550 mm and 0.56 ppm for pickerel at 400 mm); however, as concluded in this earlier memorandum, there were no exceedences of the trigger values of 0.6 ppm. Furthermore, the spring sampling event was not considered by North/South and Manitoba Hydro to replace or replicate the AEMP monitoring study results collected in the fall. Based on their results, the June 2022 sampling was not considered to be suggestive that the EIS estimates of peak mercury concentrations for Stephens Lake fish needed to be revised.

averaging seems to be the accepted practice in Manitoba and Canada as the basis for fish consumption advice.

Since the predicted peak average concentrations and human health risk assessment input assumptions have not changed, the Wilson Scientific (2021; revised 2022) consumption recommendations remain valid for jackfish, pickerel and whitefish from Gull and Stephens lakes. Specifically, for those who do not consume fish larger than standardized size and do not consume at rates greater than specified in the fish consumption recommendations, the intake of mercury for fish with the mean peak mercury concentration is estimated to be equal to the current TDIs specified by Health Canada and the World Health Organization (i.e., TDIs of 0.2 µg/kg bw/d for children up to 18 years of age and women of childbearing age and 0.5 µg/kg bw/d for all others).

With the above in mind, there are certain cautions that should be considered based on the recent fish data.

Gull Lake Cautions

North/South (2021) predicted that certain fish in Gull Lake will soon have very high mercury concentrations. As the approach for fish consumption guidance was being developed for post-impoundment conditions, North/South prepared class size estimates for the three fish species, based on predicted rate of increase for standard length fish in Gull and Stephens Lake (North/South, 2021). While there is some uncertainty in their size class estimates that are greater than standardized size, the values provided in North/South (2021) remain North/South's best estimates for most likely peak mercury concentrations in the various size classes. These estimates were used to provide additional information on fish larger than standardized sizes.

Gull Lake jackfish and pickerel larger than the standardized size are of particular concern (e.g., the largest size classes of these fish in Gull Lake are predicted to eventually have average mercury concentrations that will exceed 3 ppm). While sensitive age groups are recommended to avoid all sizes of jackfish and pickerel in Gull Lake, it is especially important that fish larger than standardized lengths are not consumed. Information from Health Canada, World Health Organization and the Province of Manitoba would support the message that consumption of such high mercury fish should be avoided by all age groups. Of particular concern, if sensitive age groups are consuming these fish on even an occasional basis (*e.g.*, a large serving once per month on an ongoing basis), the Health Canada and WHO provisional TDIs would likely be exceeded and elevated hair concentrations of mercury may also be expected. Nevertheless, it is emphasized that non-sensitive age groups are also of concern and are advised to not consume Gull Lake jackfish and pickerel larger than standard size.

Holm and Aiken (2023) also provided ridgeline plots for Gull Lake fish for various years between 1999 and 2022 as length-corrected mercury concentrations. Ridgeline plots were considered as part of the human health risk interpretation. Although Holm and Aiken (2023) re-affirmed that the North/South EIS estimates of peak mean mercury concentrations remain valid for standardized size fish from Gull Lake (i.e., 0.19 ppm for whitefish and 1.0 ppm for jackfish and pickerel), the ridgeline plots show that there is reasonable likelihood that individual fish at standardized size will exceed these average concentrations. This should not be surprising as the EIS estimates were provided as mean concentrations and so it would be expected that there would be individual fish concentrations higher and lower than the EIS estimates;

however, the ridgeline plots provide a potentially useful indication of the modelled probability that an exceedance may occur and the possible upper bound concentrations.

From an HHRA perspective, key aspects of 2022 data in the Gull Lake ridgeline plots were used by Wilson Scientific to determine the following information about modelled fish concentrations:

- 20% of whitefish at 350 mm may exceed 0.5 ppm (the mercury concentration that sensitive members of the population are advised to avoid);
- more than 80% of jackfish at 550 mm and 60% pickerel at 400 mm may exceed 0.5 ppm (the mercury concentration that sensitive members of the population are advised to avoid); and
- 6% of the jackfish at 550 mm and 8% of pickerel at 400 mm may exceed 1.5 ppm (the concentration that non-sensitive members are advised to avoid); however, there are some individual jackfish above 2.0 ppm and pickerel above 2.5 ppm.

Overall, the ridgeline plots were used to provide an estimate of the predicted frequency of mercury concentration in Gull Lake fish at standardized sizes. The ridgeline plots help illustrate the possibility that individual fish that are appreciably higher than the EIS estimates and may result in individual fish in the avoid category being consumed even when people follow the advice of not consuming fish above standardized sizes. Nevertheless, it is stressed that Wilson Scientific is aware of no regulatory precedent on how to interpret the individualized fish concentrations (i.e., provincial, federal or international guidance was not identified). This new approach of assessing fish mercury concentrations was introduced to the MHHIG, including provincial health representatives, on March 3, 2023. Although the mean concentration in fish is still likely the most relevant statistic from a risk assessment, it is recommended that this evaluation tool and potential application for risk interpretation be discussed in future meetings with the communities and the regulatory agencies.

With the opening of boat launch area at Gull Lake within the next two years, it is especially important that persons are aware of the fish consumption advice (i.e., the opening of a boat launch at a lake where fish consumption is recommended to be avoided or restricted could send mixed messages). Some people may use this boat launch primarily for navigation purposes but increased access to Gull Lake could affect fishing/harvesting patterns. While signage will be installed in summer 2023 at both downstream (Gull Lake) and upstream (Stephens Lake) boat launches (in addition to communication strategy outlined in SEMP report), it would also be productive to receive feedback from resource users and fish consumers of local lakes on the efficacy of communication and clarity of fish consumption recommendations.

<u>Stephens Lake Cautions</u>

The message of avoiding consumption of jackfish and pickerel larger than standardized size is also important for Stephens Lake. As discussed above, the size class estimates for peak mercury concentrations in fish that are greater than standardized size provided in North/South (2021) remain their best estimates for most likely mercury concentrations at peak and were used to provide information on fish larger than standardized sizes (see North/South [2021] for discussion of uncertainty). The mercury concentrations in Stephens Lake jackfish and pickerel are not expected to be as significantly elevated as Gull Lake; however, the author notes the largest size classes of these fish in Stephens Lake could approach or exceed mean concentrations of 1.5 ppm. While monitoring indicates no evidence to date, it is possible that some jackfish and pickerel caught in Stephens Lake may have originated from Gull Lake

and, thus, have mercury concentrations that are closer to the Gull Lake predictions on an individual fish basis.

The Holm and Aiken (2023) ridgeline plots for Stephens Lake show data for the years 1999 to 2022[3]. From these, the author notes there is reasonable likelihood that individual fish will exceed the EIS estimates of mean mercury concentrations for standardized size fish from Stephens Lake (i.e., 0.15 ppm for whitefish and 0.5 ppm for jackfish and pickerel); however, it is noted that this can still occur with the mean concentrations not exceeding the EIS estimates. From an HHRA perspective, key aspects of 2022 data for the Stephens Lake ridgeline plots include the following:

- 29% of whitefish at 350 mm may exceed 0.15 ppm (the EIS peak estimate);
- 31% of jackfish at 550 mm and 36% of pickerel at 400 mm may exceed 0.5 ppm (the mercury concentration that sensitive members of the population are advised to avoid); and
- No jackfish at 550 mm and pickerel at 400 mm in 2022 may exceed 1.5 ppm (the concentration that non-sensitive members are advised to avoid)[4].

As noted above, there is little regulatory precedent on how to interpret the individualized fish concentrations and further discussion with the MHHIG and regulatory agencies of its application to developing consumption recommendations may also be warranted.

Finally, the Stephens Lake pickerel concentrations from the August/September 2022 dataset are equal to the 0.5 ppm EIS predicted peak mean concentrations (Holm and Aiken, 2023) and the 0.6 ppm concentration that triggers the recommendation for development of revised consumption recommendations and communication materials has not been exceeded. Although Holm and Aiken (2023) indicated that the North/South EIS predictions remain valid, a contingency plan is under development and has been discussed with the MHHIG and provincial regulatory officials in the event that predicted peak mean concentrations are exceeded in Stephens Lake.

Lake Sturgeon Cautions

As discussed in Holm and Aiken (2023), lake sturgeon are only analyzed when they inadvertently die during AEMP sampling. In addition to the AEMP work, voluntary samples can be analyzed when submitted by community members. Information taken from the AEMP report show that in 2022, one non-juvenile lake sturgeon from Stephens Lake was analyzed (mercury concentration of 0.32 ppm for a lake sturgeon that was approximately 1,000 mm; because this concentration is between 0.2 and 0.5 ppm, it falls into the occasional consumption category). For the fall 2021 dataset, North/South (2022b) reported mercury levels in 2 lake sturgeons from Gull Lake that the author considers to be high concentrations from a risk perspective (i.e., 0.69 and 0.70 ppm for lake sturgeons that were longer than 1,200 mm; because these concentrations exceed 0.5 ppm, they fall into the category that those under 18 years of age and women of child bearing age would be recommended to avoid). Given such a limited dataset, it is difficult to draw conclusions as to whether these concentrations are representative of typical concentrations[5] (as noted in earlier years, there are also no current modelled estimates of lake sturgeon

[3] See Figure 13, Holm and Aiken, 2023.
[4] 3% of jackfish in 2015 at 550 mm exceeded 1.5 ppm
[5] The author's 2021-2022 report noted that despite a limited dataset of two mortalities, the Project biologist indicated these concentrations are likely representative of typical lake sturgeon. Further clarification has been provided and as

mercury concentrations that can be used as accurate estimates of peak concentrations). As a result, it is not possible to provide final consumption recommendations for lake sturgeon from either lake. It is recommended that MHHIG consider these results and discuss opportunities to encourage voluntary sample submission, if appropriate in light of conservation considerations.

Other Cautions

Tributaries and other lakes are not part of this assessment. Although it is possible that some higher mercury fish may migrate into these tributaries of Gull and Stephens lakes, there is no sampling program or estimates of mercury concentrations of fish in the tributaries or Clark Lake[6]. Furthermore, the risk implications of fish migration from Gull Lake into Clark Lake were not evaluated as part of this assessment. It is recommended that the MHHIG remain aware of this issue and the outcomes of fish movement studies communicated to assess the extent of movement into these other waterbodies.

It is noted that fish species other than jackfish, pickerel and whitefish have not been evaluated in Gull and Stephens lakes. The fish evaluated were the key species identified by representatives of the partner First Nations and formed the basis of the EIS. If communities or regulatory agencies desire information on fish species other than jackfish, pickerel and whitefish, it would likely be necessary for the Project biologist to provide estimates of mercury concentrations in these other fish. This in turn would involve expanding the monitoring program or voluntary submission of other fish species by the communities. It is believed that the communities and regulatory agencies are aware of this; however, if there are concerns from agencies or the communities, they should be encouraged to provide the KHLP with their input.

Overall, the Holm and Aiken (2023) fish dataset provides support for the current fish consumption recommendations for Stephens and Gull lakes being protective of human health; however, the dataset also illustrates the toxicological importance of consuming fish that are less than standardized size from both of these lakes. The approach was generally consistent with the Province of Manitoba (2007) approach for developing recreational fish consumption guidelines, Health Canada's fish consumption approach (Health Canada, 2007) and risk assessment advice from Health Canada (Health Canada, 2007; 2021) which in turn is quite consistent with the World Health Organization. At the current time, Wilson Scientific is not aware that fish consumption guideline approach or risk assessment advice from the Province of Manitoba, Health Canada or the World Health Organization has changed with respect to evaluating health risks from mercury in fish.

2.2 Wild Game

In October 2009, a wild foods workshop with representatives of the partner First Nations was held to gain insight into key wild game that were of primary concern to them from a mercury perspective. At the workshop, participants were asked about which wild foods they enjoyed eating and provided estimates of how often and how much of each food were consumed. For persons who consume wild foods, the

indicated above, no *conclusions can be provided about typical concentrations* based on the data that have been collected from Lake Sturgeon mortalities.

[6] Fish in the Aiken River, which is a tributary of Split Lake, are sampled every three years. The development of consumption guidance is outside the scope of the HHRA or related interpretation. Furthermore, the AEMP reports on fish movements, which are monitored for select species to see how many move upstream and out of the Keeyask Reservoir.

following foods and consumption rates were estimated and considered in the previous HHRA (2013) (provided as the rate when the food was in season or available):

- beaver: consumed 3 times per week (57 g/serving for young child; 200 g/serving for adult);
- muskrat: consumed once per week (57 g/serving for young child; 200 g/serving for adult);
- snowshoe hare: consumed once per week (57 g/serving for young child; 200 g/serving for adult); and
- moose: consumed 5 times per week (100 g/serving for young child; 400 g/serving for adult).

As part of the planned monitoring outlined in the Terrestrial Effects Monitoring Plan (TEMP), and the invaluable participation of a registered trapline holder and his assistants in the winter of 2022/2023, WRCS (2023) obtained and submitted 5 samples of muskrat (kidney, liver and muscle) and 6 samples of beaver (kidney, liver and muscle) from the Gull Lake area for total mercury analysis. In addition to these species, 4 samples of mink (kidney, liver and muscle) and 3 samples of river otter (kidney, liver and muscle) were received and submitted for total mercury analysis; however, there is no current knowledge of local human consumption of mink or otter. WRCS (2023) submitted these tissues for mercury analysis to confirm predicted effects (the EIS predicted an increase in mercury concentration in river otter as they consume fish).

Although WRCS (2023) does caution that the sample size for beaver and muskrat is low, WRCS indicated that their review of the information indicates that their predicted peak concentrations from the EIS remain valid and unchanged for these species. The mercury concentrations that were measured and the reaffirmed predictions in WRCS (2023) are summarized in Table 1 below.

Table 1: Summary of Measured Mercury Concentrations in Beaver and Muskrat Muscle Tissue from WRCS (2023)

Species	Range of Concentrations Reported for Winter 2022/23 Samples (mg/kg; wet weight)	WRCS Predicted Peak Concentration – Arithmetic Mean and Most-likely Range in Parentheses (mg/kg; wet weight)*
Beaver	0.0015 to 0.0026	0.01 (<0.01 to 0.05)
Muskrat	0.0088 to 0.039	0.04 (<0.01 to 0.12)

*WRCS (2023) re-affirmed that the predicted peak concentrations are the same as those estimated for the EIS and used in Wilson Scientific (2013)

Since the concentrations of mercury in beaver and muskrat muscle remain below the concentrations assumed in the previous HHRA and none of the other input assumptions have changed (i.e., TRVs remain current positions of Health Canada and WHO; other input assumptions have not changed), the previous results of no unacceptable risks from consumption of these animals remain valid for those consuming wild foods at the assumed consumption rates. Nevertheless, it is important to note that WRCS has recommended that caution is exercised in the interpretation of their dataset due to the limited sample size.

In the case of the mercury concentrations in kidney and liver of beaver and muskrat, there is no current knowledge that these organs are consumed by people and so it is unlikely that these are a key concern from a mercury perspective. In addition, although the mercury concentrations in kidneys are higher than

muscle, the maximum concentrations (i.e., 0.0182 mg/kg wet weight in beaver kidney and 0.109 mg/kg wet weight in muskrat kidney) are still relatively low and these organs represent likely only a small portion of the animal even if they were consumed. As a result, there is currently a low toxicological risk from the organs of these animals. Nevertheless, information provided in the food surveys, offered in conjunction with the Project's hair sampling program, may possibly shed light in the future on the extent that people are consuming the organs and, if so, how much.

As indicated above, there is no information suggesting that persons are consuming mink or river otter. With this in mind, the mercury concentrations reported by WRCS (2023) for mink and river otter are substantially higher than either beaver or muskrat (primarily due to their diets) and these animals would not be recommended for consumption by any age group but particularly not for the sensitive age group. As shown in WRCS (2023), the maximum muscle concentration was 1.25 mg/kg wet weight for mink (n=4) and 1.21 mg/kg wet weight for river otter (n=3). WRCS (2023) indicated that this is a very small sample size but that concentrations were in the range predicted in the EIS. Nevertheless, it may be prudent to confirm that lack of consumption of mink and river otter remains the case and that people are aware that the mercury concentrations in mink and river otter are substantially higher than muskrat and beaver.

In the case of snowshoe hare and moose, WRCS (2023) has indicated that no samples were submitted for mercury analysis by the partner First Nations in 2022 (under the voluntary sample program outlined in the TEMP), but that WRCS has reasonable confidence in their previous estimates of mercury tissue concentrations. Although WRCS (2023) has indicated that its conclusion remains that mercury concentrations in snowshoe hare and moose are unlikely to change post-impoundment, the previous estimates were based on literature values and, thus, there may be greater uncertainty with respect to the actual tissue concentrations as compared to other species. There were no previous estimates of mercury concentrations in liver or kidney of these animals due to there being no predicted increase in mercury in these land-based animals. WRCS (2023) has indicated their EIS mercury concentration estimates remain valid for snowshoe hare and moose (see Table 2). Using the same concentrations as reported in 2022, no unacceptable risks were predicted in the previous HHRA for persons consuming 5 meals per week of moose muscle or 1 meal per week of snowshoe hare muscle.

Table 2: Summary of Predicted Mercury Concentrations in Moose and Snowshoe Hare Muscle Tissue from WRCS (2023)

Species	Predicted Range of Concentrations under Peak Conditions (mg/kg; wet weight)	Predicted Arithmetic Mean Concentration under Peak Conditions (mg/kg; wet weight)*	Predicted Change in Concentrations from Prior to Impoundment to Peak Conditions
Moose	<0.01 to 0.17	0.07	No change
Snowshoe hare	<0.01 to 0.12	0.05	No change

*WRCS (2023) re-iterated that the predicted peak concentrations are the same as those estimated for the EIS

Overall, at the current time, there is no information to suggest that persons should be avoiding any of the wild game identified as frequently consumed by the partner First Nations (i.e., beaver, muskrat, snowshoe hare and moose). Nevertheless, it is a limited sample size dataset for some animals and no dataset for others and it is recommended that efforts be made to try to increase participation of the partner First Nations' voluntary submission of all wild foods for mercury testing.

2.3 Waterfowl

In October 2009, partner First Nations representatives participated in the wild food workshop noted above to provide consumption rates on the key waterfowl that were most likely to be consumed and of primary concern to them from a mercury perspective. For persons who consume waterfowl, the following foods and consumption rates were estimated and considered in the 2013 HHRA (when the food was in season or available):

- ducks: consumed once per week (57 g/serving for young child; 200 g/serving for adult); and
- gull eggs (no consumption rate was provided).

In the EIS, the mercury concentration in ducks was estimated to be equal to or less than whitefish (based on modelling of present and current concentrations and not actual sampled data), while no estimate of mercury concentrations in gull eggs was provided. No new data on these wild foods were provided in 2023 through the voluntary sampling program under the TEMP. WRCS (2023) has confirmed that they consider the duck estimates in the EIS to remain valid and have provided an estimate for Canada goose muscle. Table 3 provides the predicted peak mercury concentrations for waterfowl provided in WRCS (2023).

Table 3: Summary of Predicted Mercury Concentrations in Ducks and Canada Goose Muscle Tissue from WRCS (2022)

Species	Predicted Range of Concentrations under Peak Conditions (mg/kg; wet weight)	Predicted Arithmetic Mean Concentration under Peak Conditions (mg/kg; wet weight)	Predicted Change in Concentrations from Prior to Impoundment to Peak Conditions
Canada goose	None provided	0.03 (approximate)	No change (approximately)
Mallard duck	None provided	<0.19	Up to a 5-fold change

*WRCS (2023) re-iterated predicted peak concentrations are the same as those estimated for the EIS

In the HHRA completed for the EIS, no unacceptable risks from consumption of ducks were estimated when a mercury concentration of up to 0.19 mg/kg wet weight was assumed and one meal per week was assumed. Canada goose was not evaluated in the previous HHRA; however, with an appreciably lower predicted peak concentration of mercury, risks would be even lower for consumption of one meal per week of Canada goose (as compared to ducks). As a result, there is no current information to suggest that people should avoid consumption of mallard ducks or Canada geese. Nevertheless, similar to that discussed for mammals, it is recommended that additional efforts be explored to encourage sample submission by the partner First Nations (through the voluntary sampling program in the TEMP) for waterfowl species they may be concerned about and continue to determine if there are any refinements that could be made to estimated concentrations of mercury in waterfowl.

As noted above, the October 2009 workshop with the partner First Nations representatives indicated that consumption of gull eggs took place in the spring by some individuals. In the case of gull eggs, no measurements or predicted mercury concentrations are available and, thus, it is not possible to provide an estimate of risks from this food. If it is desired by the MHHIG that a risk interpretation is provided for consumption of this food, gull eggs will likely need to be submitted for mercury analysis if risk estimates are to be calculated for this food group.

3.0 Recommended Future Activities

3.1 Ongoing Dialogue with Partner First Nations and Agencies

The mercury and human health risk management plan and associated monitoring was developed through detailed dialogue with the partner First Nations. It is recommended this communication continues, through the MHHIG and other mechanisms such as the Project's Monitoring Advisory Committee, for meaningful inputs into upcoming HHRAs, including comfort level regarding voluntary submission of samples (wildlife, fish and plants). Through their involvement and discussion with MHHIG representatives, health agencies have had a chance to review the preliminary fish results in relation to consumption recommendations and messaging. Receiving ongoing feedback from the above representatives about monitoring results and associated risk management tools (e.g., fish consumption materials), the program will have the greatest likelihood of acceptance by both the communities and agencies.

3.2 Environmental Monitoring

With respect to the information used from environmental monitoring programs, a detailed HHRA requires the following:

- a strong dataset;
- firm statements on certainty re: confirmation of predicted concentrations; and
- a mechanism to detect early exceedances of predicted concentrations.

With the above in mind, it needs to be clear that no environmental dataset is perfect and there will always be variability in the data. Nevertheless, if EIS estimates are not accurate or are exceeded, it is important that the communities learn about this as early as possible. The Project team (toxicologist, and fish and wildlife biologists) will continue to work with community members and regulators to provide timely communication of results, review areas where additional samples may add more certainty, keeping in mind added accuracy for effort, conservation, and cultural sensitivities and circumstances. For the purpose of providing strong inputs on a future HHRA, it will be important to consider scientific and regulatory requirements and reconfirm whether current monitoring plans and approaches suffice to provide communities comfort and meet these requirements.

While there is no indication of people eating fish (subsistence or otherwise) from Gull Lake, a boat launch is now constructed (albeit not yet open to public) downstream of the Keeyask Generating Station. For this reason, there may be merit in future years to consider June sampling in Gull Lake (similar to that established in 2021 for Stephens Lake). In the case of the fall (August/September) sampling program, analysis would ideally include a reasonable likelihood that standardized size fish are estimated for all fish if possible. In the case of the fish sampling program, it is unclear if persons are consuming fish organs but if so, these may be considered for analysis in the fall (August/September) sample dataset.

To enhance the limited dataset of wildlife, exploring additional options to encourage sample submission by the partner First Nations under the voluntary sampling program of wildlife (mammals, waterfowl and gull eggs) and plants would contribute to the feasibility of a detailed HHRA. Furthermore, it may be reasonable to attempt to obtain mercury concentrations in wild game from unaffected areas for comparative purposes through the voluntary sampling program. It is also recommended that the Project biologist continue to determine if there are any refinements that could be made to the methods to estimate concentrations of mercury in wildlife.

3.3 Wild Foods Workshop

As discussed earlier, an important aspect of the interpretation of human health risks relies on the wild foods and consumption rates that were identified in the October 2009 workshop with the partner First Nations. While the food survey, developed in conjunction with the hair sampling program provided information about commonly consumed local, wild and market foods, robust information about current consumption rates is lacking. With future hair sampling events offered in communities, food surveys may offer more information in this regard. Regardless, it would be productive to revisit the results of this workshop with the partner First Nations to determine which wild foods remain the key concerns and if the consumption rates (i.e., frequency and meal sizes) are still applicable.

3.4 Testing of the Communication of Risk Messages

As noted earlier, it is important that the risk messages are communicated in an effective manner. In particular, there are certain fish sizes that need to be avoided. It would be helpful to assess whether the messages are well understood and being followed in the larger communities. This would also involve listening to the communities for other methods to communicate the messages.

4.0 Conclusions

Overall, the Holm and Aiken (2023) fish dataset provides support for the current fish consumption recommendations for Stephens and Gull lakes being protective of human health; however, the dataset also illustrates the toxicological importance of consuming fish that are less than standardized size from both of these lakes and of avoiding certain fish from Gull Lake. Although fish in Stephens Lake are predicted to have appreciably lower concentrations than in Gull Lake, it is important to continue and/or enhance communication efforts that there are fish in both Gull and Stephens lakes that people are advised to limit consumption or avoid altogether. Fish concentrations in one species in Stephens Lake reached the predicted peak mean concentrations in 2022 but it is within historical concentrations (Holm and Aiken, 2023). Finally, because there is little regulatory precedent for risk interpretation of the information taken from the ridgeline plots, it is recommended that discussions with the communities and the regulatory agencies occur in the near future.

Based on environmental data and predictions provided in WRCS (2023), there is no information to suggest that persons should be avoiding consumption of any the wild mammals or waterfowl identified as frequently consumed by the partner First Nations (beaver, muskrat, snowshoe hare, moose and waterfowl). It is recommended the Project team involved in providing inputs into and/or implementing the Mercury and Human Health Risk Management Plan continue to work together to maximize opportunities to secure a robust dataset for fish and wildlife and achieve regulatory agency acceptance of data for the purposes of an HHRA.

Finally, reconvening a wild foods workshop with the partner First Nations and testing that the communication messages are being received could be very beneficial. Although there is the possibility that the hair and food survey may provide useful information other possible approaches should be considered including a wild foods workshop, subject to community input.

5.0 Statement of Limitations

This report has been prepared by Wilson Scientific Consulting Inc. (Wilson Scientific) for the sole benefit of Manitoba Hydro. Any use that a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. Wilson Scientific accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional staff in accordance with generally accepted scientific practices current at the time the work was performed.

Any site-specific information provided by Manitoba Hydro, North/South Consultants Inc., Wildlife Resources Consulting MB Inc. or other parties has been assumed by Wilson Scientific to be accurate. Conclusions presented in this report should not be construed as legal advice.

This risk evaluation was undertaken exclusively for the purpose outlined herein and was limited to those contaminants, exposure pathways, receptors, and related uncertainties specifically referenced in the report. This work was specific to the site conditions and land use considerations described in the report. This report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations.

This report describes only the applicable risks associated with the identified environmental hazards, and is not intended to imply a risk-free site. Should any conditions at the site be observed or discovered that differ from those at the sample locations, or should the land use surrounding the identified hazards change significantly, Wilson Scientific requests that to be notified immediately to reassess the conclusions provided herein.

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Subject: **Predictions of Post-Impoundment Fish Mercury Concentrations for Application in the Mercury and Human Health Risk Management Plan Products**

To: S. Wakelin and M. Wiest
Environmental Licensing & Protection Department
Manitoba Hydro and Indigenous and Community Relations

From: J. Holm
North/South Consultants Inc.

Date: April 23, 2021

1.0 INTRODUCTION

This memorandum provides details on the methodology and rationale for the prediction of length-class specific peak fish mercury concentrations resulting from Project operations and updated fish mercury concentrations in Split Lake for application to the Mercury and Human Health Risk Management Plan products (e.g., Human Health Risk Assessment [HHRA]) and related communication products.

Post-impoundment, peak mercury concentrations predicted in the Keeyask EIS (KHLP 2012) for three fish species, Lake Whitefish, Northern Pike, and Walleye, can be used to inform consumption recommendations for the Keeyask reservoir (formerly Gull Lake including a reach of the Nelson River below Birthday Rapids) and Stephens Lake, where mercury levels are expected to increase over first three to seven years as a result of Project operation followed by a slow decline for up to 30 years. Predicted concentrations are presented separately for standardized lengths and three species-specific size classes (i.e., small, medium, and large), which allows consumers to make fish consumption choices in terms of mercury exposure based on fish species and fish size.

2.0 RELEVANCY OF EIS PREDICTIONS FOR PEAK MERCURY VALUES IN GULL AND STEPHENS LAKES

The peak mercury values estimated in the Keeyask EIS in June 2012 are still relevant at the present time. Peak mercury values for a species-specific standard length for Lake Whitefish, Northern Pike, and Walleye from both Gull Lake and Stephens Lake are summarized in Table 7-2 of the EIS Aquatic Environment Supporting Volume (KHLP 2012). The estimates were calculated using two empirical models, one based on the model developed by Johnston et al. (1991) based on recorded increases in mercury concentrations in numerous waterbodies along the Churchill River Diversion Route and a proxy model using estimates of mercury concentrations in Stephens Lake prior to and after impoundment. The modelling approaches and methodologies are described in Appendix 7E of the EIS Aquatic Environment

Supporting Volume (KHLP 2012). The dataset used as the pre-impoundment mercury concentrations to input into the model included mercury concentrations from the last three years of baseline data for Gull Lake (2001, 2002, and 2006) and the last four years of data for Stephens Lake (2001, 2002, 2003, and 2005).

There are several limitations to the Johnston et al. (1991) model(s) that must be considered when interpreting its predictions for fish mercury levels in the Keeyask reservoir and Stephens Lake:

- *"Few of the reservoirs used to build the model(s) had extensive in-lake flooding with no upstream effects, as is predicted to occur in the Keeyask reservoir;*

- *The Percentage Flooding model explained between 38% (for Northern Pike) and 57% (for Walleye) of the variation in fish mercury burden (Johnston et al. 2001), resulting in considerable uncertainties when the model is applied to predict mercury concentrations;*

- *The measurement of fish mercury concentrations used in the Johnston et al. (1991) model(s) generally began after peak concentrations occurred, such that maximum mercury burdens used for modelling were likely lower than actual burdens. This may have resulted in an underestimation of predicted concentrations in the Keeyask reservoir; and*

- *The model(s) does not include the effect of flow rate.*

The last issue may be of particular relevance for the Keeyask reservoir, which is expected to have a relatively short hydraulic residence time of up to 30 hours within the mainstem, approximately 30 days within the newly formed back-bay, and only longer in more sheltered, shallower areas farthest from the river mainstem (PE SV, Section 4.4.2.2). Fast flows and a short reservoir residence time have the potential to dilute and/or remove newly generated methylmercury in the water column before it enters the food web and is biomagnified in consumers at higher trophic levels. For a given amount of flooding, fish mercury concentrations will be lower where flow through the reservoir is high. Although most reservoirs used to build the Johnston et al. (2001 [sic][1]) models were riverine in nature, the hydraulic residence times and the ratios of lacustrine to riverine areas were likely larger than is expected for the Keeyask reservoir. Such differences in hydrology also apply to the Stephens Lake proxy model, and suggest that based on flow rates alone, the predicted fish mercury concentrations for the Keeyask reservoir tend to be an overestimate.

When considering all of the above factors that could not be (fully) accounted for in the models used to make quantitative predictions of mercury concentrations in Keeyask reservoir fish, maximum concentrations in Northern Pike and Walleye can be expected to reach or slightly exceed 1.0 ppm." (p. 7-19 of KHLP 2012)

[1] Johnston et al. (1991)

As noted in the EIS, it must be emphasized that the predictions should be used as indicators rather than absolute post-Project numbers:

"It must be emphasized that although an attempt was made to provide quantitative estimates of future mercury concentrations in the Keeyask reservoir and downstream areas, all predicted values should be treated more as indicators and not as precise quantitative predictions." (p. 7-20 of KHLP 2012)

A range of peak values is presented in the EIS based on the results of the modelling (summarized in Table 1). For example, the peak value for Walleye from Gull Lake is 1.46 ppm based on the Stephens Lake proxy model, while the most likely peak value was estimated at just over 1.0 ppm based on conditions in the reservoir. As discussed in the EIS, the peak values based on the Stephens Lake proxy model are quite high and are unlikely to occur given the relatively high rate of water flow through the reservoir (KHLP 2012). The ranges presented in the EIS are considered robust and are expected to be sufficiently high to account for any natural variations in mercury concentrations that may have occurred in since 2006. It is understood that these values may be utilized as part of the HHRA and communication products.

There is little value in re-running the models. Many of the variables used by Johnston (1991) remain unchanged: the estimate of %PF (the percentage of reservoir flooding); and b_1 (the regression constant related to the flooding contribution to the burden was taken directly from the Johnston paper). Likewise, many of the variables from the Stephens Lake proxy model also remain unchanged: percent flooding; and maximum concentrations in Stephens Lake after impoundment by Kettle GS. The one variable in both models that that could have changed over time is the baseline mercury concentrations in the three species in Gull and Stephens lakes (presented in Table 7-2 of the EIS Aquatic Environment Supporting Volume). In the case of Gull Lake, these values were calculated using the most recent mercury concentrations prior to construction; mercury concentrations were not collected again from Gull Lake until 2014, the year that construction began for the Project.

Including data collected during the construction period shows concentrations that are generally higher in the piscivorous species in 2019, but concentrations measured in 2014 and 2016 were only marginally higher than in 1999 (Figure 1 and discussed in Holm 2020a). While more recent, pre-construction mercury concentrations are available for Stephens Lake (2007, 2009, 2012, and 2018), concentrations in Stephens Lake have varied considerably without showing a consistent increasing or decreasing trend over the 1999–2018 period (Figure 2 and discussed in Holm 2020a). For example, the mean concentration in Northern Pike in 2015 was approximately twice that in 2005, but estimates in both 2012 and 2018 were considerably lower than 2015. Mercury concentrations in Lake Whitefish from both lakes have been consistently low and have not changed much over time, including between 2014 and 2019 after construction of Keeyask began.

Table 1. Estimates of mean maximum mercury concentration (ppm) of three fish species for the Keeyask reservoir and Stephens Lake (based on Table 7-2 of KHLP 2012).

Species	Lake Whitefish	Northern Pike	Walleye
Fork Length	350 mm	550 mm	400 mm
Keeyask Reservoir			
Range of Modelled[1] Means	0.18-0.19	0.81-1.33	0.83-1.46
Most Likely	0.19	1.0	1.0
Stephens Lake			
Range of Modelled[2] Means	0.12	0.40-0.41	0.43
Maximum (conservative)	0.15	0.5	0.5

[1] Estimated using the modified percent flood regression model (Johnson et al. 1991) and Stephens Lake proxy model
[2] Estimated using a proportion of flooded area to the combined area of Stephens Lake and the Keeyask reservoir

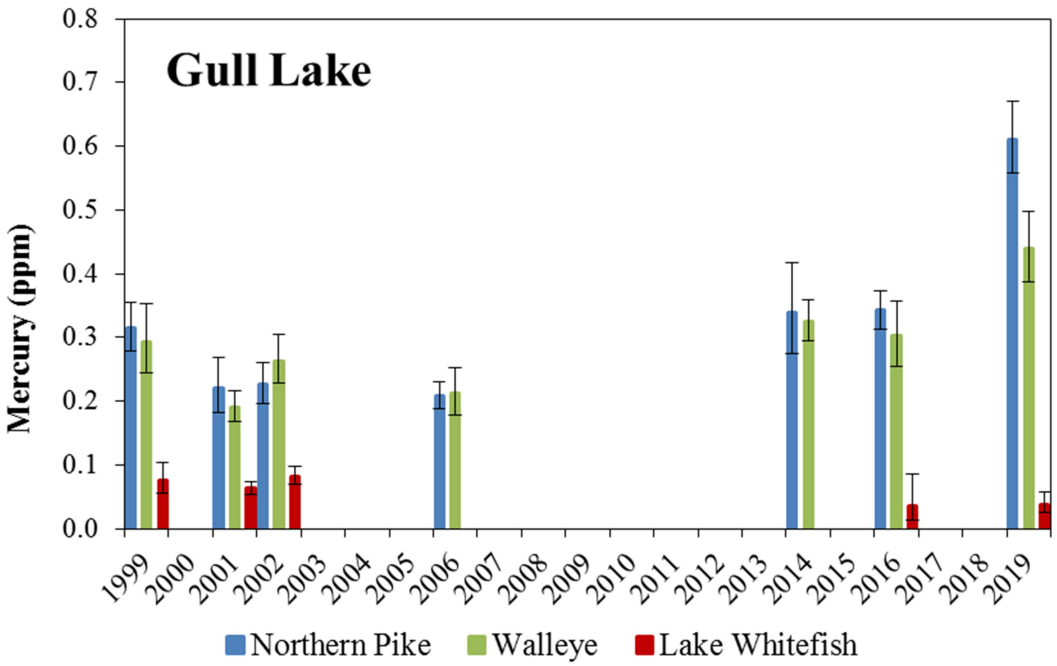

Figure 1. Standard mean mercury concentrations (± 95% confidence limits) measured in fish from Gull Lake from 1999–2019.

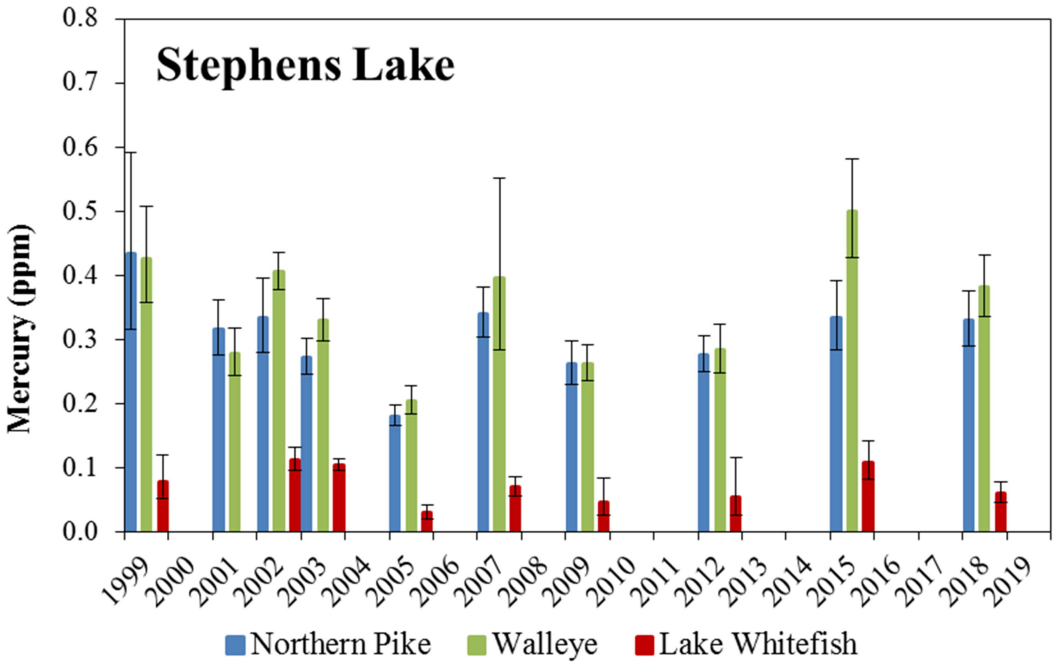

Figure 2. Standard mean mercury concentrations (± 95% confidence limits) measured in fish from Stephens Lake from 1999–2018.

3.0 ESTIMATES OF PEAK MERCURY CONCENTRATIONS FOR OTHER SIZE CLASSES OF FISH IN GULL AND STEPHENS LAKE

Both the Johnston et al. (1991) model and Stephens Lake proxy model use standard mean mercury concentrations based on a specific length for each fish species to predict peak mercury values post-Project. In contrast, the values used to inform the consumption recommendations are based on arithmetic means for a species-specific range of lengths. It is not possible to use the Johnston et al. (1991) model to generate a peak value for any other fish length since it requires regression constants (b_0, b_1) that were generated by the authors specifically for a 550 mm Northern Pike, a 400 mm Walleye, and a 350 mm Lake Whitefish.

It is possible to provide estimates for peak mean mercury concentrations for different length classes using the predicted increases for the standard length of fish provided in the EIS. The EIS predicted that there would be an increase of about 3 fold for a 350 mm Lake Whitefish and 5 fold for a 400 mm Walleye and a 550 mm Northern Pike from the reservoir, and about a 2 fold increase for all three species from Stephens Lake. However, it should be noted that this approach makes the assumption that fish of different lengths accumulate mercury at the same rate. As noted in the EIS: "*within species, mercury concentrations of younger individuals tend to increase faster than those of older fish (Schetagne and Verdon 1999; Harris and Hutchinson 2009)*" (p. 7-18 of KHLP 2012). Therefore, there is some

uncertainty associated with using the predicted increases for the standard lengths of fish, particularly for the concentrations in smaller fish. Annual monitoring of mercury concentrations of the three species from the reservoir and Stephens Lake and timely reporting of results will ensure the validity of these predictions (described in Section 5.0).

The first step is to generate arithmetic mean concentrations for the three size classes for Lake Whitefish, Northern Pike, and Walleye using the "baseline" data (Table 2). Data from 2001 to 2016 was used to generate the baseline mean concentrations for Gull Lake and data from 2001-2018 was used to generate the means for Stephens Lake. Including data collected since 2001 to calculate the baseline conditions increases the sample size (particularly for the largest length class, which generally has the fewest samples), includes more recent data than available at the time the EIS was written, and better reflects the natural variation in mercury concentrations that exists over time. Mercury concentrations from fish sampled from Gull Lake in 2019 were not included in the calculation of the "baseline" concentrations for the length classes because of potential effects of Project construction on mercury levels.

The "baseline" mean concentration of each length class was then multiplied by the predicted increase of mercury concentrations for the standard lengths of each species (i.e., multiplied by a factor of 2 for all three species in Stephens Lake, and for the reservoir were multiplied by 3 for Whitefish and by 5 for Northern Pike and Walleye) to generate the predicted peak mean concentration for each length class (Table 2).

The best estimates for the most likely fish mercury concentrations at peak for three size classes of Lake Whitefish, Northern Pike, and Walleye from the Keeyask reservoir and Stephens Lake are summarized in Table 2. It is understood that these values may be utilized as part of the HHRA and communication products.

Table 2. Estimates of peak mean mercury concentration ([Hg]; ppm) for three length classes of Lake Whitefish, Northern Pike, and Walleye from the Keeyask reservoir and Stephens Lake.

	Baseline Mean [Hg][1]			Predicted Peak Mean [Hg][2]		
Lake Whitefish	<300 mm	300-450 mm	>450 mm	<300 mm	300-450 mm	>450 mm
Keeyask Reservoir	0.042	0.072	0.178	0.126	0.216	0.534
Stephens Lake	0.061	0.092	0.159	0.122	0.184	0.318
Northern Pike	<500 mm	500-750 mm	>750 mm	<500 mm	500-750 mm	>750 mm
Keeyask Reservoir	0.152	0.308	0.709	0.760	1.54	3.55
Stephens Lake	0.171	0.352	0.924	0.342	0.704	1.85
Walleye	<400 mm	400-550 mm	>550 mm	<400 mm	400-550 mm	>550 mm
Keeyask Reservoir	0.155	0.476	0.676	0.777	2.38	3.38
Stephens Lake	0.222	0.461	0.741	0.444	0.922	1.48

[1] Calculated by averaging mercury concentrations of fish sampled between 2001-2016 from Gull Lake and between 2001-2018 from Stephens Lake.
[2] Calculated by multiplying the current mean mercury concentrations by the predicted increases in the EIS (i.e., 3 times for Lake Whitefish and 5 times for Walleye and Northern Pike from the reservoir and 2 times for all three species from Stephens Lake).

4.0 UPDATED FISH MERCURY CONCENTRATIONS IN SPLIT LAKE

An update of length-class specific fish mercury data from Split Lake with recently collected data (2019) was provided in the memorandum "Updated Fish Mercury Information for Gull, Stephens, and Split Lakes for Mercury and Human Health Implementation Group Purposes" (Holm 2020b). The mean mercury concentration of the length classes was consistent (i.e., less than a 20% difference) among sampling periods (i.e., 2002-2016 versus 2016-2019) for Walleye and Lake Whitefish. In the case of Northern Pike, there was a greater than 20% difference for only the largest size class. However, due to the small sample size (4 samples), a lack of significant difference among periods, and the difference for the combined lengths being less than the 20% threshold, this difference is likely an artifact of sampling variation rather than an actual increase in mercury concentrations over time (Holm 2020b).

Since so few Northern Pike greater than 750 mm have been analysed for mercury since 2001 (n = 21 samples), it is recommended that the range of data used to calculate the length-class specific means for the largest size class of Northern Pike include all available data in order to increase the sample size. Likewise, since no Lake Whitefish in the smallest length class have been analyzed for mercury since 2010, it is recommended all of the Lake Whitefish of the smallest size class analyzed since 2001 be included in the calculation of the mean (n = 18). The updated length-class specific mean mercury concentrations for Split Lake are summarized in Table 3 alongside the values applied to the consumption recommendations provided in 2017.

Table 3. Mean mercury concentration ([Hg]; ppm) for three length classes of Lake Whitefish, Northern Pike, and Walleye from Split Lake for two sampling periods. The top row represents the data used for the updated Keeyask MHHWG Fish Mercury and Human Health communication products in 2017 (source: Jansen 2017) and the bottom row represents current concentrations that could be used to update of these products, if required.

Species/Period	Sampling Years	Mean [Hg] by Length-Class		
Lake Whitefish		<300 mm	300-450 mm	>450 mm
2017 Concentrations	2002-2016	0.033	0.082	0.126
Current Concentrations	2013-2019*	0.031	0.094	0.134
Northern Pike		<500 mm	500-750 mm	>750 mm
2017 Concentrations	2007-2016	0.171	0.421	0.641
Current Concentrations	2013-2019*	0.183	0.398	0.729
Walleye		<400 mm	400-550 mm	>550 mm
2017 Concentrations	2007-2016	0.255	0.352	0.692
Current Concentrations	2013-2019	0.225	0.398	0.736

* Values in red include fish sampled since 2001 because of the small number of individuals captured in the length class.

In response to request for fish mercury concentrations for species specific standard length (for input into Split Lake communication materials), an updated standard mean mercury concentration for Split Lake was calculated by averaging the annual standard means calculated over the 2001-2019 period (Figure 3). As discussed in Section 3.0, using several years of mercury data to estimate mercury concentrations better reflects the natural variation in mercury concentrations that exists over time. The updated length-standardized mercury concentrations for Split Lake are summarized in Table 4.

Table 4. Average and range of annual length-standardized mercury concentration (ppm) of three fish species from Split Lake between 2001-2019.

Species	Lake Whitefish	Northern Pike	Walleye
Fork Length	350 mm	550 mm	400 mm
Mean	0.06	0.28	0.26
Range	0.03 - 0.10	0.18 – 038	0.12 – 0.41

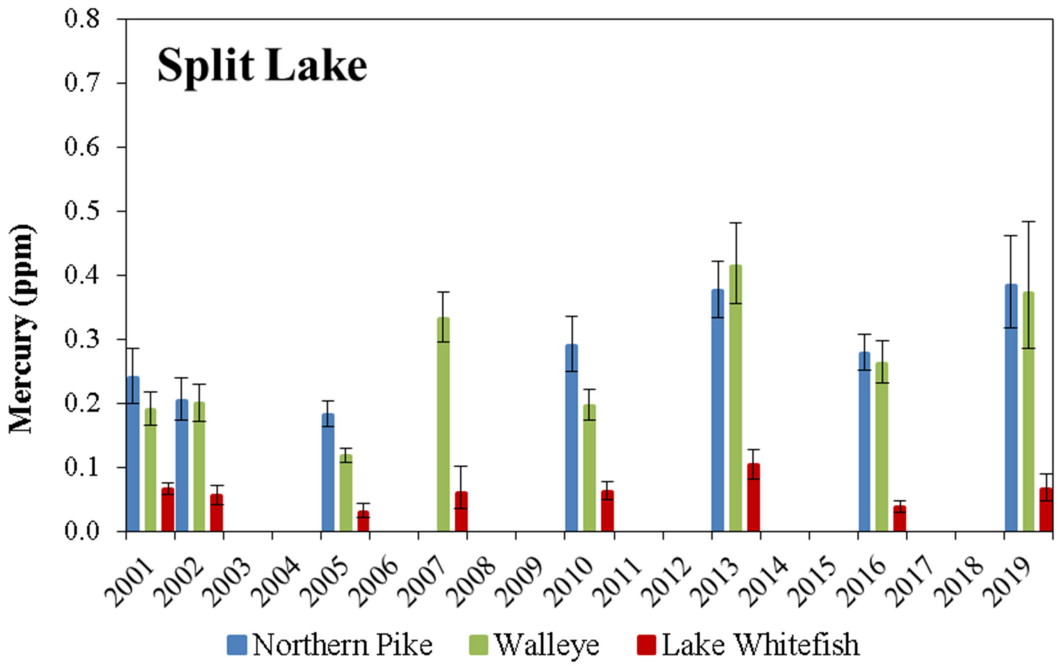

Figure 3. Standard mean mercury concentrations (± 95% confidence limits) measured in fish from Split Lake from 2001–2019.

5.0 ANNUAL POST-IMPOUNDMENT MONITORING OF FISH MERCURY

The validity of predictions about the magnitude and timing of peak mercury concentrations in fish due to the Keeyask Project will be assessed as part of the Keeyask Aquatic Effects Monitoring Program (KHLP 2015). The periodicity of post-impoundment fish mercury monitoring is outlined in the AEMP:

"*During the operation phase, monitoring will proceed yearly in the directly affected waterbodies (i.e., Keeyask reservoir, Stephens Lake) until maximum fish mercury concentrations are reached .... Thereafter, monitoring of mercury levels will be conducted every three years until concentrations have reached pre-Project levels or are considered stable at a new background level. ... For those waterbodies not hydrologically affected by the Project (i.e., Split Lake…), monitoring will proceed at a 3-yearly interval throughout the operation phase until fish mercury concentrations have reached pre-Project concentrations or are considered stable at a new background level in the Keeyask reservoir* " (p. 7-7 of KHLP 2015).

The AEMP defines how it will be determined when peak levels of fish mercury have been reached post-impoundment as:

"Maximum post-Project mercury concentrations will be considered attained for a species if standardized means (or arithmetic means if the relationship between fish length and mercury content is not significant) are not statistically different for three consecutive sampling periods (i.e., 1 year for fish from the Keeyask reservoir and Stephens Lake; every 3 years for other waterbodies) or are significantly lower in the sampling period following two sampling periods of similar concentrations. Stable post-Project concentrations at the end of the declining phase will be considered attained for a species if standardized (or arithmetic) means are not statistically different for three consecutive sampling periods" (p. 7-6 of KHLP 2015).

AEMP mercury monitoring occurs in the late-summer/early fall. To provide resource users that harvest fish from Stephens Lake information on mercury concentrations in fish earlier in the year, additional annual mercury sampling will be conducted starting in the spring 2021 concurrent with the AEMP fish community monitoring programs.

The AEMP (KHLP 2015) includes a "Management Response Framework" for fish mercury monitoring. This framework outlines the steps and events (e.g., an exceedance in a predicted benchmark) that could prompt adaptive management (e.g., adjustments in mitigation and monitoring). "*A review of the monitoring program will be undertaken throughout the implementation of the AEMP with the intent to provide a mechanism for modification(s) as data are acquired over time*" (p. 7-9 of KHLP 2015).

The results of the annual monitoring of fish mercury will be analyzed and communicated to decision makers in a timely fashion to ensure the accuracy of data used to inform the Human Health Risk Assessment. As stated in the AEMP:

"*The sharing of data and information from the different monitoring components is an integral part of the AEMP. Because of the linkages between fish mercury concentrations and human health, the timely dissemination of information between disciplines is critical. To this end, confirmed results from fish mercury monitoring will be provided, as soon as they are available, to the KHLP's Monitoring Advisory Committee and* [Mercury and Human Health Implementation Group]. *As noted in the Socio-Economic Monitoring Plan, the timely provision of the most current fish mercury concentrations will provide the basis for updates to the "Human Health Risk Assessment" and safe consumption recommendations, both of which are components of the "Mercury and Human Health Risk Management Plan" for the Keeyask Generation Project*" (p. 7-9 KHLP 2015).

6.0 LITERATURE CITED

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Subject: **Preliminary Results of 2022 Spring Mercury Sampling in Stephens Lake**

To: S. Wakelin and M. Wiest
Environmental Licensing & Protection Department
Manitoba Hydro and Indigenous and Community Relations

From: J. Holm
North/South Consultants Inc.

Date: July 19, 2022

PROGRAM OBJECTIVES:

- The validity of predictions about the magnitude and timing of peak mercury concentrations in fish due to the Keeyask Project are being assessed as part of the Keeyask Aquatic Effects Monitoring Program (Keeyask Hydropower Limited Partnership 2015). The Project biologist is confident that the annual monitoring plan identified in the AEMP is robust and sufficient to detect if the predicted peak standard size fish concentrations are exceeded.
    - Since 2009, and throughout the construction phase, monitoring for mercury in fish from Stephens Lake was conducted every three years in concert with the Coordinated Aquatic Monitoring Program, an ongoing program in which samples are collected from the south basin of the lake.
    - Since reservoir impoundment, sampling is conducted annually in Stephens Lake in the late summer/early fall, so that tracking increases in mercury over time, and comparing it with predictions is done more frequently.
- There is some food fishing on Stephens Lake, particularly by FLCN and TCN members, including cabin owners, although information to date indicates it does not serve as a primary domestic fishing source.
- To provide resource users who harvest fish from Stephens Lake information on mercury concentrations in pickerel and jackfish following impoundment earlier in the year, additional mercury sampling was conducted in the spring 2021 and 2022 concurrent with other AEMP monitoring programs. This additional monitoring event will continue annually for the next few years.
    - Developed as an early warning measure, the June sampling event is not intended to replace or replicate the AEMP monitoring study, which is required to compare the results against predictions (see above).
- Spring mercury monitoring is not being conducted on the Keeyask reservoir as it is assumed that food fishing has been non-existent or very limited on Gull Lake prior to impoundment based on feedback received from MHHIG community members.

- Whitefish were not selected for mercury monitoring in the spring because mercury concentrations were predicted to be considerably lower than in the two piscivorous species and as a fall spawning species, whitefish were not expected to be present in the area in the spring (and were not captured during either the spring 2021 or 2022 programs).

METHODOLOGY:

- Dermal punches were selected to sample tissue for mercury analysis in the spring rather than fillets to limit the number of mortalities for scientific studies. A 6 mm punch was selected to ensure sufficient tissue for mercury analysis.
- In 2022, dermal punch samples were to be collected from 16 pickerel and 16 jackfish captured in the reach of Stephens Lake below the Keeyask GS (i.e., south basin) as part of AEMP fish community monitoring studies. The number of samples was increased from eight of each species in 2021, which had been based on recommendations in Environment Canada's (2012) Metal Mining Technical Guidance for Environmental Effects Monitoring[1] (Section 3.11.4). Doubling of the samples was still within the number that could be guaranteed by the lab for a 100% rush analysis.
- A duplicate sample was collected from two pickerel and two jackfish for QA/QC purposes; these samples were placed in separate vials and analysed for mercury separately.
- The size of the fish that can be sampled using a dermal punch is limited to those larger than 200 mm as per Environment Canada's (2012) Metal Mining Technical Guidance for Environmental Effects Monitoring (Section 3.11.4.1). Above 200 mm fork lengths, dermal plugs were to be collected from a variety of lengths to facilitate the calculation of a standard mean mercury concentration.

PRELIMINARY RESULTS:

- Sixteen pickerel and 16 jackfish were sampled for mercury from 29 May to 3 June, 2022 from Stephens Lake immediately below the Keeyask station.
- Samples were analyzed for total mercury by cold vapor atomic absorption (CVAA) at ALS Environmental (Vancouver) from 9 to 16 June, 2022.
- The results of the four duplicate samples were compared by calculating the relative percent mean difference (RPMD). The RPMD values were 5.9 and 12.1% for the jackfish and 1.0 and 18.2% for the pickerel. All of the duplicates were within the British Columbia Ministry of Environment, Lands, and Parks (BCMELP, 1998) criterion that is applied for water quality duplicates (<25% RPMD) and within ALS Laboratories limits of acceptability (<40% RPMD).
- The percent moisture of dermal plugs was reasonably consistent, ranging from 75.5 to 87.9%.

[1] While the guidance provided by Environment Canada was developed to assist regulated facilities (metal and diamond mines), methodologies for environmental effects monitoring have been used in the design of monitoring programs for other industries (*e.g.*, Wuskwatim GS Aquatic Effects Monitoring Program, oil sand development Regional Aquatic Monitoring Program).

- A request was made on 20 June, 2022 for ALS Laboratories to verify the analysis results of four samples with higher mercury concentrations at length and the results were confirmed on 5 July, 2022.
- The concentration of mercury in each muscle plug collected in 2022 is plotted against the length of the fish in Figure 1. Data from fish sampled prior to impoundment (analyzed as fillets), and post-impoundment in spring 2021 (plugs/fillets) and fall 2021 (fillets) are also included in the figure for comparison.
- As was observed in spring 2021, the pickerel and jackfish sampled in the spring 2022 were of a narrower size range compared to those sampled as part of AEMP and CAMP studies. In the case of pickerel, the fish sampled were skewed toward longer fish (Figure 1). This was to be expected since these are spring spawning species (typically bigger fish) and fishing occurred in the vicinity of known spawning habitat.
- A linear regression of log transformed fork lengths and log transformed mercury concentrations was significant for both jackfish and pickerel. The standard means of a 550 mm jackfish and a 400 mm pickerel from Stephens Lake between 1999 and 2022 are plotted in Figure 2.
    - The standard mean mercury concentration of a 550 mm jackfish from Stephens Lake immediately downstream of the station in the spring of 2022 was 0.54 ppm. This value is higher than the standard mean concentrations estimated since 1999 and is above the predicted peak of 0.5 ppm. The standard mean in 2022 is still within the 95% confidence interval of the standard mean concentration in 1999.
        - Figure 1 shows that mercury concentrations of the larger jackfish (>500 mm) are still within the range of values recorded prior to impoundment. A few individual jackfish that were <500 mm had higher mercury levels for their length than has been seen historically. These fish could be accumulating mercury that is being transported downstream from the reservoir or could be fish that have moved downstream into Stephens Lake from the reservoir. Information on fish movements in the study area is being collected over several years as part of the AEMP that may help answer this question.
    - The standard mean concentration of a 400 mm pickerel from Stephens Lake immediately downstream of the station in the spring of 2022 was 0.56 ppm. This value is higher than the standard mean concentration estimated since 1999 and is above the predicted peak of 0.5 ppm. The standard mean in 2022 is still within the 95% confidence interval of the standard mean concentration in 2015.
        - The number of dermal punch samples collected was doubled in 2022 primarily because a length standardized mean could not be calculated for pickerel in spring 2021 due to a lack of a statistically significant linear relationship between log transformed mercury concentration and length. While this relationship was significant in 2022, the range of lengths of fish sampled in 2022 (320–525 mm) was similar to those sampled in spring 2021 (347–545 mm). So, while more fish were analyzed for mercury in 2022, the same length classes were used.

  - There were no pickerel sampled representing length classes between 200 and 320 mm in 2022. The estimate of the standard mean is less robust when the samples are not adequately length stratified. The absence of the lower end of the length distribution can have a considerable effect to the estimate of the standard mean – if the small fish have accumulated higher than historical concentrations then the mean may be underestimated or if they have lower mercury concentrations relative to the larger sizes classes, then the mean will be overestimated.
- A preliminary review of mercury concentrations in pickerel and jackfish sampled downstream of the Keeyask GS in spring 2022, indicates that estimated mean mercury concentrations exceed the predicted peak mercury used to develop consumption recommendations. The results are still within 20% of the prediction. Mercury monitoring as part of the AEMP is scheduled to occur in early September 2022 in Stephens Lake and will provide additional information to confirm or clarify the spring results.

NEXT STEPS:

The data presented in this memo are considered preliminary until the fish biometric data used in the analysis are confirmed by the AEMP fish studies reporting.

The fall AEMP mercury sampling will occur in September 2022 and fish movements studies are occurring throughout 2022; the results of these studies will not be available until the winter 2022/2023 and will provide more information for the interpretation of the results presented in this memo.

The spring sampling program will be repeated in 2023 after discussions of the results of the spring and fall mercury studies with MHHIG group.

REFERENCES:

British Columbia Ministry of Environment, Lands, and Parks (BCMELP). 1998. Guidelines for interpreting water quality data. Version 1, May 1998. Prepared for the Land Use Task Force Resource Inventory Committee.

Environment Canada. 2012. Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring (TGD). Available from: https://www.ec.gc.ca/esee-eem/default.asp?lang=En&n=AEC7C481-1 [accessed June 2022]

Keeyask Hydropower Limited Partnership. 2015. Keeyask Generation Project: Aquatic Effects Monitoring Program. A report prepared by Keeyask Hydropower Limited Partnership, June 2015.

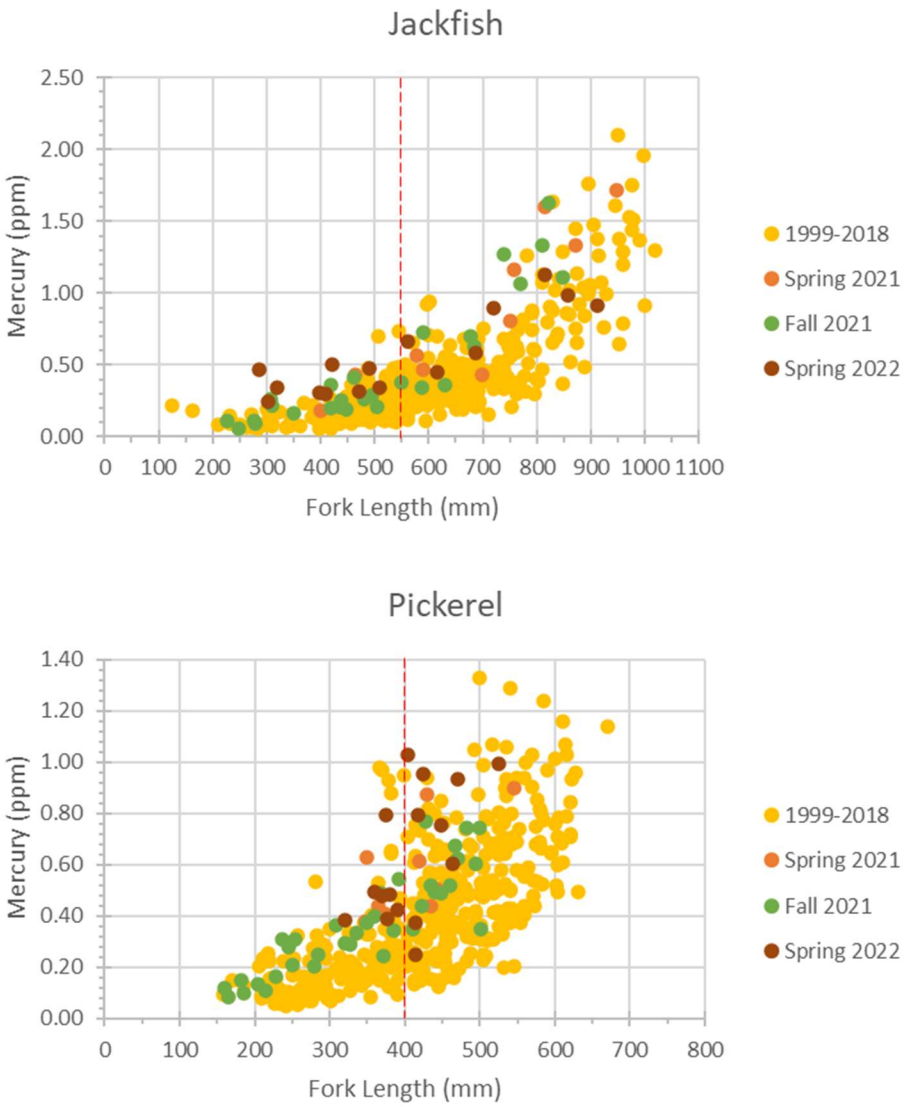


Figure 1. Concentration of total mercury in flesh samples from jackfish (top) and pickerel (bottom) collected from Stephens Lake in July/August/September 1999–2018, June 2021, September 2021, and May/June 2022 versus fish length. The dashed red lines indicate the length class used in the fish consumption recommendations.

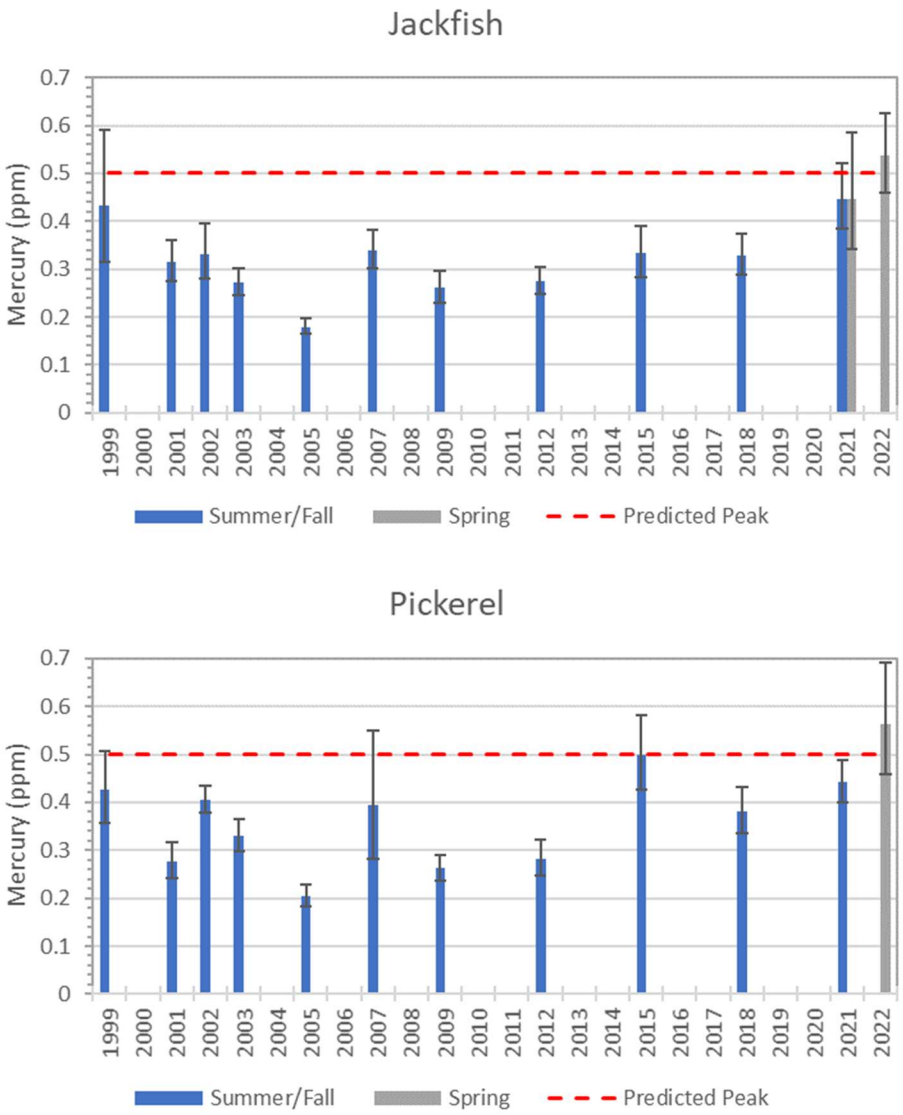


Figure 2. Standard mean mercury concentrations (± 95% confidence limits) of a 550 mm jackfish (top) and a 400 mm pickerel (bottom) from Stephens Lake from 1999–2022. The red dashed line indicates the predicted peak mercury concentration post-impoundment.

APPENDIX 4: POST-IMPOUNDMENT FISH MERCURY COMMUNICATION PROCESS

Subject: Communication Process of Mercury Fish Data Results and Consumption Recommendations, Keeyask Project PHASE 2 (Post-Impoundment)

Date: April 14, 2022

To: Mercury and Human Health Implementation Group

Purpose

The purpose of this memorandum (memo) is to outline a timely communication process with Mercury and Human Health Implementation Group (MHHIG) members on:

1. Keeyask Project related fish mercury monitoring activities and associated results.
2. Interpretation of fish mercury data for post-impoundment consumption recommendations; and the rationale for changes (or no change) to fish consumption recommendations.
3. Additional information and interpretation regarding hair sampling activities and plant and wildlife mercury concentrations.

Based on the Project assessment of risk to human health from potential mercury exposure, consumption recommendations are only prepared for fish consumption. Therefore, this memo focuses primarily on fish monitoring processes. The Project team will make every effort to present technical results and risk assessment interpretation to the MHHIG and Province for discussion in a timely manner. Timely analysis, interpretation and communication is of utmost importance in the assessment of whether consumption recommendations remain protective of human health, particularly until peak fish mercury levels have been determined.

Background

The Mercury and Human Health Implementation Group (MHHIG) developed a Mercury and Human Health Risk Management Plan to address the potential health effects from increased methylmercury in the environment (Gull and Stephens lakes) as a result of the Keeyask Project. Key components of this plan include:

- a communication strategy about fish consumption for resource users in affected waterbodies for pre- and post-impoundment conditions;
- monitoring of mercury in fish, wildlife and plants;
- voluntary hair sampling;
- periodic human health risk assessments (HHRAs)
    - Information obtained on biota, as available, will be reviewed and interpreted annually to assess whether changes to consumption guidance are required; and
- community-specific offsetting programs outlined in each partner First Nations Adverse Effects Agreements.

A suite of communication products related to Split, Gull and Stephens lakes was prepared for the operations phase. In addition, the government of Manitoba will issue a ‘Public Notice’ for Gull and

Stephens lakes (anticipated by early 2022) and has requested this notice be accompanied by corresponding Keeyask Project communication materials.

Monitoring Fish Mercury Concentrations for Consumption Recommendation Purposes

On an annual basis (January - March), the MHHIG will receive an update on the scheduled activities under the Keeyask Aquatic Effects Monitoring Plan (AEMP) for the upcoming season. Details would include month of sampling, which waterbodies, which fish species and approximate sample sizes. This includes monitoring in fish in Split, Gull and Stephens lakes and Aiken River (see Appendix A for more details).

Post-impoundment consumption recommendations prepared for Gull and Stephens lakes are based on predicted peak concentrations (outlined in the Project Environmental Impact Statement, 2012 and validated in 2021) and World Health Organization (WHO) and Health Canada guidance on acceptable rates of intake of mercury. Mercury concentrations in fish from these lakes will be reviewed annually to determine whether post-impoundment consumption recommendations reflect actual peak conditions. For Split Lake, consumption recommendations reflect existing conditions. No fish consumption recommendations are prepared for Aiken (Landing) River.

Mercury concentrations in fish may differ between sampling years because of chance events related to the relatively small sample size compared to the size of the fish population and natural year to year variation in concentrations. To avoid the potential for confusion created by frequent changes in consumption recommendations (and associated communication products) based on minor changes in fish concentrations, the MHHIG, in consultation with Provincial health representatives, outlined a process during the pre-impoundment phase to determine if and when consumption recommendations would need to be changed. General guidelines outlined below are adapted for the post-impoundment phase and consider balancing encouraging healthy fish consumption with providing timely information to communities of important changes to consumption recommendations.

Analytic and interpretive process of fish data

Mercury concentrations in whitefish, pickerel (Walleye), and jackfish (Northern Pike) from Split, Gull, and Stephens lakes will be a key source of information in determining whether fish consumption recommendations remain current or need to be revised. As mercury levels in fish from Gull Lake and, to a lesser extent, Stephens Lake rise as a result of impoundment of the Keeyask reservoir, there is an unavoidable lag between seasonal fish consumption / fish sampling and availability of preliminary sampling results. There is potential that people who consume fish from these lakes could unwittingly consume fish that exceed the acceptable mercury range, if model predictions underestimate peak fish concentrations. This is unlikely given the conservative estimate used to predict the peak concentrations, but the time lag remains an issue until peak conditions are observed and begin to decline. To enhance the information collected under the AEMP, the Aquatic team has committed to undertake supplemental sampling of pickerel and jackfish in spring (June) in Stephens Lake.[1]

The MHHIG and the Province will have the opportunity to review and discuss preliminary and final monitoring results, HHRA interpretation as information becomes available, and in a timely fashion, to

[1] "Preliminary Results of 2021 Spring Mercury Sampling in Stephens Lake" (North / South, 2021) outlines the approach and rationale for June sampling.

assess the currency of consumption recommendations. Discussion will occur prior to finalization of memos or any communication products adjustments.

If fish mercury concentrations in Gull or Stephens lakes in any species reach predicted levels, the MHHIG and province will meet to review available information and assess whether consumption recommendations should be adjusted, in consideration of general guidelines outlined below.

Analysis of Fish Concentrations

- The Aquatic team will provide preliminary results from spring and fall fish sampling events, as soon as is practicable after each event is complete to the Project Toxicologist and MHHIG for review and discussion.[2]
- *Deliverables* include: A consolidated preliminary "*Fish Mercury Concentration*" *memo* describing the results of both the spring and fall sampling in a given year for comparison to predicted concentrations and for HHRA purposes (final, vetted results are typically available by February/March);
    - Fall fish monitoring results are also included in the Project's *annual regulatory report* (submitted in June).
    - For fall program dataset, a statistical analysis will be conducted to determine if any of the mercury concentrations in the three species have changed significantly from the concentrations assumed to derive the consumption recommendations that are in place at the time of the sampling program.

KEY STEPS: Interpretation of consumption recommendations

- Project Toxicologist will prepare a draft "*Human Health Risk Assessment (HHRA)" memo* based on review and interpretation of "*Fish Mercury Concentration*" *memo*(s).
    - This *annual HHRA memo* will present an interpretation of the data and provide conclusions and recommendations on whether the communication products should be revised, including rationale for proposed changes.[3]
    - **Changes to communication products will be primarily based on a 20% change threshold (see below) and consideration of MHHIG and Province feedback.** If changes to consumption recommendations are considered after review of preliminary monitoring results, a meeting will be called in a timely manner to discuss results and next steps with the MHHIG and Province. In this case, an interim HHRA memo will be prepared for discussion.
- *Deliverable*: a *final HHRA Memo* will be prepared to reflect MHHIG discussion and submitted in partial fulfilment of annual regulatory reporting requirements.

[2] Timing will vary depending on sample size and receipt of analytic data from laboratory. Preliminary spring results may be available within 14 days, while preliminary fall results, due to larger sample size, may take up to 2 months.
[3] If aggregate hair sampling results are available and considered to be representative of community members who eat the most fish at the peak time of year, the hair and fish data could be considered and cited to the MHHIG as part of a weight-of-evidence approach.

If changes to consumption recommendations are deemed necessary:

- Communication products will be promptly revised and reviewed by MHHIG and the Province. Once finalized and printed, Mercury Community Coordinators will recall previously distributed products and replace with most current.
- In 2013, Mercury concentrations in fish and other wild foods were considered in a formal Human Health Risk Assessment (HHRA) to represent the pre-Project environment. A formal HHRA will occur in approximately 2026 (or when peak concentrations have been determined by the Aquatic team) and every five years until fish mercury concentrations reach pre-Project or stable background levels.

General guidelines for determining whether communication products should be revised:

Post-Impoundment fish consumption recommendations prepared for fish from Gull and Stephens lakes,[4] are based on predicted peak average concentrations of mercury. Predicted peak concentrations are outlined in Appendix B.

- Consumption recommendations may be revised if the measured average fish concentrations of standardized size fish exceed the predicted mercury concentrations by more than 20% (see Appendix B for threshold values and below for rationale).
- This '20% rule' would apply:
  - in the case of either increasing or decreasing fish mercury concentrations (e.g., after peak conditions have been reached in Gull and Stephens lakes) and
  - at any sampling event, subject to input from Project biologist on data quality (e.g., sample size, fish variability) and discussion with MHHIG, including provincial health representatives.
    - If changes in mercury concentrations are less than 20% for any fish species and length class, it is proposed there will be no need to revise fish consumption recommendations prior to peak conditions occurring.
- In addition to the 20% change threshold, the Aquatic team will attempt to determine whether the change in fish mercury concentrations is statistically significant.
- The MMHIG and Province will consider all relevant information in a timely manner to determine whether changes to fish consumption recommendations should be made.

Rationale for 20% threshold

The 20% threshold approach for fish mercury concentrations is applied for a variety of reasons:

- To avoid confusion by frequent updates and subsequent product recalls based on minor exceedances of the predicted mercury concentration used in these products.
- To account for variability that naturally occurs in fish.
- An increase in fish concentration of up to 20% is not expected to represent an appreciable difference in health risk.

[4] Split Lake products reflect existing conditions and will be updated based on annual review of fish monitoring results. Protocol to determine currency of Split Lake consumption recommendations will follow the decision-making guidelines outlined in this memo (e.g., 20% threshold).

Health Canada (2021) and Province of Manitoba (2007) express the acceptable intake level of mercury for sensitive individuals to one significant figure (i.e., 0.2 µg/kg bw/d) while the World Health Organization (2007) provides a value equal to 0.23 µg/kg bw/d for sensitive individuals. Allowing up to a 20% increase in mercury concentrations will mean that a person who is consuming fish at exactly the maximum acceptable amount of fish but with 20% higher mercury concentrations than predicted will now have a mercury intake of 0.24 µg/kg bw/d which rounded to 1 significant figure is equal to the Health Canada acceptable intake level of 0.2 ug/kg bw/d and is only slightly greater than 0.23 µg/kg bw/d cited by the World Health Organization. These rates would be expected to be associated with hair concentrations in the range of 2.4 ppm rather than 2.0 ppm and are still well below known health effects.

Overall, by using a 20% value as the threshold for changing consumption recommendations, it is believed that health can be protected without unduly revising communication products every time new data are received.

Additional Monitoring

In addition to fish monitoring, hair sampling, in conjunction with a food survey will be available over the next decade. Hair sampling is a reliable way to measure and keep individuals informed of their mercury exposure so they can make informed choices about their fish consumption. While eating fish is the primary source of mercury exposure, an accompanying food survey may provide additional insight into sources of mercury exposure. Timing of sampling will be determined by community input (and upon individual request) in order to capture peak consumption (e.g., late fall / early winter hair sampling). The MHHIG will assess the need to continue hair sampling after fish mercury concentrations have stabilized.

Wildlife and Plant sampling will also occur as outlined in the Terrestrial Effects Monitoring Plan (TEMP), including scheduled collections (plants and aquatic furbearers) and through submission of samples by partner First Nation community members. Mercury concentrations are expected to remain low in plants and wildlife consumed by people; nonetheless, the voluntary submission of samples will assist in confirming predictions outlined in the Project Environmental Impact Statement. In addition to the scheduled monitoring outlined in the TEMP, voluntary samples will be collected for the first 10 years of operations, at which time the need to continue sampling each component will be assessed (see Appendix A for more details).

KEY STEPS

- The MHHIG will be provided a seasonal reminder about the voluntary sampling opportunity and for which plants (blueberries, Labrador tea, northern Labrador tea, and Seneca root) and wildlife (aquatic furbearers, waterfowl, and caribou/moose) samples can be submitted, from where, and the targeted sampling timeframe.
- The Mercury Community Coordinators (or delegate) and/or Manitoba Hydro representative will ensure plant and wildlife sampling protocols and collection kits are available to community members and work with the Project wildlife biologist to coordinate receipt of collected samples.
- The Mercury Community Coordinators (or delegate) and/or Manitoba Hydro representative will provide annual updates on plant and wildlife samples provided by community members for analysis of their mercury concentrations.
- Deliverables:

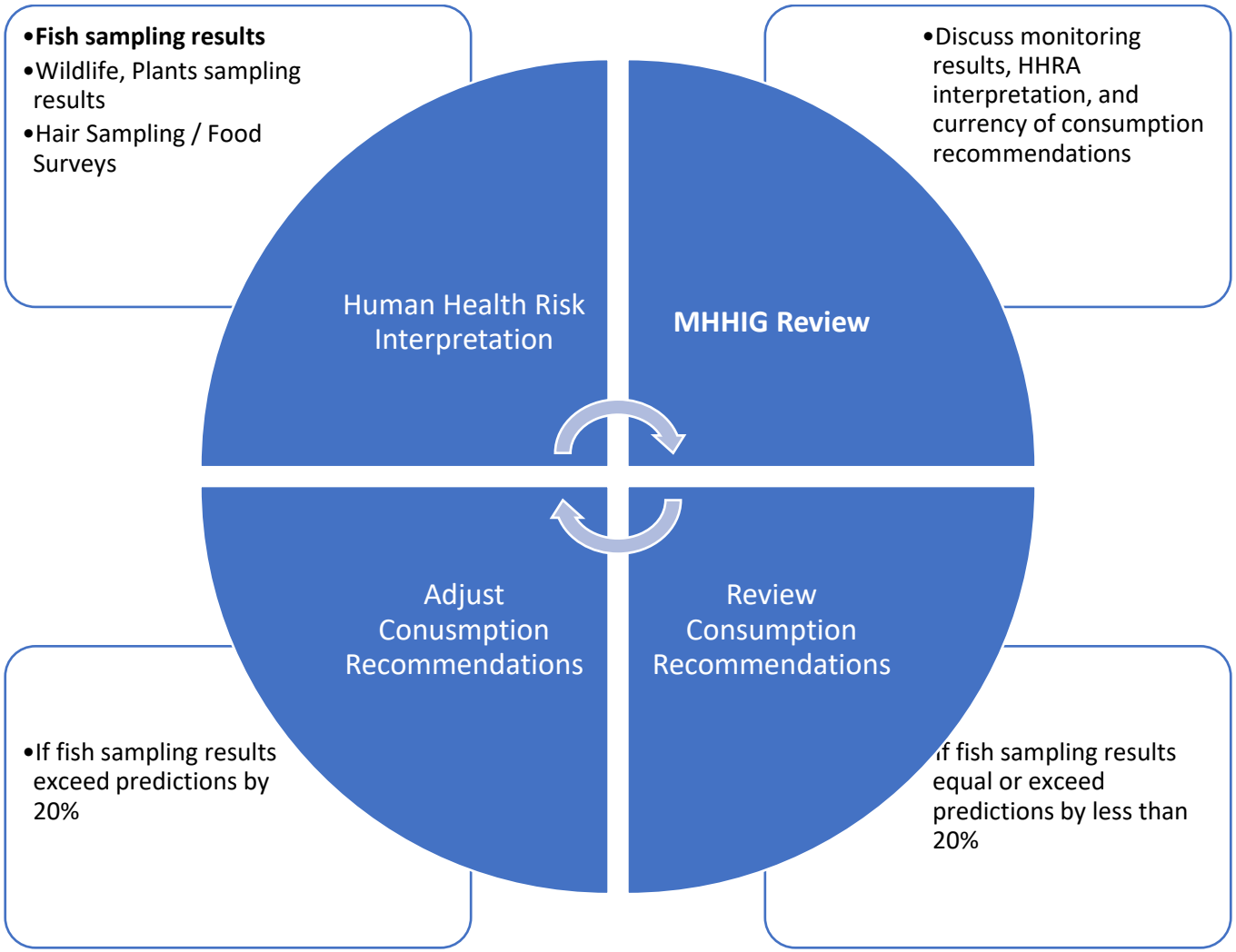
- The Project 'Hair Monitoring' consultant (Golder Associates Ltd.) will provide *confidential, individual results* within 2-6 weeks with opportunity for individualized feedback. *Aggregate results* will be shared with MHHIG (and at community level) as available and will be compiled in annual regulatory report.
- Draft "*Plant and Wildlife Mercury Concentration" memo*(s) outlining plant and wildlife concentrations, pending receipt of voluntary samples, will be prepared by Project biologist (terrestrial) within 60 days of receiving the data.
- The Project toxicologist will prepare an HHRA memo based on review the "*Plant and Wildlife Mercury Concentration*" memo(s) and submit as part of the annual regulatory report.

HIGHLIGHTS OF COMMUNICATION PROCESS

MHHIG and the Province will have the opportunity to review and discuss monitoring results, HHRA interpretation and currency of consumption recommendations prior to finalization of memos or possible communication products adjustments.

Each memo will be prepared in a standalone manner and provide as much context as possible to assist in interpretation of results. Details such as field methods, laboratory data, and quality control will be included.

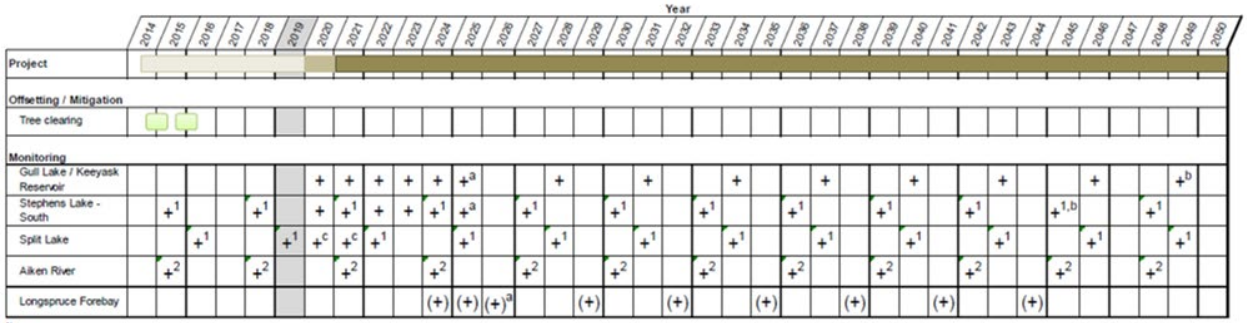
Information	Lead	Timeline / Targets	Purpose
Fish Monitoring Results / Memos for HHRA purposes	Aquatic Team (North South Consultants)	Annually: Preliminary spring results: by late July Preliminary fall results: by December Final results and memo: by March	To assess fish mercury concentrations in Gull, Stephens and Split lakes and Aiken (Landing) River. To assess validity of predicted post-impoundment peak concentrations in Gull and Stephens lakes.
HHRA Memo	Project Toxicologist, Wilson Scientific Consulting Inc.	Annually, upon receipt of available fish, wildlife and plants data. HHRA may reference aggregate hair sampling information.	Interpretation of fish concentrations to assess currency of consumption recommendations. Interim memo to be provided if consumption recommendations adjustments may be warranted after receipt of preliminary fish monitoring analysis.
HHRA (Full)	Project Toxicologist, Wilson Scientific Consulting Inc.	~2026 (after peak conditions have been confirmed to have occurred)	To assess risk to human health from consumption of wild foods harvested from the Project area.
Consumption Recommendations for Gull, Stephens and Split lakes	Project Toxicologist, Wilson Scientific Consulting Inc.	Annual review of data upon receipt (preliminary and final results); review of supplemental sampling data from Stephens Lake (~summer)	Post- Impoundment consumption recommendations for Gull and Stephens lakes reflect predicted peak conditions. Split Lake consumption recommendations reflect current conditions.
Wildlife and Plants Monitoring Results / Memos	Terrestrial Team	Annually (March), subject to monitoring schedule	To assess post-impoundment mercury concentrations in select wildlife and plant species
Hair Sampling Results / Memos	Project Hair Monitoring Consultant, Golder Associates, Ltd.	Individual results reported upon receipt of samples. Aggregate results and memo reported annually, or as available (timing and frequency determined by communities)	To understand mercury exposure in individuals to enhance informed decision making about their fish consumption.
Annual Regulatory Report	ALL	June	Submissions includes all noted reports and/or key highlights


•Fish sampling results
•Wildlife, Plants sampling results
•Hair Sampling / Food Surveys
Human Health Risk Interpretation
•Discuss monitoring results, HHRA interpretation, and currency of consumption recommendations
MHHIG Review
Adjust Conusmption Recommendations
•If fish sampling results exceed predictions by 20%
Review Consumption Recommendations
If fish sampling results equal or exceed predictions by less than 20%

Appendix A

Preliminary Fish, Plants and Wildlife Monitoring Schedules[5]

Fish Monitoring



Notes:
Grey shading indicates the year during which Keeyask reservoir will reach full supply level.
a. Assumed attainment of maximum fish mercury concentrations post-Project.
b. Assumed attainment of pre-Project mercury concentrations or concentrations that are stable at post-impoundment background levels.
c. AEMP monitoring because CAMP has no scheduled monitoring during the first two years post-flooding.
1. Ongoing monitoring carried out under CAMP; note that CAMP monitoring sites for fish mercury are all located in the south basin of the Stephens Lake.
2. Ongoing monitoring carried out due to request by War Lake First Nation and York Factory First Nation.
( ) Assumes that maximum predicted mercury concentrations in fish from Stephens Lake have been exceeded by more than 10%.

Figure 7-1: Planned schedule for mercury in fish flesh monitoring during Keeyask Generating Station construction (2014-2019); commissioning (2020); and operation (2021+). Plus = conduct monitoring activity; heavy line = end of AEMP.

Plants and Wildlife

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	Notes
5. Mercury in Plants and Wildlife Monitoring Studies																											
Plants: Collection of blueberries and Labrador tea leaves to analyze for Hg content in areas near the reservoir and in areas more than 1 km away from the reservoir and any roads. Voluntary sampling program for partner First Nations to submit samples also in place.				+			+						+														
Waterfowl: Voluntary sampling program for partner First Nations to submit waterfowl tissue samples for Hg analysis.	Voluntary submission of samples										+																
Aquatic Furbearers: Trapping program for beaver, muskrat, mink and otter, to collect tissue samples for Hg analysis in areas within 5 km of the Keeyask reservoir and Stephens Lake. Will be working with the RTL 15 trapline holder to collect samples.		+	+	+	+	+	+	+[a]			+			+			+	Results to date will be reviewed to determine if continued sampling frequency (every 3 years) is appropriate, or if it needs to be adjusted.								+	
Caribou and Moose: Voluntary sampling program for partner First Nations to submit caribou or moose tissue samples for Hg analysis.	Voluntary submission of samples										+																

[5] Schedule is provided to represent general timeline. Actual sampling years may deviate slightly due to delayed impoundment, which occurred in 2020. Graph does not show additional Gull Lake sampling (2014, 2016) or supplemental annual sampling in Stephens Lake.

Appendix B

Predicted peak fish concentrations (average, standardized length) presented in Keeyask Environmental Impact Statement, 2012 and North/South (2021).

Stephens Lake Fish

- Stephens Lake whitefish, standardized size of 350 mm: 0.15 µg/g (wet weight)
- Stephens Lake pickerel, standardized size of 400 mm: 0.5 µg/g (wet weight)
- Stephens Lake jackfish, standardized size of 550 mm: 0.5 µg/g (wet weight)

Gull Lake Fish

- Gull Lake whitefish, standardized size of 350 mm: 0.19 µg/g (wet weight)
- Gull Lake pickerel, standardized size of 400 mm: 1.0 µg/g (wet weight)
- Gull Lake jackfish, standardized size of 550 mm: 1.0 µg/g (wet weight)

20% Change Threshold based on predicted peak fish mercury concentrations. An exceedance of the values below would prompt revisions to post-impoundment fish consumption recommendations, prepared in 2021, subject to MHHIG and provincial health regulator input.

Stephens Lake Fish

- Stephens Lake whitefish, standardized size of 350 mm: 0.18 µg/g (wet weight)
- Stephens Lake pickerel, standardized size of 400 mm: 0.60 µg/g (wet weight)
- Stephens Lake jackfish, standardized size of 550 mm: 0.60 µg/g (wet weight)

Gull Lake Fish

- Gull Lake whitefish, standardized size of 350 mm: 0.23 µg/g (wet weight)
- Gull Lake pickerel, standardized size of 400 mm: 1.2 µg/g (wet weight)
- Gull Lake jackfish, standardized size of 550 mm: 1.2 µg/g (wet weight)