# LAKE MANITOBA
# LAKE ST. MARTIN

## OUTLET CHANNELS PROJECT

**MANITOBA TRANSPORTATION AND INFRASTRUCTURE**

# Aquatic Effects Monitoring Plan

June 30, 2022

Manitoba
Transportation and Infrastructure

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# DISCLAIMER

This document was developed to support the Environmental Management Program (EMP) for the Lake Manitoba and Lake St. Martin Outlet Channels Project (the Project). It has been prepared by Manitoba Transportation and Infrastructure as a way to share information and facilitate discussions with Indigenous rights-holders, stakeholders and the public. It has been prepared using existing environmental and engineering information and professional judgement, as well as information from previous and ongoing public and Indigenous engagement and consultation. The contents of this document are based on conditions and information existing at the time the document was prepared and do not take into account any subsequent changes. The information, data, recommendations, and conclusions in this report are subject to change as the information has been presented as draft. This draft plan should be read as a whole, in consideration of the entire EMP, and sections or parts should not be read out of context.

Revisions to draft plans have been informed by and will be based on information received from the engagement and consultation process, the Environmental Assessment process, Project planning activities, and on conditions of provincial and federal environmental regulatory approvals received for the Project. As these will be living documents, any changes to the plans that occur after Project approvals are received will be shared with regulators, Indigenous rights-holders and stakeholders prior to implementation of the change. Either a revision number or subsequent amendment would be added to the specific environmental management plan to communicate the revision or change.

# PREFACE

The Lake Manitoba and Lake St. Martin Permanent Outlet Channels Project (the Project) is proposed as a permanent flood control mitigation for Lake Manitoba and Lake St. Martin to alleviate flooding in the Lake St. Martin region of Manitoba. It will involve the construction and operation of two new diversion channels: the Lake Manitoba Outlet Channel (LMOC) will connect Lake Manitoba to Lake St. Martin and the Lake St. Martin Outlet Channel (LSMOC) will connect Lake St. Martin to Lake Winnipeg. Associated with these outlet channels are the development of bridges, control structures with power connections, a new realignment of Provincial Road (PR) 239, and other ancillary infrastructure.

Manitoba Transportation and Infrastructure is the proponent for the proposed Project. After receipt of the required regulatory approvals, Manitoba Transportation and Infrastructure will develop, manage and operate the Project. This Aquatics Effects Monitoring Plan (AEMP) is one component of the overall Environmental Management Program (EMP) framework, which describes the environmental management processes that will be followed during the construction and operation phases of the Project. The intent of the EMP is to facilitate the timely and effective implementation of the environmental protection measures committed to in the Project Environmental Impact Statement (EIS), the requirements and conditions of the provincial licence issued under *The Environment Act*, the federal Decision Statement issued under the *Canadian Environmental Act 2012*, and other approvals received for the Project. This includes the verification that environmental commitments are implemented, monitored, evaluated for effectiveness, and adjustments made if/as required. It includes a commitment that information is reported back in a timely manner for adjustment, if required.

A key component for the success of the EMP is environmental monitoring, such that environmental management measures are inspected and modified for compliance with environmental and regulatory requirements, including those set out in provincial and federal approvals received for the Project. As indicated, monitoring results will be reviewed and used to verify predicted environmental assessment conclusions and effectiveness of mitigation measures. If unanticipated effects occur, or if mitigation measures are inadequate, adaptive management measures and subsequent monitoring will be applied as described further in individual environmental management and monitoring plans.

Monitoring results and application of adaptive management measures will inform follow-up reporting to regulators and any required revisions to environmental management plans. Manitoba Transportation and Infrastructure has initiated discussions with rights-holders and the Rural Municipality (RM) of Grahamdale in the Project area on the establishment of an Environmental Advisory Committee (EAC). The EAC would be a platform for sharing monitoring results and discussing issues of concern. In addition, Manitoba Transportation and Infrastructure anticipates that the EAC will coordinate Indigenous Environmental Monitors and communications during the construction period and will be working with rights-holders and stakeholders on its structure and purpose.

Manitoba Transportation and Infrastructure remains committed to consultation and ongoing engagement with Indigenous rights-holders and stakeholders that are potentially impacted by the Project. Detailed EMP review discussions were incorporated into Indigenous group-specific consultation work plans. Engagement opportunities included virtual open house events, sharing draft environmental management and monitoring plans, sharing plan-specific questionnaires, and meetings to discuss related questions and recommendations. The intent has been to offer multiple avenues to share information about the Project so that rights-holders and stakeholders would be informed and could provide meaningful input into Project planning. The original draft EMP plans and questionnaires that were posted on the Project website for public review and comment are being replaced by the second draft of each plan as it becomes available. Feedback and recommendations received were used to update the current version of the draft plans, which are posted to the Project website at: https://www.gov.mb.ca/mit/wms/lmblsmoutlets/environmental/index.html.

Figure A displays a summary of the EMP process. The EMP provides the overarching framework for the Project Construction Environmental Management Program (CEMP) and the Operation Environmental Management Program (OEMP). These will be updated prior to Project construction and operation, respectively, and will consider applicable conditions of *The Environmental Act* provincial licence, *Canadian Environmental Assessment Act 2012* federal Decision Statement conditions and other approvals, any other pertinent findings through the design and regulatory review processes, and key relevant outcomes of the ongoing Indigenous consultation and public engagement processes. Until such time, these plans will remain in draft form.

The purpose of the CEMP and OEMP is to guide how environmental issues will be addressed during construction and operation, respectively, and how adverse effects of activities will be mitigated. The CEMP is supported by several specific or targeted management plans that will guide Manitoba Transportation and Infrastructure's development of the Project's contract documents and subsequently, the Contractor(s) activities, in an environmentally responsible manner and to meet regulatory compliance in constructing the Project. The OEMP will include some of the same targeted plans developed to manage issues during construction, but prior to construction completion, they would be revised and adapted to suit the specific needs during the operation phase.


Figure A: EMP Process

# LIST OF ACRONYMS AND GLOSSARY OF TERMS

## Acronyms

| | |
|---|---|
| AEMP | Aquatic Effects Monitoring Plan |
| CAMP | Coordinated Aquatic Monitoring Program |
| CEMP | Construction Environmental Management Program |
| CPUE | Catch per Unit Effort |
| DFO | Fisheries and Oceans Canada (formerly Department of Fisheries and Oceans) |
| DO | Dissolved Oxygen |
| ECCC | Environment and Climate Change Canada |
| EIS | Environmental Impact Statement |
| EOC | Emergency Outlet Channel |
| EPP | Environmental Protection Plan |
| FOMP | Fish Offsetting and Mitigation Plan |
| FRCN | Fisher River Cree Nation |
| FRWCS | Fairford River Water Control Structure |
| GWMP | Groundwater Management Plan |
| km | kilometre |
| LAA | Local Assessment Area |
| LMOC | Lake Manitoba Outlet Channel |
| LSMOC | Lake St. Martin Outlet Channel |
| OEMP | Operation Environmental Management Program |
| PAL | Protection of Aquatic Life (in reference to water quality standards, objectives and guidelines) |
| PDA | Project Development Area |
| POC | Permanent Outlet Channels (refers to both the LMOC and the LSMOC) |
| PR | Provincial Road |
| the Project | the Lake Manitoba and Lake St. Martin Outlet Channel Project |
| RM | Rural Municipality |

| | |
|---|---|
| SMP | Sediment Management Plan |
| SWMP | Surface Water Management Plan |
| TSS | Total Suspended Solids |
| WCS | Water Control Structure |
| WetMP | Wetland Monitoring Plan |

## Glossary of Terms

**Aquatic habitat:** The living and non-living components of a lake, river, wetland or other waters upon which aquatic life depends.

**Aquatic life:** Organisms temporarily or permanently living or found in water.

**Aquatic vegetation:** Submerged, floating-leaved and floating plants that only grow on or beneath the water surface. Submerged plants may be rooted in soils or free-floating.

**Baseline:** Initial environmental conditions, prior to effects of the Project.

**Construction Environmental Management Program:** Manitoba Transportation and Infrastructure's program to protect the environment during the construction of the POC.

**Contractor:** refers to the individuals, entities or groups contracted by Manitoba Transportation and Infrastructure to undertake specific Project construction, operation or maintenance activities, and includes all subcontractors and affiliates.

**Commissioning:** After construction is complete, the Water Control Structures will be opened to allow water to enter the POCs and flow mitigation will be tested to determine if the POCs are functioning as planned.

**Coordinated Aquatic Monitoring Program:** An aquatic monitoring program being conducted at over 40 waterbodies in Manitoba conducted jointly by Manitoba and Manitoba Hydro.

**Discharge:** Rate of outflow; volume of water flowing down a river, from a lake outlet, or man-made structure.

**Dissolved oxygen:** Oxygen molecules ($O_2$) dissolved in water.

**Environmental Monitor:** refers to the individuals, groups or designated representatives engaged by Manitoba Transportation and Infrastructure to monitor, inspect, and document compliance with contractual and regulatory requirements associated with the construction activities and associated works for the Project. The monitor may also be an active member (or representative) of the Project's Environmental Advisory Committee.

**Fisheries Act authorization:** Under the federal Fisheries Act, if a Project is likely to cause the death of fish or the harmful alteration, disruption or destruction of fish habitat, then an authorization from the Minister of Fisheries, Oceans and the Canadian Coast Guard must be obtained.

**Groundwater:** Water that occurs beneath the land surface and fills the pore spaces of soil or rock below saturated zone.

**Offsetting**: Measures such as habitat enhancement and restoration are required by DFO to provide additional fish production to replace the loss in production from natural habitats as a result of the construction of the Project.

**Operational Period**: Time after commissioning. The Water Control Structures may be open when water is being diverted through the POCs for flood management, or closed, when water is not being diverted for flood management. These two conditions are referred to as “operation” or “operating” and “non-operation” or “not operating”.

**Project Environmental Requirements:** Measures to protect the environment included in contract documents.

**Runoff:** Surface water that flows overland and into streams, wetlands or waterbodies, or into drainage systems.

**Stranding:** Trapping fish such that death is imminent (on land or in an isolated area of water).

**Suspended sediment:** Particulate matter that is held in the water column due to movement of the water.

**Turbidity:** A measure of the relative clarity of water.

**Water Control Structure (WCS)**: structures on the POCs that control whether and the amount of flow passing down the channels.

# 1.0 INTRODUCTION

## 1.1 Purpose and Scope

The Lake Manitoba and Lake St. Martin Outlet Channels Project Environmental Impact Statement (Project EIS) was submitted by Manitoba Transportation and Infrastructure in March 2020. The Project will require an authorization under the federal *Fisheries Act*, and to meet the requirements of the authorization, an offsetting plan to address losses to fish habitat that cannot be avoided or mitigated has been developed. This plan is presented in the Lake Manitoba Lake St. Martin Outlet Project Fish Offsetting and Mitigation Plan (FOMP).

The Project EIS provided an overview of planned monitoring; this Aquatic Effects Monitoring Plan (AEMP) provides a detailed description of monitoring that will be conducted during and after the Lake Manitoba and Lake St. Martin Outlet Channel Project (the Project) is commissioned. Results of monitoring will be used to determine whether unanticipated effects are occurring and whether modifications to planned mitigation measures are required. This plan also addresses anticipated requirements for monitoring that will be set out in provincial and federal licenses and permits for the Project; the final draft of this plan will be amended after final regulatory approvals are received to incorporate any additional monitoring requirements.

This AEMP does not include monitoring related to the management of the effects of construction activities; these are described within specific components of the Construction Environmental Management Program (CEMP). This AEMP also does not include monitoring specific to offsetting works that will be specified under the *Fisheries Act* authorization for this Project; monitoring for offsetting is described in the offsetting plan but methods will be consistent with those set out in this AEMP.

This AEMP has benefited from input received during the environmental review process from rights-holders, stakeholders, and regulators, and the final draft will be further amended to reflect results of on-going discussions. In addition, this plan has been revised after the initial draft issued in 2020, taking into consideration results from modelling and other physical environment studies conducted after completion of the Project EIS, as well as the on-going supplementary studies of the aquatic environment.

It should be noted that several other environmental management plans developed for the Project deal with water management, including a Surface Water Management Plan (SWMP), Groundwater Management Plan (GWMP), Wetland Monitoring Plan (WetMP), and a Sediment Management Plan (SMP).

## 1.2 Objectives

The specific objectives of this AEMP are to:

- Verify the anticipated effects to water quality and fish and fish habitat based on the environmental assessment completed for the Project;
- Determine the effectiveness of mitigation measures;
- Assess the need for additional mitigation measures if initial measures are not adequate;
- Determine the effectiveness of any additional/adapted measure(s); and
- Confirm compliance with regulatory requirements relevant to surface water quality and fish and fish habitat set out in the Project approvals (e.g., *Canadian Environmental Assessment Act 2012* approvals, *The Environment Act* provincial license; *Fisheries Act*).

# 2.0 OVERALL APPROACH

Monitoring activities described in this AEMP were identified based on an understanding of the existing environment and the anticipated changes that will occur because of the Project. As a flood mitigation project, changes to surface water flow are the primary drivers of environmental change. Water flows from Lake Manitoba via the Fairford River to Lake St. Martin, which drains via the Dauphin River to Sturgeon Bay on Lake Winnipeg (Appendix 1, Figure 1-1). The Fairford River Water Control Structure (FRWCS) is used to maintain suitable levels on Lake Manitoba upstream of the dam. Until 2011, the control structure was effective in managing Lake Manitoba levels within the desirable range; however, the 2011 flood resulted in extensive flooding on Lake Manitoba, Lake St. Martin, and the Dauphin River.

The Lake St. Martin Emergency Outlet Channel (EOC) was constructed from Lake St. Martin to the Dauphin River, via the Buffalo Creek system, to reduce flooding and was operated in both 2011 and 2014. The proposed Project will provide permanent flood mitigation channels. The route differs from the EOC in that there are two separate channels, one routed from Lake Manitoba to Lake St. Martin and a second from Lake St. Martin to Lake Winnipeg without entering the Dauphin River (Appendix 1, Figure 1-1). The two outlet channels (POCs) are intended to work together:

- The 24 kilometre (km) Lake Manitoba Outlet Channel (LMOC) will work in tandem with the existing FRWCS to help regulate water levels and mitigate flooding on Lake Manitoba; and
- The 24 km Lake St. Martin Outlet Channel (LSMOC) will restore a more natural water regime to Lake St. Martin and will also provide flood protection by mitigating increased inflows from operation of the FRWCS, as well as additional inflows from the planned outlet from Lake Manitoba.

During diversion of flow through the POCs, new pathways by which fish may move from upstream to downstream lakes will be created, as well as changes in habitat that may attract spawning fish, particularly at the channel outlets. When not in operation, a small baseflow will be provided to maintain dissolved oxygen (DO) levels at a level sufficient to support fish that may remain in the channels during periods of non-operation [1].

Operation of the POCs will substantially reduce the magnitude of flood flow in the Fairford and Dauphin rivers, but will also result in smaller reductions in median flows. However, flows in the rivers will continue to exhibit typical seasonal variation and will remain within historical ranges (KGS 2021a). Construction of the LMOC will divert flow from a portion of the Birch Creek watershed and result in a permanent reduction in creek discharge. Similarly, the construction of the LSMOC will divert a portion of flow in the Buffalo Creek watershed, permanently reducing discharge in the creek. It is currently proposed that flow reduction in the

[1] During periods of drought, (i.e., close to the 10th percentile) the baseflow in the LSMOC would be reduced to provide more water to the Dauphin River. Baseflow within LSMOC would be maintained at a level that would maintain sufficient DO in the channel to prevent fish kills.

lower portion of Birch Creek will be mitigated by the diversion of water from the LMOC during the open water season when the channel is not in operation. Similarly, it is proposed that water from the LSMOC will be provided to wetlands downstream of the channel during dry periods to help maintain wetland function. It is possible that some of the flow provided to the wetlands may eventually filter to Buffalo Creek augmenting flows during dry periods, though the potential magnitude of the effect cannot be estimated. Flow reductions in Buffalo Creek may be partially mitigated by the input of additional water into upstream wetlands during periods when the LSMOC is operated for flood control. Resultant effects to flow in Buffalo Creek, if any, would be detected during wetland monitoring that will be conducted by Manitoba Infrastructure and Transportation. For the purposes of this AEMP, effects to flow in Buffalo Creek due to water inputs to upstream wetlands are considered negligible.

Specific monitoring plans have been developed for the following aquatic components:

- surface water quality and sediment quality[2] (Section 3.0);
- aquatic habitat, including the newly wetted habitat in the POCs and representative shoals in Lake St. Martin, Sturgeon Bay and Lake Winnipeg to confirm that no unanticipated sedimentation occurs (Section 4.0);
- fish, which are addressed in studies focused on the fish community (Section 5.0), spawning including spawning migrations (Section 6.0), and use of newly created habitat in the POCs (Section 7.0); and
- mercury in fish flesh (Section 8.0).

For each aquatic component, a rationale for the proposed monitoring activity is provided based on potential effects identified during the environmental assessment, as well as from input received during the environmental review process from rights holders, stakeholders, and regulators, and ongoing modeling to better define environmental effects. Monitoring is described in terms of individual studies, and for certain effects, several studies will contribute to assessing a particular effect. Where appropriate, management thresholds are established against which post-Project conditions can be compared to determine whether follow-up actions are required. Monitoring study design is described in terms of the frequency of monitoring, field and laboratory methods, parameters to be measured, and data analysis. An overall schedule and description of reporting is provided in Section 9.0.

[2] Sediment quality will only be monitored if TSS sampling indicates the mobilization of large amounts of sediments.

## 2.1 Monitoring Phases

For the purposes of the monitoring program, Project phases have been divided into supplemental data collection prior to commissioning, monitoring during channel commissioning, and monitoring conducted during the operational phase (Appendix 2, Table 2-1).

The operational phase consists of three functional states:

1. when the WCSs are open and water is being diverted, referred to as channel operation. It is anticipated that the WCSs would typically be opened in spring or early summer and closed later in summer or fall prior to freeze-up. In the case of severe floods, when the channels cannot be closed before freeze-up, they would be operated all winter, perhaps at a reduced flow rate, until the following spring or summer, depending on water levels;
2. in the immediate period following WCS closure, which is referred to as post-operation of the channels. The duration of this period is dependent on the timing of channel operation but would be extended to include hatch of any fish eggs that were laid during channel operation; and
3. when the WCSs are closed beyond the post-operation period defined above. This is referred to as non-operation. During this phase, a baseflow will be pass through both channels [3].

Supplemental data studies are being conducted prior to channel commissioning where Manitoba Transportation and Infrastructure has determined through internal review and input from rights holders, stakeholders, public and regulators that additional data are needed. These additional data are required to provide the basis for pre/post-Project comparisons in the AEMP studies (Appendix 2, Table 2-2).

Monitoring of effects described in this AEMP will begin during commissioning of the POCs, which is expected to be completed prior to the start of the fall spawning window identified by DFO (September 15). Post-commissioning monitoring will continue in the subsequent winter and following open water season to confirm that conditions during non-operation are suitable to support any fish that enter the channels.

Due to the unpredictable requirement for operation of the channels for flood mitigation, it is not possible to schedule future monitoring by year. Therefore, operation studies were assigned based on channel usage, as defined in Appendix 2, Table 2-1. An operational event will trigger monitoring that will include studies when the WCSs are open and may continue for up to a year after they are closed, depending on the period during which the WCSs were open and the study. For example, if the POCs are operational during the spring spawning period, then spring spawning fish and larval drift studies will be conducted concurrent with operation. If operation continues into the fall, lake whitefish spawning period, then fall surveys of fish migration in the Dauphin and Fairford rivers and larval drift studies the following spring would be conducted. The duration of post-WCS closure study is defined for each study in the following sections. This AEMP also describes monitoring that will occur in the POCs after they have not been operated for three years to confirm

[3] During periods of drought, (i.e., close to the 10th percentile) the baseflow in the LSMOC would be reduced to provide more water to the Dauphin River. Baseflow within LSMOC would be maintained at a level that would maintain sufficient DO in the channel to prevent fish kills.

that conditions are suitable to support fish that may remain within the channels. The three year period is based on the anticipated time that inputs of leaf litter and other organic matter from the adjoining watershed may be sufficient to accumulate on the substrate and thus affect suitability as fish habitat; this duration may be modified based on results of post-commissioning studies.

Monitoring is proposed to be repeated for at least two periods when the channels are operated for flood mitigation, after the channels have been commissioned. It is anticipated that operation will occur on average once every three years, though given that wet periods typically occur for multiple years, this may result in operation for several consecutive years followed by no operation for several years. Monitoring will need to include typical channel operation conditions (i.e., lower magnitude floods where the POCs are operated for less than 6 months) and more extreme conditions (i.e., high magnitude flood where operation of the POCs are operated for more than 6 months). Monitoring during periods of non-operation will be repeated at approximately three year intervals until the channels are operated again and until it is demonstrated that the suitability of aquatic habitat in the channels does not decline during periods of non-operation. If after 10 years of non-operation conditions in the POCs are still suitable to support fish, then further monitoring during non-operation will be suspended.

After the second round of operational monitoring, Manitoba Transportation and Infrastructure will review results to date and determine future monitoring plans for both periods of operation and non-operation. A description of reporting with respect to study results is provided in Section 9.0.

## 2.2 Study Area

The study area for the AEMP overlaps with the Project Development Area (PDA) and Local Assessment Area (LAA) as defined for the Surface Water and Fish and Fish Habitat Assessments in the Project EIS. The study area (Appendix 1, Figure 1-1) includes:

- the channels (LMOC and LSMOC);
- excavated inlets and outlets at both channels;
- Watchorn Bay on Lake Manitoba;
- Sturgeon Bay on Lake Winnipeg;
- the Fairford River;
- the Dauphin River;
- Lake St. Martin;
- Birch Creek downstream of Reed Lake; and
- Buffalo Creek and Big Buffalo Lake.

The rationale and maps showing the specific sampling locations for each of the monitoring studies described in this AEMP are provided with each of the study descriptions. In response to concerns raised by Fisher River Cree Nation and other First Nations, a targeted aquatic habitat study will be conducted at selected locations near McBeth Point and Reindeer Island in Lake Winnipeg outside of Sturgeon Bay. This study is described in Section 4.5.

The spatial extent of the study area is sufficient to document Project-related effects. If effects are of greater magnitude than anticipated, the spatial extent of monitoring would be modified to document unanticipated changes if there is a risk that effects extend beyond the monitoring area. For example, marked changes to water quality as a result of POC operation are not anticipated. However, if monitoring sites at the mouth of the Dauphin River, at the outlet of the LSMOC and in Sturgeon Bay indicate marked changes from upstream sites in the Fairford River and Watchorn Bay that could be linked to operations of the POCs, then sampling would be extended to sites near the mouth of Sturgeon Bay and into Lake Winnipeg.

## 2.3 Adaptive Management

Manitoba Transportation and Infrastructure will use an adaptive management approach to determine whether monitoring study results indicate the need for a change in monitoring activities or mitigation measures. Manitoba Transportation and Infrastructure will retain an environmental consultant experienced in the conduct of monitoring studies described in this AEMP as well as in the analysis and interpretation of biological data, with emphasis on water quality, lake whitefish, walleye and sucker species. These components were selected as being of particular interest due to concerns raised during Project review with respect to effects to water quality within the study area and beyond, and the importance of these fish species to domestic, commercial, and recreational fisheries. Monitoring to address potential effects to these species also addresses other aquatic biota, given that studies provide information on aquatic habitat and the fish community as a whole. If analysis by the environmental consultant indicates that a benchmark indicating adverse effects of concern has been exceeded, then Manitoba Transportation and Infrastructure and their consultants will undertake a review to examine the potential for linkages to the Project and the need for changes to mitigation measures. It is anticipated that this review will be conducted in consultation with regulators. Manitoba Transportation and Infrastructure will also discuss results with directly affected rights-holders and the RM of Grahamdale and use input on observed changes shared by resource users and other rights-holders to inform the review and decision making. Modification of mitigation measures will be implemented if and as required, and subsequent monitoring will indicate whether the modified mitigation successfully addressed the environmental issue or whether further changes are required.

A two-staged approach is being used for adaptive management based on the development of two benchmarks: an early warning trigger, typically defined as a statistically significant change from baseline conditions as described for each environmental component; and a management threshold, the level of an indicator when the magnitude of an adverse effect attributed to the Project is sufficient that it may result in long term adverse effects to water quality and/or a key fish species (i.e., lake whitefish, walleye, and sucker where sucker support a fishery [4]). The early warning trigger is intended to highlight that a change has occurred. Detection of a statistically significant change from baseline conditions may indicate the need to modify the monitoring program to acquire additional information, and subsequent evaluation of potential causes of the change to determine whether it is related to the Project. Management thresholds indicate that

[4] Monitoring and mitigation measures are focussed on these key species but measures to protect these species will also protect other species and components of the aquatic ecosystem.

additional mitigation or management actions may need to be undertaken. Benchmarks are described for specific environmental components in the following sections of this AEMP. In most instances, collection and analysis of supplemental data is required before the numerical value of the benchmark can be calculated but the data that will be used to calculate benchmarks are described.

Results of monitoring will be reviewed after each field program to determine the answers to relevant key questions as described in this AEMP. Key questions will be addressed in consideration of:

- Is there a statistically significant difference from pre-Project conditions, i.e., has an early warning trigger been passed?
- Is the nature of the pre/post-Project difference sufficient to exceed a management threshold, i.e., is there a need to review and potentially modify mitigation measures?
- What is the monitoring result in comparison to anticipated effects based on the environmental assessment?

Where it is determined that further assessment is required, the following questions will be considered:

- Are further investigations required to determine if the effect is related to the Project? Are modifications to the monitoring plan required?
- What are the potential implications to the aquatic ecosystem, in particular species valued in a fishery (i.e., lake whitefish, walleye, and sucker)?
- Has a management threshold been reached and is additional mitigation required?
- If additional mitigation is required, what are potential methods and how could they be applied?
- What monitoring is required to determine whether the new mitigation measures are functioning as intended?

Where monitoring results show environmental changes that are not attributed to the Project, this information will be provided to Manitoba Environment, Climate, and Parks or other appropriate regulators. It should be noted that some changes (e.g., detection of invasive species) will be reported immediately as a condition of scientific collection permits required to conduct monitoring.

# 3.0 SURFACE WATER QUALITY

## 3.1 Rationale

Water quality is a key component of the aquatic environment and is critical for the maintenance of aquatic ecosystem health and, due to its importance to aquatic ecosystems, is required as part of effects monitoring. Monitoring of surface water quality will determine whether effects are as anticipated based on the environmental assessment as follows:

- The potential effect of changes in flow patterns due to operation of the channels, while not expected to affect water quality, has been raised as a concern during the environmental review process and will be considered.
- Temporary increases in suspended sediment may occur in some areas during channel operation as a result of changes in flow patterns. Armoring of channels and routine inspections and maintenance of erosion prone areas is expected to prevent erosion in the channels themselves.
- Depleted concentrations of DO in the POCs during periods of non-operation under ice cover is a concern, but it is expected that the provision of baseflow through the channels as a mitigation measure will prevent declines to critically low concentrations. Monitoring has been designed to confirm that baseflows are sufficient.

Surface water quality monitoring to address Project effects related to these linkages includes the following components:

- A surface water quality monitoring study at key locations throughout the study area to document spatial changes during channel operation.
- A study to monitor DO concentrations in the LMOC and LSMOC.
- A study to document spatial and temporal changes in total suspended solids (TSS) during channel operations to document sediment transport.

Sampling related to the management of construction-related effects (e.g., sampling of TSS conducted as part of the Surface Water Management Plan) is conducted under the Construction Environmental Management Program (CEMP).

## 3.2 Approach

### 3.2.1 Key Questions and Study Overview

Monitoring studies have been designed to address the following key questions with respect to water quality:

- Does water quality change as a result of operation of the POCs?
- Does DO in the POCs decline to critically low levels during periods of non-operation, in particular during late winter?
- Does the concentration of TSS during POC commissioning and operation reach concentrations that could be harmful to aquatic life?
- What are the estimated sediment loads being transported in the channels compared to the Dauphin and Fairford rivers?

Three studies will be conducted to monitor effects to water quality:

- Water quality survey during POC operation and for a sampling event post operation as described in Section 3.3.
- DO monitoring in POCs during non-operation as described in Section 3.4.
- TSS concentrations will be monitored during and for a period post operation as described in Section 3.5. TSS monitoring will be conducted to monitor sediment mobilization and transport during operation of the channels.

### 3.2.2 Baseline Information

Baseline data for the surface water quality program includes:

- data collected as part of EOC monitoring program (2011-2015; NSC and KGS 2016), primarily in the north basin of Lake St. Martin, in the Dauphin and Fairford rivers, and Sturgeon Bay;
- data collected as part of POC baseline studies, in particular on Watchorn Bay, Birch Bay on Lake St. Martin and Birch Creek (AAE Tech Services 2016);
- data collected by the Province of Manitoba (historic to present) at one location each on the Dauphin and Fairford rivers; and
- supplemental data collected at AEMP sites, fall 2020 - fall 2021 to provide a comparable record at all sites (NSC 2021a, 2022a); and

Additional pre-commissioning data will be collected as necessary and in consideration of the on-going environmental review process. It is currently planned to repeat sampling at the AEMP sites so that there are a minimum of three years of data for all sites.

### 3.2.3 Identification of Benchmarks

The environmental assessment concluded that the Project would not cause changes in water quality in the study area as a whole, but that there would be localized effects to concentrations of TSS during POC commissioning, and to DO within the POCs during winter under baseflow conditions.

The benchmarks in relation to each of the key questions are as follows:

- Does water quality change as a result of operation of the POCs?

  The early warning trigger identified for surface water quality parameters is a change from background conditions, defined as the pre-Project baseline for lakes and rivers, and the upstream lakes for the POCs. If a change is detected, comparisons would be made to upstream water quality to determine whether the change is due to incoming water or conditions within the study area. The biological significance of the change would be determined by comparing to guidelines for the Protection of Aquatic Life (PAL)[5] .

Management thresholds are provided for TSS and DO below. If an unanticipated increase occurs in water quality parameters besides TSS and DO, then the potential cause and biological effect would need to be investigated.

- Does DO in the POCs decline to critically low levels during periods of non-operation, in particular during late winter?

  The early warning trigger is a change for background conditions recorded during winter in upstream lakes. The management threshold will be a decline to critically low concentrations (i.e., <3 mg/L).

- Does the concentration of TSS during POC commissioning and operation reach concentrations that could be harmful to aquatic life?

  The early warning trigger is a change in background conditions from baseline in the receiving environment (i.e., Birch Bay and Sturgeon Bay). The management threshold is an increase above a daily average of 25 mg/L relative to reference locations in the nearshore of Birch Bay and Sturgeon Bay that are not affected by the plume from the POCs.

There is no benchmark for the final key question addressed by the water quality studies.

- What are the estimated sediment loads being transported in the channels compared to the Dauphin and Fairford rivers?

[5] PAL based on Manitoba and Canada guidelines:

Manitoba Water Stewardship (MWS). 2011. Manitoba Water Quality Standards, Objectives, and Guidelines. Manitoba Water Stewardship Report 2011-01. July 4, 2011. 68 pp.

Canadian Council of Ministers of the Environment (CCME). 1999 (Updated to 2020). Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg.

The information gathered by this study will be used in conjunction with the sediment deposition monitoring as described in Section 4.4.

## 3.3 Surface Water Quality Monitoring

### 3.3.1 Purpose

Monitoring will be conducted to determine whether water quality conditions change due to channel operations, specifically whether the change in flow patterns affects water quality. The reduction in flow in Birch and Buffalo creeks will not be linked to operation of the channels but monitoring will be conducted concurrently for greater efficiency.

This study will address the following key question:

- Does water quality as represented by a suite of parameters change as a result of operation of the POCs?

### 3.3.2 Timing

Water quality monitoring will be conducted during POC commissioning, and immediately prior to, during, and following POC operation for flood mitigation as described in Section 2.1.

Samples will be collected during four sampling sessions in each monitoring year to capture seasonal variability (i.e., once in spring, summer, fall, and winter).

### 3.3.3 Field and Laboratory Methods

Sampling sites for the water quality monitoring program will be similar to those sampled during baseline studies. Sampling sites will be located at the following locations (Appendix 1, Figure 1-2):

- Two sites in Lake Manitoba in Watchorn Bay (offshore of the proposed LMOC and nearshore at the proposed LMOC);
- Two sites in Birch Creek (at Provincial Road [PR] 239 and near the outlet at Lake St. Martin);
- Two sites in the Fairford River (at highway 6 and near the outlet at Lake St. Martin);
- One site in the LMOC near Lake St Martin;
- Five sites in Lake St. Martin (Birch Bay, middle of the south basin, at the Narrows, middle of the north basin, and the eastern bay near the proposed inlet to the LSMOC);
- Three sites in the Dauphin River (at Lake St. Martin, near the provincial monitoring station at the “Big Bend”, and at Sturgeon Bay);
- One site in Big Buffalo Lake;
- One site in Buffalo Creek at the Dauphin River;
- One site in the LSMOC near Sturgeon Bay; and
- Two sites in Lake Winnipeg in Sturgeon Bay (nearshore at the proposed outlet of the LSMOC and offshore of the proposed LSMOC).

### 3.3.4 Parameters

*In situ* parameters will include temperature, pH, DO, turbidity and conductivity and Secchi disk depth (lake sites). Laboratory analyses will include a suite of physical parameters, nutrients, and metals (including mercury) and major ions. These are listed in Appendix 2, Table 2-3. Additional parameters including, pesticides, hydrocarbons, cyanobacteria cell counts, microcystin, and *Escherichia coli* will be included during the summer sampling season when concentrations are expected to be the highest. Samples will be collected at sampling stations on the upper Fairford and Dauphin Rivers and at Birch Creek at its confluence with Lake St. Martin to provide a measure of background conditions when the channels are not in operation. When the channels are in operation, samples will also be collected at the outlets of the LMOC and LSMOC. Hydrocarbon and pesticide parameters are listed in Appendix 2, Table 2-4.

### 3.3.5 Data Analysis

Analyses will focus on key indicators and include pre/post Project comparisons and comparison to guidelines.

## 3.4 Dissolved Oxygen Monitoring in the POCs

### 3.4.1 Purpose

Fish require adequate concentrations of DO in water to survive. Depleted concentrations of DO in the POCs during periods of non-operation under ice cover are a concern, but it is expected that planned mitigation (i.e., baseflows in both channels) will prevent declines to critically low concentrations. Monitoring has been designed to confirm that mitigation is sufficient.

This study will address the following key question:

- Does DO in the POCs decline to critically low levels during periods of non-operation in late winter?

### 3.4.2 Timing

Monitoring will be conducted during periods of maximum DO depletion in late winter. Monitoring will be conducted at the following times:

- during the winter following POC commissioning;
- during the winter following POC operation for flood mitigation; and
- after extended periods of non-operation (3 years).

During the winter following commissioning, additional monitoring may be conducted on a monthly basis to determine how DO concentrations may change as winter progresses.

### 3.4.3 Field and Laboratory Methods

DO concentrations will be measured during late winter at each of the following sites (Appendix 1, Figure 1-3):

- one near the POC inlets;
- one immediately upstream and one immediately downstream of the WCS in the LMOC;
- two sites in representative pools along the LSMOC
- one site each near the downstream end of the POCs (lowermost pool in the LSMOC).

### 3.4.4 Parameters

Dissolved oxygen and water temperature will be recorded at each of the monitoring locations.

### 3.4.5 Data Analysis

Data analysis will focus on comparing DO concentration to the PAL required to support fish as well as lethal limits as described in Section 3.2.3.

Monitoring results will be used to assess the potential for fish mortality to occur within the LMOC and LSMOC during periods of non-operation under ice cover.

## 3.5 TSS Monitoring

### 3.5.1 Purpose

The LSMOC and LMOC are not expected to be sources of sediment post-commissioning due to armouring. Operation of the LMOC and LSMOC during flood conditions may result in a change in the amount of sediment that is moved downstream from Lake Manitoba through the Fairford River, Lake St Martin, and the Dauphin River to Sturgeon Bay.

This study addresses the following key questions:

- Does the concentration of TSS during POC commissioning and operation reach concentrations that could be harmful to aquatic life?
- What is the sediment load transported in the channels compared to the Dauphin and Fairford rivers?

### 3.5.2 Timing

Monitoring will be conducted during POC commissioning and immediately prior to, during and shortly after operation of the POCs for flood mitigation based on timing described in Section 2.1.

### 3.5.3 Field and Laboratory Methods

TSS monitoring will be conducted by deploying turbidity loggers at key locations to provide a continuous record of turbidity conditions during commissioning [6] and periods of operation. A detailed sediment monitoring plan is presented in the Sediment Management Plan for this Project. Results of the monitoring presented here will indicate whether channel armouring and other sediment controls are effective. If sediment releases from the channels are of concern, monitoring activities will be re-evaluated and adjusted to provide a more detailed assessment of TSS concentrations during operations. It is currently assumed that TSS introductions will be minimal during operation.

Water samples will be collected during the period of operation from each logger location and analyzed for turbidity and TSS concentration. This will allow for the development of site-specific turbidity/TSS relationships and allow the conversion of turbidity logger data to TSS and provide a continuous TSS record at each logger location.

Loggers will be deployed shortly before the onset of channel operation to establish initial turbidity/TSS conditions and will remain in place until after channel operation has ceased and TSS concentrations have returned to pre-operation baseline conditions.

Loggers will be deployed at the following locations (Appendix 1, Figure 1-4):

- the Fairford River at Lake Manitoba;
- the Fairford River at Lake St. Martin;
- Watchorn Bay on Lake Manitoba at the LMOC;
- outlet of the LMOC at Birch Bay on Lake St. Martin and a nearby reference location (to be selected based on field conditions, not shown on Appendix 1, Figure 1-4);
- the Dauphin River at Lake St. Martin;
- the Dauphin River at Sturgeon Bay;
- the LSMOC at Lake St. Martin; and
- the outlet of the LSMOC at Sturgeon Bay and a nearby reference location (to be selected based on field conditions, not shown on Appendix 1, Figure 1-4).

### 3.5.4 Parameters

Key parameters to be monitored include turbidity and TSS.

[6] The sediment management plan provides a detailed protocol for use of turbidity loggers to monitor potential TSS increases during commissioning.

### 3.5.5 Data Analysis

Analysis will focus upon temporal changes to turbidity/TSS at each logger location. Comparison in trends of TSS between logger locations will provide insight into sediment transport throughout the system during periods of operation. Using TSS concentrations as inputs, an empirical model will be used to calculate sediment loading into Lake St. Martin and Sturgeon Bay following each operation.

Comparison of TSS concentrations measured at the outlets of the POCs to PAL (increase of 25 mg/L above background as measured at the nearby reference locations) will identify the potential for adverse effects on aquatic biota related to inputs from the channels.

## 3.6 Adaptive Management

The need for the implementation of adaptive management will follow the process set out in Section 2.3. The nature of mitigation cannot be determined at this time, however, potential measures are provided below based on the key questions. It should be noted that current assessments indicate that none of the changes presupposed in the key questions will occur.

1. Does surface water quality as represented by a suite of parameters change as a result of operation of the POCs?

   Apart from the localized effects with respect to TSS and DO described below, no changes to surface water quality that would have adverse effects to biota are expected; if unanticipated changes occur, than these would need to be addressed.

2. Does DO in the POCs decline to critically low levels during periods of non-operation during late winter?

   Planned mitigation measures include providing a permanent baseflow to the LSMOC and LMOC [7]. If DO concentrations decline to critically low levels despite the baseflows, measures to be considered include increasing the baseflow.

3. a. Does the concentration of TSS during POC commissioning reach concentrations that could be harmful to aquatic life?

   b. Does the concentration of TSS during POC operation for flood mitigation reach concentrations that could be harmful to aquatic life?

   The current mitigation plan during commissioning is the use of real-time turbidity loggers to track increases in turbidity (surrogate for TSS) attributed to construction activities during opening of the WCSs such that they could be manipulated to maintain TSS concentrations within target levels.

[7] During periods of drought, (i.e., close to the 10th percentile) the baseflow in the LSMOC would be reduced to provide more water to the Dauphin River. Baseflow within LSMOC would be maintained at a level that would maintain sufficient DO in the channel to prevent fish kills.

If increases in TSS are greater than anticipated, the POCs will be inspected to determine whether armouring in the channels is functioning as intended.

In the event that TSS monitoring indicates that the load of sediment transported via the channels is greater than expected and deposition occurs in Lake St. Martin and Sturgeon Bay, then sediment quality sampling that was conducted at key locations in fall 2020 and 2021 (NSC 2022b) will be repeated.

# 4.0 AQUATIC HABITAT

## 4.1 Rationale

Aquatic habitat is the physical, chemical, and biological environment in which aquatic organisms live. Consequently, changes to aquatic habitat can affect the organisms that live there. The Project may affect aquatic habitat through the following linkages:

- construction of the LMOC and LSMOC will create new aquatic habitat that will be available to fish;
- excavation in Watchorn Bay, Lake St. Martin, and Sturgeon Bay at the channel inlets and outlets will disrupt existing habitat including benthic invertebrates at these locations. Habitat may further evolve both between and during periods that flow is diverted through the channels;
- sediments may be transported when flow is passed through the channels both during commissioning and operation for flood mitigation. Increased water velocity at the channel outlets may mobilize sediments at the channel outlets. Mobilized sediments may deposit further downstream, potentially altering the substrate composition in depositional areas;
- operation of the LSMOC is expected to increase the water velocity at the Narrows between the south and north basins of Lake St. Martin to a greater extent than occurs naturally during floods. The increased velocity may change substrate composition in the vicinity of the Narrows; and
- construction of the POCs will reduce the inflow and thereby change existing aquatic habitat in the Birch Creek and Buffalo Creek systems. Flow reductions will be mitigated in part: it is proposed that the lower section of Birch Creek will receive diverted water from the LMOC when it is not in operation; and Buffalo Creek may receive drainage from rewatering of wetlands during dry periods.

Aquatic habitat monitoring will document habitat conditions in the LMOC and LSMOC to provide the basis for determining their suitability to support fish that may use those areas prior to, during and following channel operation. Monitoring at the inlets and outlets of the POC will document whether these areas are stable and supporting a benthic invertebrate community or are experiencing erosion or sedimentation. Monitoring of substrate at key locations in Lake St. Martin and Sturgeon Bay will indicate whether changes are occurring as a result of flow diversion through the channels. Habitat conditions in Birch and Buffalo creeks will be recorded during fish surveys (Section 5.5), but habitat before and after construction of the channels will not be quantified because under existing conditions habitat varies widely depending on seasonal and inter-annual variations in flow. Dissolved oxygen is an important habitat characteristic that will be addressed under water quality (Section 3.4).

Diversion of flow through the POCs will reduce flows in the Dauphin and Fairford rivers, in particular at flood levels and to a lesser extent at median and lower flows. Hydraulic modeling to determine changes to water velocity and depth in the rivers indicates that current sediment transport processes will be maintained (i.e., non-depositional reaches will not become depositional) and water levels and velocities will remain within the ranges known to support fish migrations (KGS Group 2021a). Therefore changes in the hydrograph of the rivers are not expected to affect fish use and are not considered further in terms of effects to habitat.

An additional study will be undertaken outside of the study area to address specific concerns raised by Fisher River Cree Nation, who noted that fine sediments appeared at nearshore locations in Lake Winnipeg beyond the mouth of Sturgeon Bay in the years following operation of the EOC. This additional study will document existing substrate at locations selected in consultation with FRCN fishers and provide the basis for post-Project comparison.

## 4.2 Approach

### 4.2.1 Key Questions and Overview of Studies

Monitoring studies have been designed to address the following key questions with respect to aquatic habitat:

- What is the water depth and substrate of aquatic habitat available to fish in the LMOC and LSMOC during periods when the channels are not in operation and does it change over time, both after operation and if the channels are not operated for more than three years?
- How does habitat, in particular substrate and the benthic invertebrate community, in the excavated inlets and outlets differ from nearby natural areas and does it change over time, both after operation of the channels and if the channels are not operated for more than three years?
- Do fine sediments accumulate on rocky reefs in Birch Bay that may be affected by sediment releases during operation of the LMOC and, if so, does the substrate revert to the pre-diversion condition over time due to wind and wave action?
- Do fine sediments accumulate on rocky reefs in Sturgeon Bay that may be affected by sediment releases during operation of the LSMOC and, if so, does the substrate revert to the pre-diversion condition over time due to wind and wave action?
- Does the substrate composition in the vicinity of the Lake St. Martin Narrows change as a result of operation of the LSMOC?
- Does the substrate composition at selected nearshore sites in Lake Winnipeg (i.e., at mouth of Sturgeon Bay, off of McBeth Point, southeast shore of Reindeer Island) change after operation of the LSMOC?

Several studies will be conducted to address these questions:

- Aquatic habitat (substrate type, water depth and benthic invertebrates composition and abundance) will be recorded within the excavated inlets and outlets and at representative sites within the channels after commissioning and during and after operation as described in Section 4.3;
- Substrate will be assessed at selected sites in Lake St. Martin and Sturgeon Bay pre-commissioning and again after commissioning and operation as described in Section 4.4;
- Substrate and the presence of suspended material will be assessed at selected sites in Lake Winnipeg pre-commissioning and after commissioning and operation as described in Section 4.5;

### 4.2.2 Baseline Information

Bathymetric and substrate classification is available for existing habitat at the inlets and outlets of both channels, portions of the Fairford and Dauphin Rivers, Lake St. Martin, and the southern portion of Sturgeon Bay (AAE Tech Services 2016; NSC 2016a; NSC 2022c).

Benthic invertebrate information has been collected from the inlet and outlet areas of both channels (AAE Tech Services 2016; NSC 2016a; NSC 2019a).

Supplemental high resolution bathymetric and substrate classification data were collected at selected areas within Birch Bay during fall 2021 (NSC 2022c). Additional substrate information was also collected in the Lake St. Martin Narrows during fall 2021 (NSC 2022c). A supplemental study will be conducted during summer 2022 to obtain high resolution substrate data at selected monitoring locations in Sturgeon Bay and in the vicinity of MacBeth Point in Lake Winnipeg.

### 4.2.3 Identification of Benchmarks

Early warning triggers for the aquatic habitat studies will generally be based on pre-/post-comparisons to determine whether changes are greater than can be attributed to natural spatial and temporal variation as follows:

- Substrate in the inlets and outlets and channels will be compared to post-construction conditions to determine whether changes occur over time;
- Benthic invertebrate community composition and abundance in the inlets and outlets will be compared to nearby similar reference sites to determine whether areas are re-colonized. The benthic invertebrate community that develops in the channels will be compared to that at the inlets and outlets as well as the reference sites in the natural lake environment;
- Substrate along transects at select locations will be compared between pre- and post-operation to determine the extent of fine sediment deposition within Lake St. Martin and Sturgeon Bay; and
- A similar approach will be used to compare substrate classification maps in the vicinity of McBeth Point. Comparison between years will be provided to describe changes in habitat and sediment type.

If changes to aquatic habitat are observed to exceed the above-stated early warning triggers (i.e., changes that appear greater than can be attributed to natural variation), then the need for further studies would be considered in the context of potential biological effects as discussed in Section 2.3.

## 4.3 Aquatic Habitat at the POCs

### 4.3.1 Purpose

Aquatic habitat monitoring will be conducted in the inlet/outlet areas and within the LMOC and LSMOC to determine the suitability of the habitat to support fish and other aquatic biota that may use those areas prior to, during, and following channel operations.

This study will address the following key questions:

- What is the depth and substrate of aquatic habitat available to fish in the LMOC and LSMOC during periods when the channels are not in operation and does it change over time, both after operation and if the channels are not operated for more than three years?
- How does habitat, in particular substrate, in the excavated inlets and outlets differ from pre-construction and does it change over time, both after operation of the channels and if the channels are not operated for more than three years?
- What is the species composition and abundance of the benthic invertebrate community that develops in the excavated inlets and outlets and POCs?

### 4.3.2 Timing

Initial habitat and benthic invertebrate assessment will occur one year after the channels have been wetted during commissioning. Waiting one year will allow time for altered and newly created habitat to become established and stabilize.

Subsequent sampling will be conducted following POC operation for flood mitigation to document how conditions in the channels may change due to operation based on the timing set out in Section 2.1.

Additional monitoring will be conducted if a non-operational period extends for three years to determine whether conditions in the channels change over time, in particular whether organic or inorganic materials accumulate within the channels.

### 4.3.3 Field and Laboratory Methods

Habitat conditions in the LMOC and the inlets and outlets of both channels will be recorded using standard boat-based sonar to collect hydroacoustic information describing water depth and substrate classification. Substrate samples will be collected from survey areas to help interpret and validate substrate classifications derived from the hydroacoustic data.

Methods for habitat mapping/description in the LSMOC will be determined once the channel has been constructed and sampling conditions are known. It is anticipated that a combination of remote sensing (i.e., collection of aerial imagery) and field measurements of habitat parameters will be used.

Benthic invertebrates will be collected at the inlet and outlet of each channel as well as at several locations within each channel and nearby reference areas. Sampling locations within the channels will be determined once the channels are constructed and substrate information is available such that representative habitats can be selected.

Benthic invertebrate samples will be collected using a ponar dredge. Replicate samples will be collected at each sampling location. Samples will be preserved at the collection site and delivered to a laboratory for analysis.

### 4.3.4 Parameters

Habitat parameters will include water depth, substrate and distribution of aquatic macrophytes.

Benthic invertebrate samples will be sorted and enumerated in a laboratory. Indices of species composition and diversity will be calculated.

Habitat information will be supplemented by the results of DO sampling collected during studies described in Section 3.4.

### 4.3.5 Data Analysis

Physical habitat parameter analyses will include production of bathymetric and substrate classification maps for survey areas and calculation of spatial area for different habitat classes. As additional years of data are acquired, comparison between years will be provided to describe changes in habitat within the channels.

Water quality conditions will be described based upon results of studies described in Section 3.4.

Benthic invertebrate species composition and density will be calculated. Changes in benthic invertebrate community and diversity indices will be compared between sampling years and to pre-Project data.

## 4.4 Substrate Composition in Lake St. Martin and Sturgeon Bay

### 4.4.1 Purpose

Substrate monitoring will be conducted at selected shoals within the modelled sediment plume from channel commissioning in Lake St. Martin and Sturgeon Bay (Hatch 2021; KGS Group 2021b; Hatch and KGS Group 2022) to determine whether long-term changes in substrate composition have occurred. These studies will address the fate of fine sediments transported during operation of the POCs. Modelling conducted to-date has indicated that fine sediments may be deposited along the outflow of the LMOC and LSMOC, but fines deposited on coarse substrates are expected to be sorted such that current areas of coarse substrate remain free of fines. Monitoring will also confirm the prediction that substrate composition in the vicinity of the Lake St. Martin Narrows will not change during operation of the LSMOC due to the incremental increase in velocity through the Narrows.

The following key questions will be addressed:

- Do fine sediments accumulate on rocky reefs in Birch Bay due to operation of the LMOC and, if so, does the substrate revert to the pre-diversion condition within three years[8]?
- Do fine sediments accumulate on rocky reefs in Sturgeon Bay due to operation of the LSMOC and, if so, does the substrate revert to the pre-diversion condition over time within three years?
- Does the substrate composition in the vicinity of the Lake St. Martin Narrows change as a result of operation of the LSMOC?

### 4.4.2 Timing

Sampling in Lake St. Martin was conducted in 2021 (NSC 2022c) and work in Sturgeon Bay is planned for 2022.

Sampling will occur immediately after the first operation and, if sediment deposition is observed, be repeated three years later in conjunction with non-operational monitoring to determine whether sediments have re-mobilized. The requirement for additional monitoring will be evaluated following completion of monitoring for the first operation.

### 4.4.3 Field and Laboratory Methods

Substrate conditions will be recorded using boat-based sonar to collect hydroacoustic information describing water depth and substrate classification. Substrate samples will be collected from survey areas to help interpret and validate substrate classifications derived from the hydroacoustic data.

### 4.4.4 Parameters

Physical habitat parameters will include water depth and substrate type. Physical substrate samples will be analyzed for particle size.

### 4.4.5 Data Analysis

Physical habitat parameter analyses will include production of bathymetric and substrate classification maps for survey areas and calculation of spatial area for different habitat classes. As additional years of data are acquired, comparison between years will be provided to describe changes in habitat and sediment type.

[8] The three year period is based on the anticipated time that inputs of leaf litter and other organic matter from the adjoining watershed may be sufficient to accumulate on the substrate and thus affect suitability as fish habitat; this duration may be modified based on results of post-commissioning studies.

## 4.5 Lake Winnipeg Substrate at McBeth Point and Other Selected Locations

### 4.5.1 Purpose

Fisher River Cree Nation (FRCN) fishers identified that fine sediments appeared at fishing sites off of McBeth point approximately a year after operation of the EOC and then dispersed over the following years; although the origin is not certain, fishers felt it was likely that the sediments originated from operation of the EOC. To determine whether operation of the LSMOC results in similar mobilization of inorganic and organic material, monitoring will be conducted within Sturgeon Bay at McBeth Point and other locations near Reindeer Island to document conditions at several locations where fine sediments/debris may accumulate in nearshore areas. These data will be used to confirm if sediment accumulations occur after operation of the LSMOC.

The following key question will be addressed:

- Does the substrate composition at selected nearshore sites in Lake Winnipeg (i.e., at mouth of Sturgeon Bay, near McBeth Point, southeast shore of Reindeer Island) change after operation of the LSMOC?

### 4.5.2 Timing

Sampling will be conducted at least once prior to commissioning to document baseline conditions. A second year of sampling may be conducted prior to commissioning if inter-annual variability is a concern or of interest.

Sampling will continue annually for three years following the first operation based on the observation by Fisher River fishers that fine materials appeared approximately one year after EOC operation (i.e., required time to be transported out of Sturgeon Bay). The requirement for additional monitoring will be evaluated following completion of monitoring for the first operation.

### 4.5.3 Field and Laboratory Methods

Substrate conditions at McBeth Point and additional areas within Sturgeon Bay will be recorded using standard boat-based sonar to collect hydroacoustic information describing water depth and substrate classification. Substrate samples will be collected from survey areas to help interpret and validate substrate classifications derived from the hydroacoustic data.

The characteristics of the water immediately above the substrate surface will be recorded with a Kemmerer sampler and photographed. Analysis of TSS and total organic carbon will be conducted at each site.

### 4.5.4 Parameters

Physical habitat parameters will include water depth and substrate type. Physical substrate samples will be analyzed for particle size, while analysis of TSS and total organic carbon will be conducted from water samples at each site.

### 4.5.5 Data Analysis

Physical habitat parameter analyses will include production of bathymetric and substrate classification maps for all survey areas and calculation of spatial area for different habitat classes. As additional years of data are acquired, comparison between years will be provided to describe changes in habitat and sediment type.

Water quality conditions will be described.

## 4.6 Adaptive Management

The need for the implementation of adaptive management will follow the process set out in Section 2.3, first considering whether a change from pre-Project conditions has occurred and, if so, whether effects are greater than anticipated in the environmental assessment and require the implementation of mitigation measures. The nature of mitigation cannot be determined at this time; however, potential measures are provided below based on the key questions. It should be noted that current assessments indicate that none of the changes pre-supposed in the key questions will occur.

1. What is the water depth and substrate type of aquatic habitat available to fish in the LMOC and LSMOC during periods when the channels are not in operation and do they change over time, both after operation and if the channels are not operated for more than three years [9]?

   If depth and substrate in the channels are not as predicted in the environmental assessment, or the channels are very unstable or become heavily silted with fine sediments or organic matter, then the potential effects to biota would be considered. If, for example, large amounts of organic material accumulate in the channels and this creates adverse conditions for the survival of fish due to the development of critically low concentrations of DO, then the need to remove organic material as part of channel maintenance would be considered.

2. How does habitat, in particular substrate, in the excavated inlets and outlets differ from pre-construction and does it change over time, both after operation of the channels and if the channels are not operated for more than three years?

   If substrates at the inlets and outlets are unstable or experience extensive sediment deposition and do not support benthic invertebrates, then the need for measures to stabilize the substrates would be considered.

[9] The three year period is based on the anticipated time that inputs of leaf litter and other organic matter from the adjoining watershed may be sufficient to accumulate on the substrate and thus affect suitability as fish habitat.

3. Do fine sediments accumulate on rocky reefs in Birch Bay due to operation of the LMOC and, if so, does the substrate revert to the pre-diversion condition over time?

   If the release of sediments as a result of operation of the LMOC is greater than predicted and these sediments deposit over rocky reefs in Birch Bay and are not readily remobilized, then the potential effect to fish (i.e., lake whitefish spawning) would be considered based on results of the pertinent monitoring study (Section 6.5). If sedimentation is found to cause an adverse effect to fish (as per the benchmarks identified in Section 6.2.3, i.e., larval lake whitefish emergence in Birch Bay), then means to reduce sediment deposition would be considered. The appropriate means would depend on the source of the sedimentation.

4. Do fine sediments accumulate on rocky reefs in Sturgeon Bay that may be affected by sediment releases during operation of the LSMOC and, if so, does the substrate revert to the pre-diversion condition within three years?

   If the release of sediments as a result of operation of the LSMOC is greater than predicted and these sediments deposit over rocky reefs in Sturgeon Bay and are not readily remobilized, then the potential effect to fish would be considered based on results of the pertinent monitoring study (fish community, Section 5.4). If sedimentation is found to cause an adverse effect, then means to reduce sediment deposition would be considered. The appropriate means would depend on the source of the sedimentation.

5. Does the substrate composition in the vicinity of the Narrows change as a result of operation of the LSMOC?

   If operation of the LSMOC increases velocity in the vicinity of the Lake St. Martin Narrows to the extent that all substrates required for spawning are scoured away, the survey would be extended to determine whether substrates were shifted to nearby areas of lower velocity. There is limited opportunity for remediation at the site. Other measures to support lake whitefish spawning in Lake St. Martin would need to be investigated.

6. Does the substrate composition at selected nearshore sites in Lake Winnipeg (i.e., at mouth of Sturgeon Bay, off of McBeth Point, southeast shore of Reindeer Island) change after operation of the LSMOC?

   No effects to substrate in Lake Winnipeg are predicted, but this study is being conducted to address concerns of FRCN based on observed changes following operation of the EOC. If changes are observed following operation of the POCs and are attributed to the Project, then suitable mitigation measures would be identified in consultation with the FRCN and other local fishers.

# 5.0 FISH COMMUNITY

## 5.1 Rationale

Fish are an important component of the aquatic ecosystem. Waterbodies in the study area support domestic, commercial, and recreational fisheries. Monitoring of the fish community will address whether effects are as predicted in the environmental assessment and determine whether mitigation strategies to minimize effects to the fish community are effective. Five main potential pathways by which the Project could affect fish were identified during the assessment, as follows:

- transfer of adult and larval fish from Lake Manitoba to Lake St. Martin and from Lake St. Martin to Sturgeon Bay during operation of the outlet channels;
- possible stranding and subsequent mortality of fish in the outlet channels following operation;
- changes to groundwater inflow potentially affecting the success of lake whitefish egg incubation in Lake St. Martin;
- effects related to changes in flow, in particular reducing the attraction to the Dauphin and Fairford rivers and creating an alternate attraction to fish at the LMOC and LSMOC outlets; and
- effects of sediment inputs on the fish community in Lake St. Martin and Sturgeon Bay.

The environmental assessment determined that these effects will likely not be significant, based on planned mitigation. Monitoring will confirm these predictions or, if effects are greater than predicted, determine whether additional mitigation is required.

Studies to address the fish community in this AEMP are presented in three sections: measurement of fish community metrics (this section); studies to examine specific Project effects on spawning (Section 6.0) and studies to address effects at the POCs (Section 7.0). The input of sediment is addressed as a component of total suspended sediment transport studies (Section 3.5) and aquatic habitat (Section 4.0).

The studies described in this section will determine whether the fish community is changing over time. The fish population is the ultimate metric of interest for the monitoring studies; even if changes in spawning directly linked to the Project are observed, if recruitment continues to support the existing fish population and fisheries, then no changes to Project mitigation measures would be required. Results of the fish community monitoring will need to be considered in conjunction with studies described in Section 6.0 (spawning) and at the POCs (Section 7.0) to determine whether any observed changes are linked to the Project. Results of water quality (Section 3.0) and aquatic habitat (Section 4.0) monitoring would also be examined to determine whether a possible causal link to the Project exists.

The fish community can be affected by many factors external to the Project, including:

- stocking of walleye as a component of the offsetting for the EOC operation may increase walleye recruitment;
- changes in water temperatures and flows linked to variations in weather and climate;

- eutrophication;
- the arrival and proliferation of invasive species, in particular zebra mussel and spiny waterflea, which are known to occur in adjacent waterbodies; and
- changes in the effort and species targeted in the commercial fishery.

To assist in determining whether changes are related to the Project as opposed to external factors, results of fish community monitoring will be considered in the context of regional changes detected in other Manitoba waters (e.g., commercial fishing records from other areas of Lake Winnipeg and Lake Manitoba, the Coordinated Aquatic Monitoring Program conducted by Manitoba Department of Natural Resources and Northern Development and Manitoba Hydro [CAMP; 2008-ongoing]).

## 5.2 Approach

### 5.2.1 Key Questions and Overview of Studies

Fish community studies have been designed to address the following questions:

- Does the species composition and abundance of the fish community in Lake St. Martin change over time, specifically after channel operation?
- Does the species composition and abundance of the fish community in Sturgeon Bay change over time?
- Does the fish community of Birch Creek and Buffalo Creek change following construction of the POCs?

To address these questions, three studies will be conducted:

- fish community monitoring in Lake St. Martin;
- fish community monitoring in Sturgeon Bay; and
- fish community monitoring in Birch and Buffalo creeks.

### 5.2.2 Baseline Information

Information pertinent to fish abundance and species composition includes:

- long-term commercial fish harvest data collected by the Province of Manitoba in Lake Manitoba, Lake St. Martin, and Sturgeon Bay;
- fish community data (i.e., experimental gillnetting, length, weight, spawning condition) collected from north basin of Lake St. Martin and numerous sites in southern Sturgeon Bay in spring and fall as part of monitoring for the EOC (2011-2015; NSC 2016b);
- fish community data collected from the north and south basins of Lake St. Martin (i.e., experimental gillnetting, length, weight, age and growth) as part of supplemental studies for the Project (2018, 2021; NSC 2019b and NSC 2022d);
- supplemental studies conducted during spring and fall 2018 to document fish use of habitat occurring at the inlet and outlet of the LSMOC (NSC 2019c); and
- long-term fish community data (i.e., experimental gillnetting, length, weight) collected annually in August from Sturgeon Bay as part of CAMP (2008-ongoing).

One more sample year of fish community data will be collected from Lake St. Martin as part of supplemental data collection prior to POC commissioning.

Baseline data describing fish use of Birch Creek includes:

- aquatic habitat surveys conducted in fall 2015 and spring 2016 (AAE Tech Services 2016);
- brief site visits conducted in spring 2018 (NSC 2019d) and spring 2020; and
- supplemental data describing aquatic habitat and fish use collected in spring 2021 under extreme low flow conditions (NSC 2022e) and in 2022 under extreme high flow conditions.

Baseline data describing fish use of the Buffalo Creek drainage was collected prior to, during and following EOC operation and includes:

- spawning investigations in the lower section of Buffalo Creek conducted from fall 2011 to spring 2015, including collection of fish eggs, larval fish, and spawning adults (NSC 2016b);
- fish utilization studies of Buffalo Creek as part of EOC monitoring (2011-2015; NSC 2016b);
- fish utilization studies of Big Buffalo Lake as part of EOC monitoring, and following EOC operations (2011-2015 [NSC 2016b]; Big Buffalo Lake was not sampled following the 2014/2015 EOC operation);
- supplemental data collected in spring 2021 (flow conditions in 2021 were very low) to describe fish use following changes in habitat (in particular the loss of beaver dams preventing access from the Dauphin River) as a result of the EOC operation (NSC 2022e); and
- supplemental data collected in spring 2022 under high flow conditions.

### 5.2.3 Identification of Benchmarks

The environmental assessment predicted that operation of the POCs would not result in significant long-term changes in the fish communities of Lake Manitoba, Lake St. Martin or Sturgeon Bay. The fish community studies will provide the basis for determining whether an overall change is occurring, but results of other studies in this AEMP will be needed to determine whether observed changes are due to the Project. In addition, as noted in Section 5.1, the fish community is subject to many other stressors influences, including climate change, invasive species, fisheries, stocking of walleye, and eutrophication, and these factors would need to be considered when examining potential causes of change. Comparison to other areas, where the fish community is not affected by the Project, will be important in determining whether changes are occurring as a result of external factors.

Early warning triggers indicate that a detectable change has occurred, and an examination of on-going monitoring is needed to confirm that data being collected are adequate to determine the potential causes of the effect. Management thresholds indicate a magnitude of change where mitigation measures may need to be evaluated and modified.

Benchmarks in relation to each of the key questions/studies are as follows:

- Does the species composition and abundance of the fish community in Lake St. Martin change over time, specifically after channel operation?

  Key indicators, specifically catch per unit effort (CPUE) of the total fish community and key species (walleye, lake whitefish, northern pike, white sucker and shorthead redhorse) and population characteristics for walleye and lake whitefish including year class strength, size distribution and condition will be used to address this key question. The early warning trigger will be based on detection of a statistically significant change from pre-commissioning period; the magnitude of a detectable change will depend on the specific parameter. The management threshold will be a change in a key indicator to outside of the range detected during previous studies. Numerical values for these benchmarks will be calculated after completion of supplemental studies listed in Section 2.1.

- Does the species composition and abundance of the fish community in Sturgeon Bay change over time?

  Benchmarks will be same as set out for Lake St. Martin but be based on data collected at the CAMP sites sampled in Sturgeon Bay.

- Does the fish community of Birch Creek and Buffalo Creek change following construction of the POCs?

  Fish use of these creeks is highly variable and flow dependent, therefore, numerical benchmarks will not be applied. Rather, survey results will be considered in terms of the presence/absence of common species in spring and summer, the presence of a definite spawning run of white sucker in spring, and presence of larval drift of spring-spawning species as observed during pre-commissioning studies.

## 5.3 Fish Community Monitoring in Lake St. Martin

### 5.3.1 Purpose

Fish community composition monitoring in Lake St. Martin is being conducted to address the following question:

- Does the species composition and abundance of the fish community in Lake St. Martin change over time, specifically after channel operation?

  The intent of this study is to identify whether there is a change - the cause of the change would need to be determined based on results of other studies. It should be noted that the ultimate metric of concern for the studies is the abundance and condition of the key species in the fish community. Metrics assessed in other studies (e.g., larval fish studies to determine whether reproduction is successfully occurring in Birch Bay) provide causal links to the potential changes in the fish community; however, the importance of changes recorded in larval fish abundance would be assessed in terms of the ultimate affect on adult fish abundance.

### 5.3.2 Timing

Monitoring will be conducted at approximately three year intervals to determine whether the fish community is changing over time. During periods when the POCs are in operation, monitoring will be conducted in the year following operation. The timing of monitoring may be adjusted depending on the duration and effects observed during POC operation. For example, if the timing of operation may have affected lake whitefish spawning success, then monitoring of the fish community in Lake St. Martin would be adjusted to confirm that fish which had been hatched during POC operation would have sufficient time to grow large enough to be susceptible to capture in the sampling gear.

### 5.3.3 Field and Laboratory Methods

Fish community sampling will be conducted using standard experimental and small mesh gill nets comparable to those used during EOC monitoring, Project baseline data collection and the CAMP program in Sturgeon Bay described in Section 5.4. Sampling locations post-Project will be comparable to those used during the pre-commissioning studies (Appendix 1, Figure 1-5). It should be noted that some shifts in location may be required depending on water levels and flows in a given year.

### 5.3.4 Parameters

At each sampling location, captured fish will be enumerated by species, measured for length and weight, and information describing their spawning condition will be noted. Ageing structures will also be collected.

Sampling effort (i.e., duration of gill net set) will be recorded for each sampling location.

Annual landings of the commercial catch by species in Lake St. Martin will be obtained, and interviews with the Provincial Fisheries Manager and commercial fishers will be conducted to obtain estimates of effort, and conditions that affected the fishery to provide context for the catch data.

### 5.3.5 Data Analysis

Fish community and population metrics will be calculated for each year in which sampling occurs. Fish community metrics include overall richness (number of species), presence of invasive species, and relative abundance. These descriptive metrics will be compared qualitatively to pre-Project data to determine whether they fall within the pre-Project range as well as comparison to nearby areas such as Sturgeon Bay (sampled under the CAMP). Population metrics for individual species include CPUE, condition, length-frequency distribution, and year class strength (walleye and lake whitefish). CPUE and condition will be statistically compared to pre-Project data. Length-frequency distributions will be qualitatively compared to the variation observed during pre-Project sampling in 2018, 2021 and an additional year prior to Project commissioning. Year-class strength will be examined for absent year classes and changes in recruitment patterns before/after the Project (e.g., consistent year class strength, erratic recruitment).

The commercial catch data will be compared to catches over time, excluding years that the fishery was not in operation, to determine whether marked changes in catch have occurred. These data will be both an index of change over time and also an input into explaining potential changes in the experimental gillnetting results.

## 5.4 Fish Community Monitoring in Sturgeon Bay

### 5.4.1 Purpose

Fish community monitoring in Sturgeon Bay will rely on monitoring conducted under CAMP. This program is designed to identify long term changes in fish communities and populations and will be used to address the following key question:

- Does the species composition and abundance of the fish community in Sturgeon Bay change over time?

### 5.4.2 Timing

Fish community in Sturgeon Bay is monitored annually under CAMP. Data for all years will be requested in years when monitoring is conducted on Lake St. Martin (Section 5.3).

### 5.4.3 Field and Laboratory Methods

Fish community sampling will be conducted using standard experimental gill nets also used for fish community monitoring in Lake St. Martin (Section 5.3). See Appendix 1, Figure 1-6 for representative sampling locations.

### 5.4.4 Parameters

At each sampling location, captured fish will be enumerated by species, measured for length and weight, and information describing their spawning condition will be noted. Ageing structures will also be collected.

Sampling effort (i.e., duration of gill net set) will be recorded for each sampling location.

Annual landings of the commercial catch by species in Sturgeon Bay will be obtained, and interviews with the Provincial Fisheries Manager and commercial fishers will be conducted during years when monitoring occurs on Lake St. Martin (see Section 5.3) to obtain estimates of effort, and conditions that affected the fishery to provide context for the catch data.

### 5.4.5 Data Analysis

Raw data will be requested from the CAMP program.

Fish community and population metrics will be calculated for each year in which sampling occurs. These include species abundance, condition, and growth. Community composition will be compared to existing baseline data to determine whether the post-Project monitoring data falls within the expected variation.

The commercial catch data will be compared to catches over time, excluding years that the fishery was not in operation, to determine whether marked changes in catch have occurred. These data will be both an index of change over time and also an input into explaining potential changes in the experimental gillnetting results.

# 5.5 Fish Utilization of Birch and Buffalo Creek Drainages

## 5.5.1 Purpose

Investigations will be conducted to determine the extent to which fish continue to use habitat in Birch and Buffalo creeks following changes in flow after construction of the POCs.

The following key question will be addressed:

- Does the fish community of Birch Creek and Buffalo Creek change following construction of the POCs?

## 5.5.2 Timing

Monitoring will be conducted during the first spring following construction and commissioning of the POCs when a portion of the creeks' watershed have been diverted into the drainage ditches adjacent to the POCs. Monitoring will be repeated in the future when the POCs are being monitored under non-operation conditions (i.e., during periods of natural low runoff/flow) to determine whether there are changes in the fish community in the long term.

## 5.5.3 Field and Laboratory Methods

Fish will be collected from selected representative locations in Birch and Buffalo creeks.

Sampling methods will be determined by site conditions. It is anticipated that a combination of sampling methods will be used, likely including backpack electrofishing, hoop nets and drift traps. Habitat conditions will be documented with photographs and *in situ* measurements of selected parameters (e.g., velocity, wetted width and depth).

Monitoring will be comprised of several short sampling sessions per sampling year to maintain effort at a reasonable level while providing sampling coverage throughout spring. This is to account for the timing of spawning-related movements of large-bodied fish into the lower creek reaches, during spring and to examine change in fish abundance as flow recedes following the spring freshet.

## 5.5.4 Parameters

At each sampling location, captured fish will be enumerated by species, measured for length and weight, and information describing their spawning condition will be noted.

Sampling effort will be recorded for each sampling location.

## 5.5.5 Data Analysis

Analyses will include the calculation of relative abundance and CPUE for each species and for each location.

Comparison of site-specific fish use metrics (relative abundance, CPUE) will be generated for baseline conditions and following flow reduction.

## 5.6 Adaptive Management

The intent of the fish community studies is to determine whether a detectable change in the fish community has occurred; however, the results of fish community investigations would need to be considered in conjunction with other studies in this AEMP to determine whether a change is attributable to operation of the POCs. For example, if lake whitefish in Lake St. Martin exhibit poor year classes, an analysis would be conducted to first determine how the timing of poor year classes coincides with operation of the POCs as well as flows on the Dauphin and Fairford rivers, and secondly, whether results of fall migration or spring larval studies correspond with poor year classes. Context for observed changes would also be obtained from similar monitoring programs conducted on nearby waterbodies (e.g., sampling conducted by CAMP). Lake whitefish populations may be affected by factors apart from the Project, such as the proliferation of invasive zebra mussels, increases in invasive spiny water flea, increases in water temperature linked to climate change, and fish harvests.

The need for additional mitigation measures with respect to the Project will be determined based on the magnitude of effects observed in relation to monitoring benchmarks set out in Section 5.2.3. Two benchmarks (i.e., early warning triggers and management thresholds) were identified in Section 5.2.3. In general, the early warning triggers indicate that a statistically significant change in key indicators has occurred and a review of the monitoring program is required to determine whether modifications to the study are needed to better define potential effects. The early warning trigger is intended to proactively modify the scope of the studies, if and as required, such that information to address potential adverse effects is obtained in a timely manner. In the case of the fish community metrics, the analysis would also examine whether changes are linked to the Project or external factors. The management threshold benchmark set out for the fish community indicate whether changes to or additional mitigation measures are required. The discussion below provides some potential measures, but the appropriate response would need to be determined based on an analysis of all monitoring results.

*Does the species composition and abundance of the fish community in Lake St. Martin change over time, specifically after channel operation?*

The management threshold will be a change in the key indicators (specifically CPUE of the total fish community and key species [walleye, lake whitefish, northern pike, white sucker and shorthead redhorse]) and population characteristics for walleye and lake whitefish including year class strength, size distribution and condition) to outside of the range detected during previous studies. A potential increase in walleye year class strength in years when stocking is conducted could indicate effects of stocking as an offset for the EOC.

Population-level effects as a result of the Project would most likely occur as a result of decreased recruitment, due to adverse effects on spawning, egg hatch or larval fish survival. These effects would be addressed through measures set out in relation to the spawning studies, Section 6.7. Effects could also occur due to an increase in fish movement into Lake St. Martin from Lake Manitoba or from Lake St. Martin into Lake Winnipeg. Potential effects due to increased fish movement would be assessed through monitoring as outlined in Section 7.3.

*Does the species composition and abundance of the fish community in Sturgeon Bay change over time?*

Benchmarks will be the same as set out for Lake St. Martin but will be based on data collected as part of CAMP in Sturgeon Bay.

Possible Project-related causes could be linked to sediment transport (adaptive management is provided in Section 3.6) and reduced reproductive success as addressed in studies on the Dauphin River and associated adaptive management in Section 6.7. It should be noted that changes to fish populations in Sturgeon Bay might also result from changes to Lake Winnipeg and determining linkages to the Project could be challenging.

*Does the fish community of Birch Creek and Buffalo Creek decrease following construction of the POCs?*

In the absence of mitigation, fish use of the creeks is expected to decrease. Proposed inputs of flow to Birch Creek are expected to maintain current spring use and extend the period through the open water season that fish habitat is provided. Therefore, survey results will be compared to existing conditions anticipating an increase. If no increase is observed or use declines, then conditions in the creek will be examined to determine if additional flow or other habitat modifications are required.

Buffalo Creek is expected to decline in suitability for fish. This decline is being addressed for offsetting and information obtained through monitoring is intended to document the change in fish usage.

# 6.0 FISH SPAWNING

## 6.1 Rationale

The environmental assessment identified several pathways by which the Project could affect fish spawning success, and ultimately, fish populations:

- changes to groundwater inflow potentially affecting the success of lake whitefish egg incubation in Lake St. Martin, specifically Birch Bay;
- changes to spawning habitat in Lake St. Martin, as a result of sediment deposition and/or changes in velocity;
- effects related to reducing the attraction flow to the Dauphin and Fairford rivers and/or creating an alternate attraction to fish at the LMOC and LSMOC outlets; and
- changes to spawning habitat in Sturgeon Bay due to sediment deposition.

The environmental assessment determined that these effects will likely not be significant, based on planned mitigation. Monitoring will confirm these predictions or, if effects are greater than predicted, determine whether additional mitigation is required.

The studies described in this section will determine whether there are changes to numbers of spawning adults, as well as drifting post hatch larvae. Potential effects to spawning habitat will also be identified based on the input of sediment at the outlets of the POCs (Section 3.5) and deposition of sediment on coarse substrates (Section 4.4).

## 6.2 Approach

### 6.2.1 Key Questions and Overview of Studies

The Project has the potential to affect spawning fish in the Dauphin and Fairford rivers and Lake St. Martin through several pathways. These include attraction of fish to the outlets of the POCs rather than the rivers to spawn, a reduction of groundwater input into Lake St. Martin (specifically Birch Bay) that may affect spawning habitat for lake whitefish, and an increase in water velocity through the Narrows that may affect spawning by lake whitefish in this area. However, the environmental assessment predicted that these changes will be small in magnitude and have little effect on fish populations. The following studies will be conducted to confirm this prediction.

Fish spawning studies have been designed to address the following questions:

- Does the timing and magnitude of spring spawning movements in the Dauphin and Fairford rivers change over time, specifically during POC operation?
- Does the timing and magnitude of fall movements and, in particular, lake whitefish spawning movements in the Dauphin and Fairford rivers change over time, specifically during POC operation?

- Does the occurrence and density of lake whitefish larvae within Lake St. Martin in the spring (including Birch Bay and the Narrows) change over time?
- Does the species composition and number of larval fish passively drifting in the Fairford and Dauphin rivers change over time, specifically during POC operation?

To address these questions, four studies will be conducted to assess:

- spring fish use of the Dauphin and Fairford rivers, with emphasis on spawning migrations of sucker and walleye;
- fall fish use of Dauphin and Fairford rivers, with emphasis on the fall spawning migration by lake whitefish;
- larval lake whitefish emergence on Lake St. Martin; and
- larval fish drift in the Dauphin and Fairford rivers.

### 6.2.2 Baseline Information

Information pertinent to fish spawning includes:

- data collected during EOC monitoring to document lake whitefish spawning and the presence of other fish species in the lower Dauphin River (2011-2014; NSC 2016b);
- supplemental studies conducted during spring and fall 2018 to document fish use of habitat occurring at the inlet and outlet of the LSMOC (NSC 2019c);
- supplemental studies conducted in fall 2020 and 2021 to document fish use of the Dauphin and Fairford rivers, with emphasis on documenting the timing and magnitude of lake whitefish movements through the Dauphin River, Lake St. Martin, and the Fairford River (NSC 2021b, 2022f); and
- supplemental studies conducted during spring 2021 to document species occurrence and abundance of fish in the Fairford and Dauphin rivers (NSC 2022f).

An additional spring sampling event 2021 to document species occurrence and abundance of fish in the Fairford and Dauphin rivers will be completed prior to POC commissioning.

Information pertinent to larval fish movements in the Dauphin and Fairford rivers includes:

- data documenting downstream larval fish movements from Lake St. Martin to Sturgeon Bay collected during and between periods of operation of the EOC (2012-2015; NSC 2016b); and
- data from supplemental studies conducted during spring 2021 (NSC 2022g) and 2022 to describe larval fish movements from Lake Manitoba to Lake St. Martin and from Lake St. Martin to Sturgeon Bay.

An additional spring sampling event documenting larval fish movements in the Dauphin and Fairford rivers will be completed prior to POC commissioning.

Information pertinent to the abundance and distribution of larval fish in Lake St. Martin includes:

- data collected during spring 2012-2014 in the north basin during EOC studies (NSC 2016b);
- data collected during the Project EIS baseline studies to document the occurrence, abundance, and distribution of larval fish in Lake St. Martin (2016-2018; AAE Tech Services 2016);

- supplemental studies conducted during spring and fall 2018 to document fish use of habitat occurring at the inlet and outlet of the LSMOC (NSC 2019c); and
- data collected during supplemental studies conducted during spring 2021 (NSC 2022g) and spring 2022 to document the occurrence, abundance, and distribution of larval fish in Lake St. Martin.

Additional data documenting larval fish abundance in Lake St. Martin will be collected prior to POC commissioning.

### 6.2.3 Identification of Benchmarks

The fish spawning studies will provide direct information on the relative number of adult spawners and newly hatched larval fish and as such provide the most direct indication as to whether operation of the POCs is potentially affecting fish populations. However, spawning is highly variable among years, depending on environmental conditions such as stream flow, water temperature, and lake elevation. Early warning triggers have been identified to indicate that a change may have occurred and that study design should be reviewed to confirm that data being collected are adequate to determine the potential causes of the effect. Management thresholds indicate a magnitude of change where mitigation measures may need to be evaluated and modified.

Benchmarks in relation to each of the key questions/studies are as follows:

- Does the timing and magnitude of spring spawning movements in the Dauphin and Fairford rivers change over time, specifically during POC operation?

  Results of standardized boat electrofishing conducted prior to commissioning will be compared during operation based on the presence/absence of key species, and a categorical comparison of abundance over the three days with the highest catches (coinciding with peak spawning movement), i.e., low, medium and high. The early warning trigger is the decline of key species by one category and the absence of less frequent species in one year; the management threshold is a change observed over two monitoring cycles.

- Does the timing and magnitude of fall movements and, in particular, lake whitefish spawning movements, in the Dauphin and Fairford rivers change over time, specifically during POC operation?

  Results of standardized boat electrofishing conducted prior to commissioning will be compared during operation based on a categorical comparison of abundance over the three days with the highest catches (coinciding with peak spawning movement), i.e., low, medium and high. The early warning trigger is the decline of lake whitefish by one category; the management threshold is a change observed over two monitoring cycles.

- Does the occurrence and density of lake whitefish larvae within Lake St. Martin in the spring (including Birch Bay and the Narrows) change over time?

  The early warning trigger is a decline in the frequency of larval fish capture in any of the three areas where sampling occurs (i.e., south basin, Narrows and north basin). The management threshold is if the decline in frequency occurs for two monitoring cycles.

- Does the species composition and number of larval fish passively drifting in the Fairford and Dauphin rivers change over time, specifically during POC operation?

  The early warning threshold is a statistically significant decline in the CPUE of a key species. The management threshold is the absence of a key species for one year.

## 6.3 Spring Fish Use of the Dauphin and Fairford Rivers

### 6.3.1 Purpose

Monitoring will be conducted to determine the extent to which, if any, operation of the channels affects use of the Dauphin and Fairford rivers by spring spawning species. These include (but are not limited to) walleye, white sucker, and Shorthead Redhorse.

The following key question will be addressed:

- Does the timing and magnitude of spring spawning movements into the Dauphin and Fairford rivers change over time, specifically during POC operation?

### 6.3.2 Timing

Monitoring will occur during April/May if the POCs are in operation. Activities would be conducted concurrently with the larval drift studies (Section 6.6). The frequency and duration of monitoring will be as described in Section 2.1.

### 6.3.3 Field and Laboratory Methods

Fish will be collected from the Fairford and Dauphin rivers using a boat-based electrofisher to document fish use during spring and to determine the presence of spawning fish.

It is anticipated that monitoring will be comprised of several short sampling sessions per sampling year to maintain effort at a reasonable level while providing sampling coverage throughout spring. This is to account for the timing of spawning-related movements of large-bodied fish during spring -and to examine change in fish abundance as flow recedes following the spring freshet.

### 6.3.4 Parameters

At each sampling location, captured fish will be enumerated by species, measured for length and weight, and information describing their spawning condition will be noted.

Sampling effort (i.e., number of seconds the electrofisher was in operation) will be recorded for each sampling location.

### 6.3.5 Data Analysis

Analyses will include the calculation of size, condition, relative abundance, and CPUE for each species and for each location.

Comparison of site-specific fish use metrics (relative abundance, CPUE, and number of spawners) will be provided between baseline conditions and following flow reduction.

## 6.4 Fall Fish Use of the Dauphin and Fairford Rivers

### 6.4.1 Purpose

Monitoring will be conducted to determine the extent to which, if any, operation of the channels affects use of the Dauphin and Fairford rivers by fall spawning species and other species that use the rivers as a fall movement corridor. In particular, the investigations will be conducted to determine the extent to which, if any, operation of the channels affects the lake whitefish spawning migration in the Dauphin and Fairford rivers.

The following key question will be addressed:

- Does the timing and magnitude of the fall movements and, in particular, lake whitefish spawning movements in the Dauphin and Fairford rivers change over time, specifically during POC operation?

### 6.4.2 Timing

Monitoring will be conducted during fall in years that flood waters are diverted through the POCs after mid-September to October, coincident with the timing of lake whitefish spawning movements. Monitoring will only be conducted during years when the channels are operated during the spawning migration period. The frequency and duration of monitoring will be as described in Section 2.1.

### 6.4.3 Field and Laboratory Methods

Fall fish movements into the Dauphin and Fairford rivers will be monitored using boat electrofishing. Boat electrofishing was used to assess the timing and magnitude of fall whitefish movements during EOC studies in 2011-2014 and in the Dauphin and Fairford rivers during supplemental studies conducted during fall 2020, spring 2021, and fall 2021. While this method does not provide a total count of migrants, CPUE based on boat electrofishing catches provides a means for comparison of fish abundance between sampling sessions and years and will be used to obtain a relative estimate of fish abundance. Boat electrofishing will be conducted periodically through fall (mid-September to freeze up) to capture changes in fish occupation ion the rivers and movement patterns as fall progresses. Sampling will be conducted in the Fairford River at a location immediately downstream of the FRWCS and at a second location immediately upstream of Lake St. Martin. Similarly, sampling will be conducted in the Dauphin River at a location immediately downstream of Lake St. Martin and at a second location immediately upstream of Sturgeon Bay.

Split-beam hydroacoustic technology was used during supplemental studies to provide an assessment of fall fish activity in the Dauphin River during 2020 and 2021. The technology provides an enumeration of fish movements past a "receiver station" by direction and fish size, but does not identify fish to species and cannot determine repeated upstream and downstream movements by individual fish. While this method provided useful information regarding fish activity in the Dauphin River, boat electrofishing is efficient and more flexible with respect to use in the widely varying flow conditions experienced in the Dauphin and Fairford rivers. Split-beam hydroacoustic technology may be used in the future as a secondary method of monitoring fish activity if information in addition to boat electrofishing CPUE is required.

### 6.4.4 Parameters

Fish captured by boat electrofishing will provide species identification, size data, and information describing the spawning condition of migrating fish.

### 6.4.5 Data Analysis

Boat electrofishing data will be analyzed to describe species composition, size and spawning condition of fish moving into the Fairford and Dauphin rivers during fall. Catch-per-unit effort from the boat electrofishing catches will be calculated to compare relative fish abundance between years and locations. Fish abundance data collected during POC operation will be compared to pre-operation data to determine changes in fish movements in the Dauphin and Fairford rivers.

## 6.5 Spring Larval Lake Whitefish Emergence on Lake St. Martin

### 6.5.1 Purpose

The LMOC has the potential to affect lake whitefish spawning through several linkages. First, following construction of the LMOC there is the potential to affect local groundwater discharges in the vicinity of the channel outlet. A reduction in groundwater discharge to Birch Bay on Lake St. Martin could reduce the suitability of the bay for lake whitefish spawning if groundwater upwellings are one of the factors influencing lake whitefish spawning success. However, it is expected that any reduction in groundwater discharge would be negligible relative to surface flow. Operation of the LMOC may also affect lake whitefish spawning habitat in Birch Bay as a result of the deposition of fine sediments transported during channel operation on areas of coarse substrate. Additionally, an increase in water velocity through the Narrows during LMOC operation may adversely affect lake whitefish spawning at that location.

Monitoring will be conducted to determine whether operation of the LMOC affects lake whitefish reproductive success within Lake St. Martin. Larval lake whitefish will be sampled at several locations in Lake St. Martin including Birch Bay and the Narrows (Appendix 1, Figure 1-7).

The following key question will be addressed:

- Does the occurrence and density of lake whitefish larvae within Lake St. Martin in the spring (including Birch Bay and the Narrows) change in relation to channel operations??

### 6.5.2 Timing

Monitoring for larval lake whitefish in Lake St. Martin will occur the spring after commissioning to determine whether effects occurred in Birch Bay and in the years when the channel is operated after September 15 to determine whether lake whitefish successfully spawned in Lake St. Martin. The frequency and duration of monitoring will be as described in Section 2.1.

### 6.5.3 Field and Laboratory Methods

Larval fish will be collected from the surface waters of Lake St. Martin using a neuston sampler. Volume of water filtered by the sampler will be measured to allow for the calculation of larval fish densities.

Sampling will occur immediately after ice break up, a period when larval whitefish have very recently hatched, are poor swimmers, and are generally associated with the surface of the water column.

Although the Birch Bay area and Narrows of Lake St. Martin are the most likely areas to be affected by the Project, larval fish sampling will be conducted throughout the north and south basins to provide comparison of larval catches from other areas of the lake.

### 6.5.4 Parameters

Larval fish densities will be estimated based upon the catch and the volume of water filtered by the neuston sampler.

### 6.5.5 Data Analysis

Larval fish catches will be enumerated by species, sample, and sampling location. Larval lake whitefish (and other species) densities will be calculated for each sample site and sampling area. Comparison between sampling areas and sampling years will be provided. Baseline data will be compared with post-construction data to determine whether a change in lake whitefish reproductive success has occurred.

## 6.6 Spring Larval Fish Movements in Rivers

### 6.6.1 Purpose

The objective of this study is to determine the species composition and numbers of larval fish that may passively drift down the Fairford and Dauphin rivers during and immediately after POC operation. This study will provide context for the number of drifting larval fish found in the POCs (Section 7.4) and also indicate the success of spring and fall spawning fish during operation of the POCs. It should be noted that drifting larval lake whitefish hatch the spring after eggs are laid; therefore, the success of fall spawning during or immediately after closure of the WCSs is determined by drift the following spring.

The following key question will be addressed:

- Does the species composition and number of larval fish passively drifting in the Fairford and Dauphin rivers change over time, specifically during POC operation?

### 6.6.2 Timing

Monitoring studies will be conducted during channel operation to determine the species composition and abundance of larval fish that drift down the Fairford and Dauphin rivers. In years when the channels operate during the lake whitefish fall spawning migration (after September 15), monitoring will also occur in the spring following operation. The frequency and duration of monitoring will be as described in Section 2.1.

### 6.6.3 Field and Laboratory Methods

Larval fish drift will be monitored at the following locations (Appendix 1, Figure 1-7):

- Fairford River downstream of Lake Manitoba;
- Fairford River upstream of Lake St. Martin;
- Dauphin River downstream of Lake St. Martin;
- Dauphin River upstream of confluence with Buffalo Creek; and
- Dauphin River downstream of Buffalo Creek but upstream of the influence of Sturgeon Bay.

Larval fish will be captured using larval drift traps. Two traps will be set at each sampling location and will sample continuously during each sampling session. Flow meters will be used to estimate the volume of water that is sampled.

Monitoring will be comprised of several sampling sessions per sampling year to maintain sampling effort at a reasonable level while providing coverage throughout spring. This is to account for differences in the timing of hatch and at which larvae of different species are vulnerable to passive movement with water flow. Specifically, larval lake whitefish drift immediately after ice off, while spring spawning species such as walleye and sucker drift later in spring.

### 6.6.4 Parameters

Larval fish densities will be estimated based upon the catch and the volume of water sampled by the drift traps.

### 6.6.5 Data Analysis

Data will be analyzed to provide an estimate of larval movements by species, location and date during each sampling year. Comparisons will be provided for the Dauphin and Fairford rivers for periods of varying discharge.

## 6.7 Adaptive Management

Two levels of benchmark were identified in Section 6.2.3: early warning triggers indicate that a change may have occurred, and that study design should be reviewed to confirm that data being collected are adequate to determine the potential causes of the effect; and management thresholds indicate a magnitude of change where mitigation measures may need to be evaluated and modified. The early warning trigger is intended to proactively modify the scope of the studies, if and as required, such that information to address potential adverse effects is obtained in a timely manner. In the case of the fish spawning metrics, the analysis would also examine whether related variables have been affected. For example, if a decline in the emergence of larval lake whitefish is observed on Lake St. Martin, then potential linkages to the Project such as changes to aquatic habitat from increased sedimentation would be examined. The management threshold benchmark indicates that a change in spawning has occurred, although that may not ultimately affect the fish community. However, the need for changes to mitigation measures would be assessed. The discussion below provides some potential measures, but the appropriate response would need to be determined based on an analysis of all monitoring results.

*Does the timing and magnitude of spring spawning movements in the Dauphin and Fairford rivers change over time, specifically during POC operation?*

The management threshold for spring spawning movements in the Dauphin and Fairford rivers is a change in fish CPUE observed over two monitoring cycles (i.e., two separate flood events).

Management actions would depend on the cause of the change. For example, if fish are aggregating at the outlet of the LMOC rather than moving up the Fairford River, recruitment would be monitored to determine if spawning success at the outlet was comparable to that of the Fairford and if not, what measures could be taken to improve the outlet as spawning habitat.

*Does the timing and magnitude of the fall lake whitefish spawning movement in the Dauphin and Fairford rivers change over time, specifically during POC operation?*

As with the spring spawning studies, the management threshold is a change in CPUE during the peak fall spawning run observed over two monitoring cycles.

Changes in lake whitefish numbers may be linked to external factors such as warmer water temperatures and this possibility would be assessed by determining whether monitoring in other areas has shown similar declines. Management actions would depend on the cause of the change. For example, if fish are aggregating at the outlet of the LSMOC rather than moving up the Dauphin River, recruitment would be monitored to determine if spawning success at the outlet was comparable to in Lake St. Martin and the Dauphin River and if not, what measures could be taken to improve the outlet as spawning habitat. Other potential measures would include stocking to supplement fish production.

*Does the occurrence and density of lake whitefish larvae within Lake St. Martin in the spring (including Birch Bay and the Narrows) change over time?*

The management threshold for larval fish abundance in Lake St. Martin is a decline in the frequency of capture in standard neuston tows for two flood events. The appropriate mitigation would depend on the cause for this decline. For example, if unanticipated sedimentation occurs in the spawning habitat in the south basin of Lake St. Martin then substrate may be placed to create new spawning shoals.

*Does the species composition and number of larval fish passively drifting in the Fairford and Dauphin rivers change over time, specifically during POC operation?*

The management threshold for larval drift in the rivers is the absence of a key species for a single year, or a decline in the CPUE below the range observed during pre-commissioning studies for two flood events. Potential management measures would depend on the cause of the decline, which could be due to reduced populations of adult fish, a degradation of spawning habitat in the rivers, or conditions in Lake St. Martin upstream where many of the larval fish originate.

# 7.0 EFFECTS AT THE PERMANENT OUTLET CHANNELS

## 7.1 Rationale

The Project has the potential to affect the fish community through several pathways directly linked to operation of the POCs, as follows:

- increased movements of adult and larval fish from Lake Manitoba to Lake St. Martin and from Lake St. Martin to Sturgeon Bay via the channels may result in a loss to upstream populations;
- attraction of fish away from the Fairford River and to the new inflow in Lake St. Martin during operation of the LMOC and away from the Dauphin River and to the new inflow in Sturgeon Bay during operation of the LSMOC may result in a reduction in successful spawning and ultimately recruitment;
- possible stranding and subsequent mortality of fish in the POCs following closure of the WCSs; and
- possible mortality of fish occupying the channels when the WCSs are closed due to DO declining to critically low concentrations.

The environmental assessment indicated that these effects were not significant, based on planned mitigation. However, monitoring is required to confirm these assessments and determine whether modifications to planned mitigation measures are required as described in Section 7.9. Results of studies described in this section will provide information on direct effects to fish at the channels and, taken together with results of studies described in Sections 5.0 and 6.0, indicate whether fish interactions with the channels have the potential to result in adverse effects to the fish community as a whole. For example, the numbers of fish attracted to spawn at the POC outlets, if any, will be compared to numbers using the Dauphin and Fairford rivers during operation to determine whether there is a potential for a detectable reduction in recruitment.

## 7.2 Approach

### 7.2.1 Key Questions and Overview of Studies

Monitoring of the POCs has been designed to address the following questions:

- What is the number and species composition of adult and juvenile fish that move downstream through the LMOC and LSMOC during channel operation?
- What is the number and species composition of larval fish that passively drift downstream through the LMOC and LSMOC during channel operation?
- Do fish use habitat at the LMOC and LSMOC outflows during periods of channel operation, specifically for spawning?

- Do fish become stranded (i.e., trapped on dry land or within wetted habitat from which they cannot move to an adjoining lake and death is therefore imminent) within the LMOC and LSMOC following closure of the WCSs?
- Do fish use habitat within the LMOC and LSMOC after WCS closure, making them potentially vulnerable to mortality?
- Does fish mortality occur within the LMOC and LSMOC during periods of low DO concentrations?

To address these questions, six studies will be conducted to assess:

- Adult and juvenile fish movement through the POCs;
- Larval drift through the POCs;
- Fish use of the POC outlets during channel operation;
- Fish stranding after WCS closure;
- Fish use of the POCs when the WCSs are closed; and
- Fish mortality after low DO, if observed.

### 7.2.2 Baseline Information

Data will be collected after the POCs are constructed.

### 7.2.3 Identification of Benchmarks

Fish use of the POCs will be examined in the context of potential adverse effects to the fish community in Lake Manitoba, Lake St. Martin and Sturgeon Bay. Therefore, benchmarks are a proportion of the potentially affected fish community: early warning triggers are meant to indicate a level below which relatively few fish are present in the POCs and an effect would be unlikely; and management thresholds are intended to indicate when a negative effect to the fish community may occur. However, exceedance of a management threshold does not indicate that an adverse effect to the fish community is occurring; rather it indicates that a targeted investigation is required to determine whether an adverse effect is occurring and, if so, help identify the appropriate mitigation measure. Results of monitoring programs focused on the fish community (Section 5.0) and fish spawning (Section 6.0) would be a key input to this investigation. Adaptive management measures to be considered for the POCs are provided in Section 7.9.

Benchmarks in relation to each of the key questions/studies are as follows:

- What is the number and species composition of adult and juvenile fish that move downstream through the LMOC and LSMOC during channel operation?

  Fish moving downstream through the POCs represent a loss to the upstream population and a gain to the downstream population. However, fish will also be able to move back upstream via the Fairford and Dauphin rivers. The early warning trigger is set at 5% of the harvest in 2000-2010 in the upstream commercial fishery (i.e., Lake Manitoba in the vicinity of the Fairford River for the LMOC and Lake St.

Martin for the LSMOC)[10]. This level of emigration is not expected to have an adverse effect on the sustainability of the fish population. The management threshold is set at 20% of the commercial fishery for the upstream commercial fishery, as emigration at this level may affect fish numbers; however, movements through the channels will also be considered in the context of fish movements recorded during other studies. For example, a large number of lake whitefish migrate upstream and downstream in the Dauphin River each year and movement of these fish downstream via the LSMOC during operation instead of the Dauphin River would not affect the population.

- What is the number and species composition of larval fish that drift downstream through the LMOC and LSMOC during channel operation?

  As with adult and juvenile fish, the transfer of larval fish represents a loss to upstream fish populations but not a net loss of fish. Larval drift downstream via the Fairford and Dauphin rivers occurs naturally and will be recorded during operation of the POCs (Section 6.6). If the number of larvae per unit of flow moving through the POCs is comparable to that in the two rivers, then the net amount of downstream movement is not affected by the Project (i.e., the same number of larvae would have moved downstream if all flow had passed via the rivers). The early warning trigger will be if the concentration of larvae is 10% greater in the POCs than the rivers and the management threshold will be 50% higher. The potential importance of downstream drift would also be considered in terms of the total numbers (i.e., if larvae drifting in the POCs represent less than 10% of the total drift in the Dauphin and or Fairford rivers and the channels, then this would not be a concern even if the density is higher).

- Do fish use habitat at the LMOC and LSMOC outflows during periods of channel operation, specifically for spawning?

  The early warning trigger for fish aggregating at the outflows would be numbers markedly higher than present overall in the lake, i.e., a CPUE that is 30% greater than the average catch in the lake. This would indicate that fish are attracted to the outlets. The management threshold would be if the CPUE at the outlets is greater than during the spawning runs in the Fairford and Dauphin rivers for the LMOC and LSMOC outlets, respectively. Exceedance of the management threshold would not indicate that an adverse effect is occurring, only that further investigation is required.

- Do fish become stranded within the LMOC and LSMOC following closure of the WCSs?

  This question is intended to address fish mortalities due to being trapped on the banks or isolated pools in the POCs as water levels drop, or on the drop structures in the LSMOC. The early warning trigger is set at 25 stranded fish observed along either the LMOC or the LSMOC. The management threshold is set at 50 fish at which point a salvage would be conducted.

[10] These years were selected because they represent the last decade where fishing was conducted annually prior to the 2011 flood.

- Do fish use habitat within the LMOC and LSMOC?

  The early warning trigger is a CPUE that is 20% of the CPUE in the Fairford and Dauphin rivers during comparable times of year. The management threshold is 50% of the CPUE in the rivers. Exceedance of the management objective does not indicate that an adverse effect to fish populations is occurring, but rather that conditions in the channels should be assessed as described in Section 7.9.

- Does fish mortality occur within the LMOC and LSMOC during periods of low oxygen concentrations?

  Criteria would be similar to those for mortality as a result of stranding, i.e., the early warning trigger is set at 10 fish and the management threshold is set at 50 fish.

## 7.3 Fish Movement through the POCs

### 7.3.1 Purpose

Operation of the LMOC and LSMOC may result in increased movements of fish from Lake Manitoba to Lake St. Martin and from Lake St. Martin to Sturgeon Bay via the channels. The effects of these movements on fish populations are expected to be minimal, but monitoring will be required to determine the extent to which downstream fish movements occur during channel operation, and whether there is an effect on the fish community related to increased downstream movements.

The following key question will be addressed:

- What is the number and species composition of adult and juvenile fish that move downstream through the LMOC and LSMOC during channel operation?

### 7.3.2 Timing

Downstream fish movements in the LMOC and LSMOC will be monitored during operation of the POCs for flood mitigation. The frequency and duration of monitoring will be as described in Section 2.1.

### 7.3.3 Field and Laboratory Methods

Split-beam hydroacoustics will be used to enumerate fish moving downstream past the WCSs in the LMOC and LSMOC (Appendix 1, Figure 1-8). “Receiver stations” will be installed in the channels immediately downstream of the WCSs at the onset of operation and will remain in place for the period of operation. The use of split-beam hydroacoustic technology provides an enumeration of fish movement past the receiver station by direction and size but does not identify fish to species.

Periodic fish sampling will be required to determine fish species moving through the channels and assist in analysis of hydroacoustic data. It is anticipated that a suite of fish capture techniques may be used, possibly including boat electrofishing, hoop nets, or gill nets. Captured fish will be enumerated by species and location, measured for size and examined for spawning status and external injuries.

### 7.3.4 Parameters

Data collected with the split-beam hydroacoustic program will include daily counts of fish moving downstream past the receiver station, and size estimates for fish moving past the station.

Fish captures will provide species identification and additional biological data.

### 7.3.5 Data Analysis

Hydroacoustic and fish capture data will be analyzed to provide daily counts of the number and size of fish and an estimate of the species composition of fish moving downstream within the channels.

## 7.4 Larval drift through the POCs

### 7.4.1 Purpose

This study will monitor larval fish movements from Lake Manitoba to Lake St. Martin and from Lake St. Martin to Sturgeon Bay to determine the species composition and numbers of larvae that may passively drift down the POCs during operation.

The following key question will be addressed:

- What is the number and species composition of larval fish that passively drift downstream through the LMOC and LSMOC during channel operation?

### 7.4.2 Timing

Monitoring studies will be conducted during operation of the POCs for flood mitigation. The frequency and duration of monitoring will be as described in Section 2.1.

### 7.4.3 Field and Laboratory Methods

Larval fish drift will be monitored at the following locations:

- inlet and outlet of the LMOC; and
- inlet and outlet of the LSMOC.

Larval fish will be captured using larval drift traps comparable to those used in the Dauphin and Fairford rivers (Section 6.6). Two traps will be set at each sampling location and will sample continuously during each sampling session. Flow meters will be used to estimate the portion of channel flow that is sampled.

It is anticipated that monitoring will be comprised of several sampling sessions per sampling year to maintain sampling effort at a reasonable level while providing coverage throughout spring. This is to account for differences in the timing of hatch and at which larvae of different species are vulnerable to passive movement with water flow. Specifically, larval lake whitefish drift immediately after ice off, while spring spawning species such as walleye and sucker drift later in spring.

### 7.4.4 Parameters

Larval fish densities will be estimated based upon the catch and the volume of water sampled by the drift traps.

### 7.4.5 Data Analysis

Data will be analyzed to provide an estimate of larval movements by species, location and date during each sampling year. Comparisons will be provided to drift in the Dauphin and Fairford rivers described in Section 6.6.

## 7.5 Fish use of the Outlets during Channel Operation

### 7.5.1 Purpose

This study will determine the extent to which, if any, fish will be attracted to spawn at the outlets during channel operation.

The following key question will be addressed:

- Do fish use habitat at the LMOC and LSMOC outflows during periods of channel operation and are fish using these areas for spawning?

### 7.5.2 Timing

Monitoring will be conducted during operation of the channels for flood mitigation. The frequency and duration of monitoring will be as described in Section 2.1.

### 7.5.3 Field and Laboratory Methods

Sampling will be conducted downstream of the control structure at the LMOC and downstream of the final drop structure on the LSMOC.

A suite of sampling methods will be used to document fish occurrence and habitat use within the channel outflows. Fish capture methods will be based on site conditions (e.g., water velocity and depth) but it is expected that a combination of methods including boat electrofishing, gill nets, and/or hoop nets will be used. Captured fish will be enumerated by species and location, measured for size and examined for spawning status and external injuries.

Habitat use will focus on spawning (i.e., are fish spawning in the outflows). The occurrence and success of spawning in outflow areas will be documented by the collection of fish eggs, using egg mats, during spring and/or fall. Larval drift will also be recorded in drift traps, as described in Section 6.6.

The timing of the spawning-related activities to be documented will dictate the timing of studies. For example, during spring, larval lake whitefish hatch shortly after ice off, adult walleye and white sucker move to spawning areas and begin to spawn concurrently or shortly thereafter, and larval walleye and white sucker

hatch about 2-3 weeks after spawning occurs. During fall, lake whitefish and cisco begin to congregate prior to spawning as temperatures decrease below about 8°C, with actual spawning occurring at temperatures ranging from 0-5°C. Consequently, a series of short-duration field campaigns (2-4 days) will be conducted at two week intervals during spring and/or fall during each monitoring period to provide snapshots of biological activity over a broader time period, allow field investigations to target specific biological occurrences, and document general spring and fall fish activity and habitat use as the season progresses.

### 7.5.4 Parameters

Adult and juvenile fish will be identified to species, measured and examined to determine sex and state of spawning condition.

Eggs and larval fish will be identified and enumerated by species and sampling location.

### 7.5.5 Data Analysis

Adult and juvenile fish data will analyzed by location (e.g., LMOC inlet) to describe the fish species, size of fish and spawning status of fish using outflow habitat during spring and fall.

Fish egg data will be used to provide descriptions of where spawning may have occurred at each location.

Larval fish occurrence and abundance data will be used to examine where spawning may have occurred (channel inlet vs outfall areas) and spawning success.

## 7.6 Fish Stranding in the Channels after WCS Closure

### 7.6.1 Purpose

Fish could be stranded within the POCs following closure, in particular if drawdown within the channels occurs rapidly. Within the LSMOC, fish may be stranded on the rock ramps comprising the downstream slope of the drop structures or along the shores of the channel. Channel closure is expected to increase water levels upstream of the control structure in the LMOC to the level of Lake Manitoba, but rapid drawdown could strand fish between the LMOC control structure and Lake St. Martin.

The following key question will be addressed:

- Do fish become stranded within the LMOC and LSMOC following closure of the WCSs?

### 7.6.2 Timing

Monitoring will occur immediately following WCS closure during commissioning and following closure after operation for flood mitigation. The frequency and duration of monitoring will be as described in Section 2.1.

### 7.6.3 Field and Laboratory Methods

Searches will be conducted along both banks of the LMOC downstream of the WCS to look for stranded fish immediately following closure of the channel. Stranded fish will be enumerated to species and locations where stranding occurs will be recorded. Size data will be collected from stranded fish.

Monitoring will also be conducted along the LSMOC during closure to look for fish that may become stranded on the downstream portions of the drop structures as waters recede. If a total of more than 50 fish are observed at all of the drop structures combined then a fish salvage will be implemented immediately to collect and release stranded fish. If a salvage is implemented, salvage crews will be stationed at each drop structure as required, and salvaged fish will be enumerated by location and species, measured and examined for injury and released into the LSMOC. Salvage crews will remain onsite until water levels within the LSMOC have stabilized. Salvaged fish will be enumerated by species and salvage location.

### 7.6.4 Parameters

Parameters include fish species and distribution, fish counts, and fish size data.

### 7.6.5 Data Analysis

Survey results will be analyzed to describe the occurrence, abundance, and distribution of stranded fish.

## 7.7 Fish Use of the POCs following Closure and during Non-Operation

### 7.7.1 Purpose

Fish may be attracted to the POCs, increasing their potential vulnerability to sub-optimal habitat conditions in the POCs. Surveys will be conducted to determine whether fish remain within the POCs following WCS closures.

The following key question will be addressed:

- Do fish use habitat within the LMOC and LSMOC?

### 7.7.2 Timing

Monitoring will occur a few weeks after WCS closure during commissioning and following closure after operation for flood mitigation. The frequency and duration of monitoring will be as described in Section 2.1.

### 7.7.3 Field and Laboratory Methods

Surveys will be conducted in fall if the WCSs are closed before mid September to document the numbers and species of fish present within the POCs both upstream and downstream of the WCSs. Surveys will be repeated in spring to document the fish that successfully overwintered in the channels. If the POCs are operated through the winter, then surveys will be conducted a few weeks after channel closure during the

open water season to allow fish the opportunity to move out of the channels. Surveys will be repeated if channels are not operated for an extended period (three or more years) to determine the numbers of fish still present. Surveys will also be repeated if conditions in the channels might significantly change (for example if the baseflow in the LSMOC would be reduced during drought conditions).

Fish will be captured using a combination of methods including boat electrofishing, backpack electrofishing, and gillnetting. Captured fish will be enumerated by species and location and will be measured and examined to determine spawning status (i.e., juvenile fish, adult fish in spawning condition).

### 7.7.4 Parameters

Parameters include fish species and distribution, fish counts, and fish size data. Fishing effort and biological parameters of captured fish (length, weight, state of sexual maturity) will be recorded.

### 7.7.5 Data Analysis

Survey results will be analyzed to describe the occurrence, abundance, and distribution of fish within POCs at various time periods following WCS closure.

## 7.8 Fish Mortality due to Dissolved Oxygen Depletion

### 7.8.1 Purpose

If low DO concentrations are recorded during winter water quality monitoring (Section 3.4), surveys will be conducted to determine whether fish mortality has occurred.

The following key question will be addressed:

- Does fish mortality occur within the LMOC and LSMOC during periods of low oxygen concentrations in winter?

### 7.8.2 Timing

Monitoring will be determined based upon results of DO monitoring described in Section 3.4.

### 7.8.3 Field and Laboratory Methods

Shoreline searches for fish mortalities in LMOC will be conducted by boat immediately after ice break up if ice conditions permit. If ice cover precludes the use of a boat, searches will be conducted by foot. Searches will focus on areas within the LMOC where recorded DO conditions were lowest, but other representative areas along the channel will also be searched.

Shoreline searches in the LSMOC will be conducted by foot immediately after ice break up in spring. Searches will focus along the banks of representative pools where DO has been monitored and are known to contain fish (Section 7.7).

### 7.8.4 Parameters

The occurrence, distribution, abundance, and distribution of fish mortalities will be recorded.

### 7.8.5 Data Analysis

Counts of fish mortalities will be tabulated by species and location.

## 7.9 Adaptive Management

The need for additional mitigation measures with respect to the POCs will be determined based on the magnitude of effects observed in relation to monitoring benchmarks set out in Section 7.2.3 and the risk to fish populations in Lake Manitoba, Lake St. Martin, and Lake Winnipeg. If changes to mitigation measures are required, the response would need to be determined based on effects observed in the POCs in conjunction with effects observed in the study area as a whole.

Two benchmarks (i.e., early warning triggers and management thresholds) were identified in Section 7.2.3. In general the early warning triggers indicate that a significant number of fish are present at the POCs, and a review of the monitoring program is required to determine whether modifications to the study are needed to better define potential effects. The early warning trigger is intended to proactively modify the scope of the studies, if and as required, such that information to address potential adverse effects is obtained in a timely manner. With respect to the POCs, the management threshold is the trigger to examine whether adverse effects to fish at the POCs are of sufficient magnitude to affect the fish communities in the study area.

The following discussion provides potential adaptive management measures that may be implemented if management thresholds are exceeded for each of the key questions.

*What is the number and species composition of adult and juvenile fish that move downstream through the LMOC and LSMOC during channel operation?*

Fish moving downstream through the POCs represent a loss to the upstream population and a gain to the downstream population. However, fish will also be able to move back upstream via the Fairford and Dauphin rivers. The management threshold is set at 20% of the commercial fishery as emigration at this level may affect fish numbers; however, as noted in Section 7.2.3, movements through the channels will also be considered in the context of fish movements recorded during other studies.

If a large number of fish are moving downstream then current commercial fisheries production data and other data sources (e.g., Lake St. Martin fish community data [Section 5.3]; CAMP data collected in the north basin of Lake Manitoba) would be examined in detail to determine if a downward trend in fish populations is observed. If necessary, measures to reduce fish emigration would need to be investigated.

*What is the number and species composition of larval fish that drift downstream through the LMOC and LSMOC during channel operation?*

The transfer of larval fish represents a loss to upstream fish populations but not a net loss of fish. Larval drift downstream via the Fairford and Dauphin rivers occurs naturally and will be recorded during operation of the POCs (Section 6.6). The management threshold will be a CPUE of larval drift in the POCs 50% higher than in the rivers.

As noted in Section 7.2.3, drift would also be considered in terms of total numbers compared to the rivers and in the context of other monitoring results, for example whether recruitment of key species (i.e., the year class strength) is notably lower in years of POC operation. If an adverse effect is observed, then measures to enhance recruitment in upstream lakes to offset these losses may be considered. These measures would depend on the adverse effect noted but may include the creation of spawning habitat and stocking.

*Do fish use habitat at the LMOC and LSMOC outflows during periods of channel operation, specifically for spawning?*

The management threshold would be a CPUE at the outlets that is greater than during the spawning runs in the Fairford and Dauphin rivers for the LMOC and LSMOC outlets, respectively, indicating that a fish are aggregating at the outlets. Exceedance of the management threshold would not indicate that an adverse effect is occurring, only that further investigation is required. In particular, the numbers of fish spawning at the outlets, and the fate of spawn (i.e., do eggs hatch) would be investigated. If conditions at the outlets do not support successful egg hatch, then measures to improve conditions would be investigated (e.g., placement of suitable substrate, extension of POC operation to allow for egg hatch).

*Do fish become stranded within the LMOC and LSMOC following closure of the WCSs?*

The management threshold for mortality due to stranding is set at 50 fish. Measures to mitigate stranding would depend on the location and timing of trapped fish. Potential measures include:

- modification of the shutdown procedure to induce fish to leave the POCs to reduce the incidence of stranding;
- recontouring the channel if there are isolated pools or other structures that are trapping fish; and
- conducting a fish salvage if large numbers of fish are stranded on the rock ramps at the downstream sides of the drop structures.

*Do fish use habitat within the LMOC and LSMOC?*

The management threshold is 50% of the CPUE in the rivers, but exceedance of threshold does not indicate that an adverse effect to fish populations is occurring, but rather that conditions in the channels should be assessed to determine if they are suitable to support fish production (rather than just conveying fish to the downstream waterbody) or if modified shut down procedures should be employed to trigger fish to leave the channels as the WCSs are closed.

*Does fish mortality occur within the LMOC and LSMOC during periods of low oxygen concentrations?*

Criteria would be like those for mortality due to stranding, i.e., the management threshold is set at 50 fish. If DO is reaching critically low levels, then methods of increasing DO such as increasing flow through the channels when they are not being operated for flood mitigation would be investigated. In addition, potential causes, and remedies for DO depletion would be examined (e.g., is organic matter accumulating in the channels during periods between use for flood mitigation and increasing the biological oxygen demand?).

# 8.0 MERCURY IN FISH FLESH

## 8.1 Rationale

Disruption and inundation of organic materials can increase the activity of bacteria that convert inorganic to organic mercury (i.e., methylmercury). Methylmercury can be taken up by aquatic organisms and passed up the food chain, becoming more concentrated in organisms higher up the food chain. Elevated concentrations of mercury in fish flesh can lead to human health concerns if fish is a large part of the diet. Although it is expected that the Project will not result in increased mercury concentrations in fish because flood mitigation will reduce overland flooding and associated inundation of organic soils. This parameter will be monitored to address concerns of local resource users. Initial monitoring will be conducted after commissioning of the POCs as this will be when organic soils in the immediate drainage basin are disrupted by construction and new areas within the drainage ditches are wetted.

## 8.2 Approach

### 8.2.1 Key Questions and Overview of Studies

Monitoring will address the following key question in respect to mercury in fish flesh:

- Will construction and commissioning of the Project result in increases in fish mercury concentrations that exceed baseline concentrations in Lake Manitoba, Lake St. Martin, and Sturgeon Bay?

One study will be conducted to address this question:

- Mercury concentrations in the flesh of fish from Lake Manitoba, Lake St. Martin and Sturgeon Bay will be monitored after commissioning of the POCs to determine if mercury concentrations increase and, if so, determine if it may be related to the Project.

### 8.2.2 Baseline Information

Total mercury concentration data was collected as part of EOC monitoring and as part of baseline studies for the Project (NSC 2013). Supplemental data were collected in fall 2018, fall 2020 and fall 2021.

### 8.2.3 Benchmark

The benchmark for the fish mercury monitoring program will be compared to the baseline total mercury concentration in walleye, northern pike, and lake whitefish from Lake Manitoba, Lake St. Martin and Sturgeon Bay based on recently collected data. Comparisons will also be made to the concentrations recorded during the EOC monitoring and available data from the commercial fishery. If there is a statistically significant increase in mercury concentration, then further steps would be taken as set out under adaptive management (Section 8.4).

## 8.3 Fish Mercury Concentration Monitoring

### 8.3.1 Purpose

Mercury concentrations in the flesh of fish from Lake Manitoba, Lake St. Martin and Sturgeon Bay will be monitored.

### 8.3.2 Timing

Initial mercury monitoring will be conducted following commissioning of the POCs. Subsequent mercury monitoring may be conducted after channel operation, generally in conjunction with fish community sampling on Lake St. Martin, if an increase in mercury concentrations is recorded after channel commissioning. The time frame over which mercury concentrations continue to increase in fish following changes to the aquatic environment varies and can be in the order of five years (i.e., period before peak concentrations are reached). Consequently, additional samples will be collected from commercial catches for five years after commissioning. If operation of flood mitigation occurs during this period, then samples will also be collected during fish community studies.

### 8.3.3 Field and Laboratory Methods

Tissue samples will be collected from a sample of walleye, northern pike, and lake whitefish for mercury analysis. When biological studies are not being conducted as part of this AEMP, fish will be purchased from commercial fishers. A range of fish lengths will be sampled if available.

### 8.3.4 Parameters

Parameters measured will include fish length, weight, age and total mercury.

### 8.3.5 Data Analysis

To reduce the effect of fish size/age and to facilitate comparisons over time, mean mercury concentrations will be standardized to a common fish length. These standard means will be calculated from unique regression equations, by species and waterbody, based on the analysis of logarithmic transformations of muscle mercury concentration and fork length.

## 8.4 Adaptive Management

If mercury concentrations significantly increase following commissioning of the channels, this information would be conveyed to the appropriate regulators to determine whether changes need to be communicated to consumers of fish. Other data sources (e.g., other mercury monitoring done of commercial fish catches, province wide studies such as CAMP) would be examined to determine whether this increase is attributable to the Project or other causes.

If an increase in mercury concentrations attributable to the POCs occurs after commissioning, then monitoring of mercury concentrations will occur again after diversion of water through the POCs for flood mitigation.

# 9.0 SCHEDULE AND REPORTING

As discussed in Section 2.1, monitoring activities for the Project are being conducted during several time periods:

- Supplemental data collection – additional studies planned prior to commissioning, as identified in Appendix 2, Table 2-2;
- Commissioning and immediate post-commissioning – will provide information on conditions in the POCs after they are wetted; and
- Operational phase – includes periods when the POCs are diverting water for flood mitigation, the year following operation, and times of non-operation.

The frequency and timing of studies during each time period is presented in Appendix 2, Table 2-5.

As discussed in the preceding sections, the supplemental data, in conjunction with data collected during operation of the EOC and to support the environmental assessment, will be used to calculate numeric values for benchmarks that have been identified in this AEMP. Prior to commissioning of the POCs, a report will be produced providing the numerical values of the benchmarks.

Commissioning (i.e., initial diversion of flow through the POCs) is currently planned to occur outside of the sensitive timing periods defined by DFO (i.e., commissioning is planned to occur between July 1 – September 15). Results of monitoring conducted during and in the year following commissioning will be used to determine whether modifications are required to monitoring planned for flood events when flows are diverted through the POCs (i.e., operation monitoring) as follows:

- Results of TSS and other water quality monitoring downstream of the outlets during commissioning will indicate whether diversion of flow through the POCs has the potential to have greater than anticipated effects to water quality. In particular, the need to extend the spatial extent of monitoring will be assessed;
- Habitat conditions in the channels after being wetted, including both open water and under ice, will be evaluated to determine whether there are any immediate concerns with fish survival. DO concentrations and water depth will be the focus of this analysis;
- The numbers and species of fish that are present in the channels as a result of the flow diversion and wetting will be assessed to determine whether there is a concern with stranding of fish in the channels and whether potential modifications to ramp down procedures should be implemented; and
- Water quality, habitat, and fish will be examined in Birch Creek and Buffalo Creek after the channels have been commissioned to document conditions in the creeks and provide assurance that conditions are suitable for the survival of fish.

During the operational phase, annual workplans will be developed prior to each open water season when monitoring is required or anticipated to be required based on flood projections, considering the results of the previous studies, and status of operation/non operation of the POCs. If benchmarks were exceeded in the preceding monitoring period and the need for adaptive management (including modifications to the monitoring program, and development and implementation of additional mitigation) was identified, then monitoring activities would be adjusted accordingly.

Reports that document the methods and results of the studies will be produced within one year of completion of the field studies conducted in that particular year. Where a second year of study is required, reporting would be completed prior to the start of the following field season such that results can inform activities to be implemented in that year. Reports will provide the following information:

- The objective of the particular study;
- Methods, including a description of any departure from the methods set out in the AEMP;
- Results of the study and comparison to pre-Project conditions, where applicable;
- Comparison to previous monitoring results, where relevant;
- Comparison to benchmarks set out in the AEMP;
- A discussion of results in comparison to anticipated effects identified during the environmental assessment, indicating whether unanticipated changes may be occurring; and
- Recommendations for modifications to the monitoring program, if any.

A synthesis report describing aquatic monitoring results will be prepared after two cycles of monitoring related to channel operation have been completed. The synthesis will include:

- A summary of monitoring studies and results completed to date, including in relation to the magnitude of flood events;
- Comparison of monitored parameters pre and post-Project, and in reference to anticipated environmental effects;
- A comparison to management thresholds, where relevant;
- A discussion of the overall changes observed as a result of the Project;
- A description of recommended and/or implemented changes to mitigation measures (e.g., fish salvage, shut down procedures for POCs to reduce fish stranding); and
- Recommendations for future monitoring.

# 10.0 REFERENCES

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NSC and KGS Group. 2016. Lake St. Martin Emergency Outlet Channel Assessment of Effects and Development of Habitat Compensation – Volume 3: Water Quality. A report prepared for Manitoba Infrastructure and Transportation.

# APPENDIX 1

## Figures

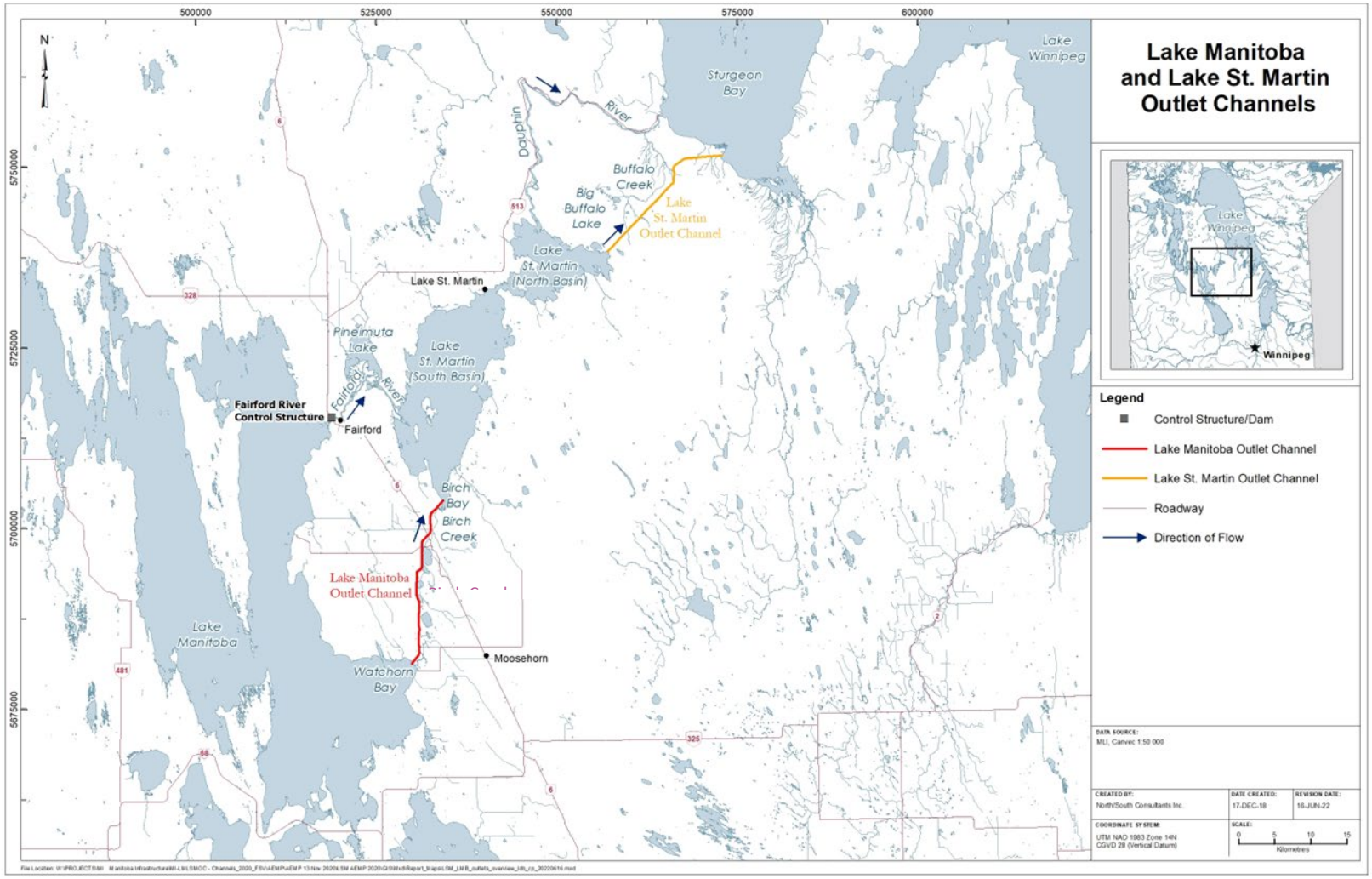


Figure 1-1: Location of Lake Manitoba and Lake St. Martin Outlet Channels and other waterbodies referenced in the AEMP. Arrows show direction of flow.

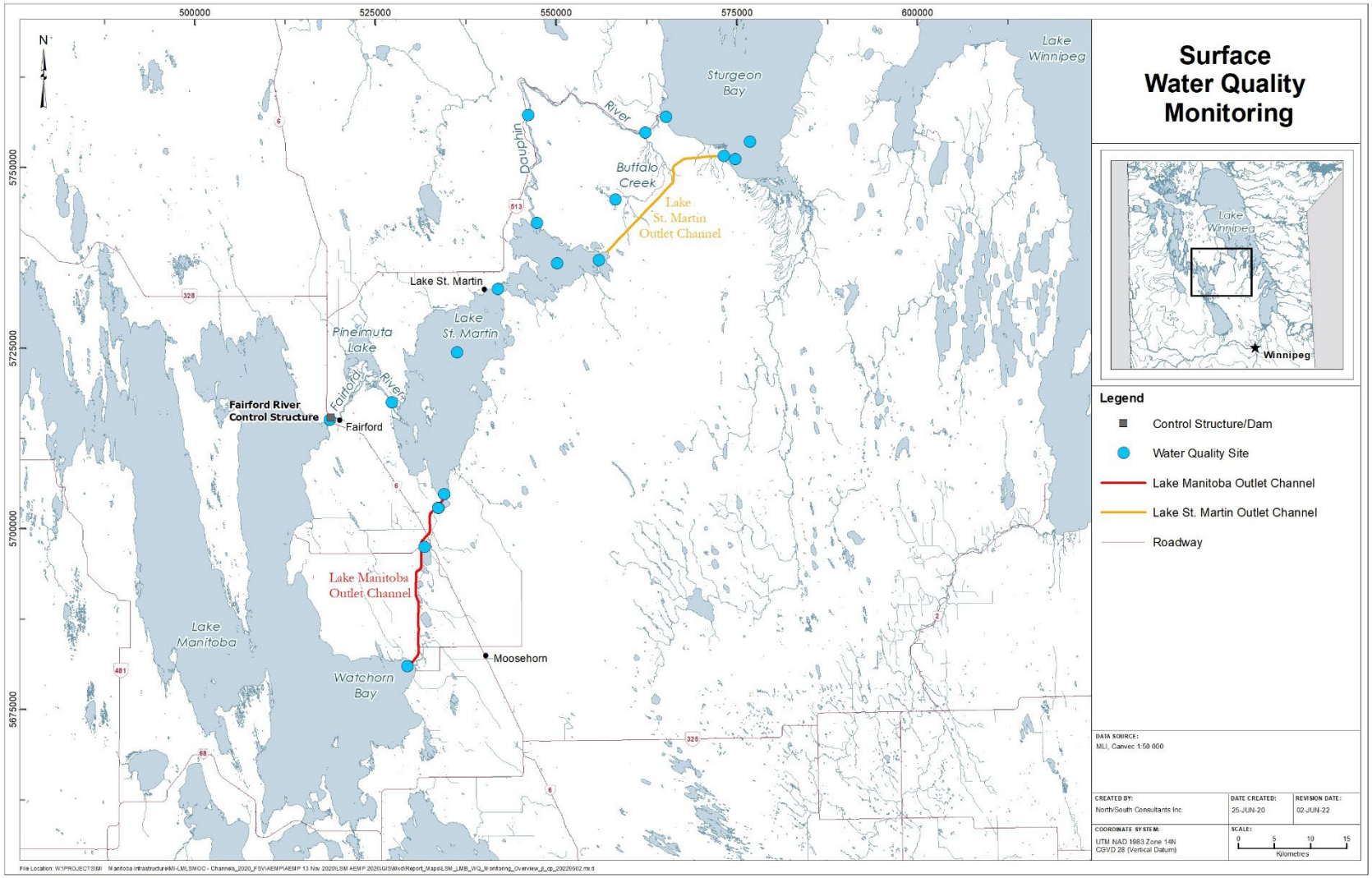


Figure 1-2: Location of surface water quality sampling sites.

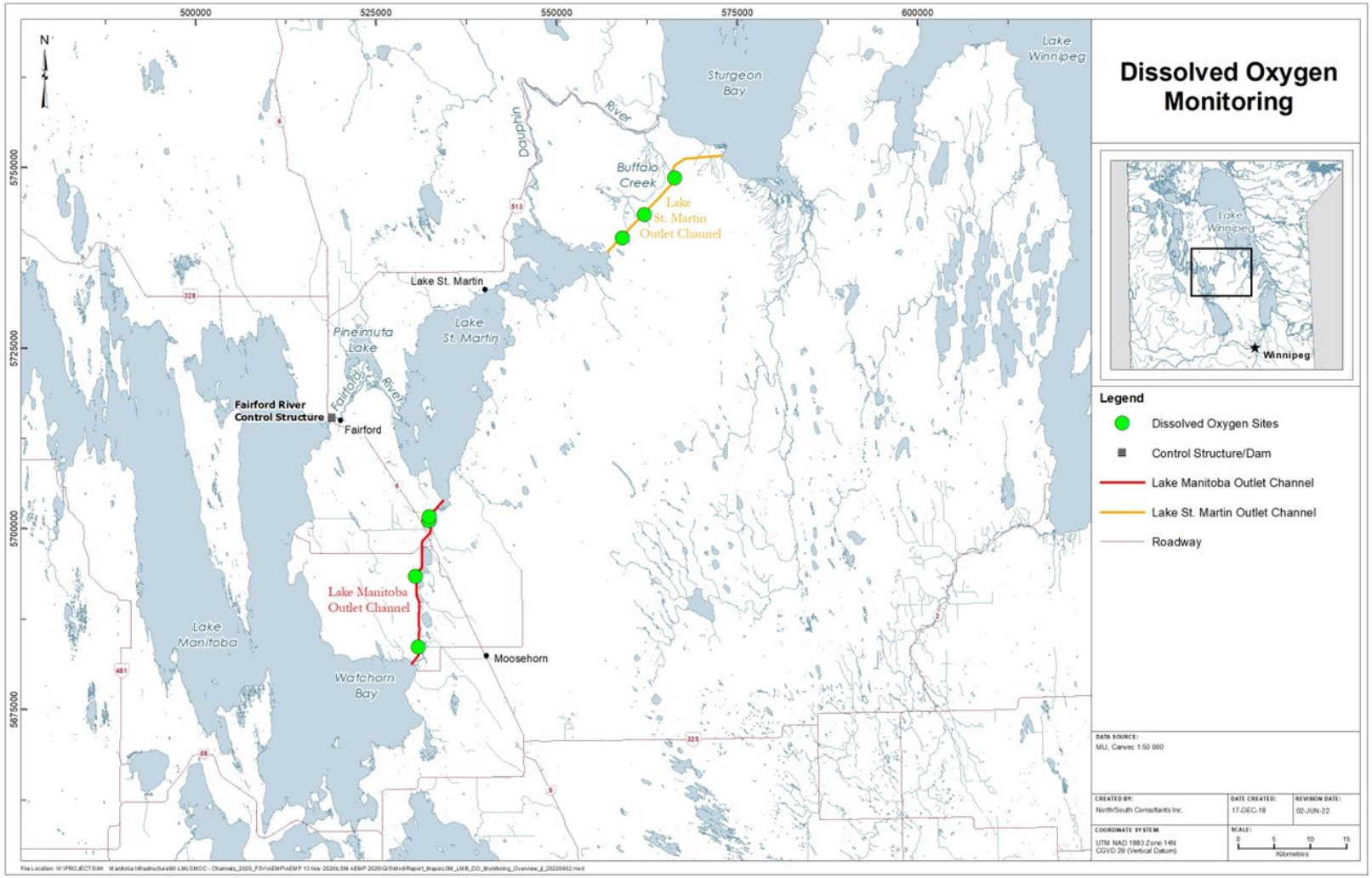


Figure 1-3: Location of DO monitoring sites.

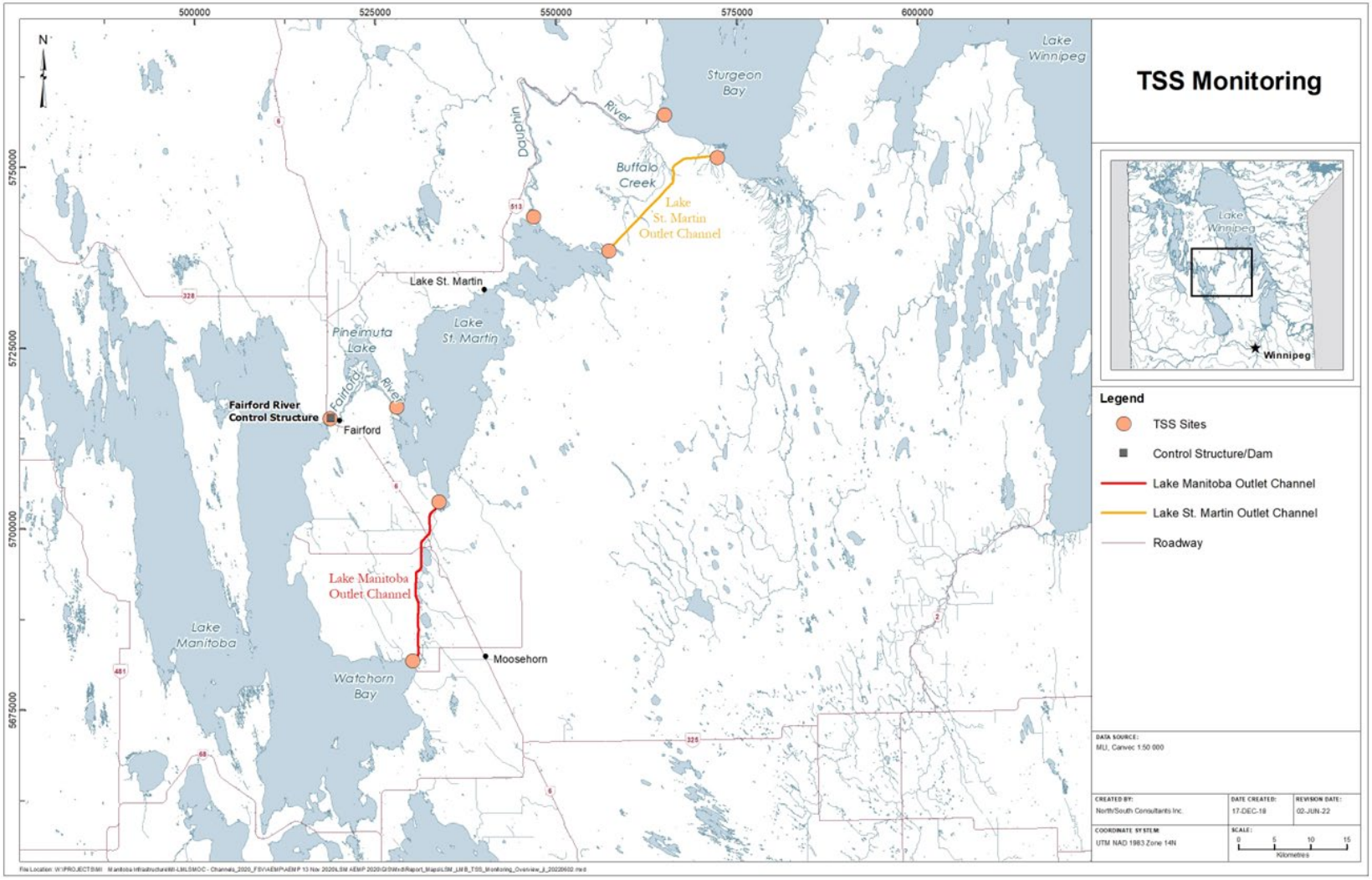


Figure 1-4: Location of turbidity logger and TSS sampling sites

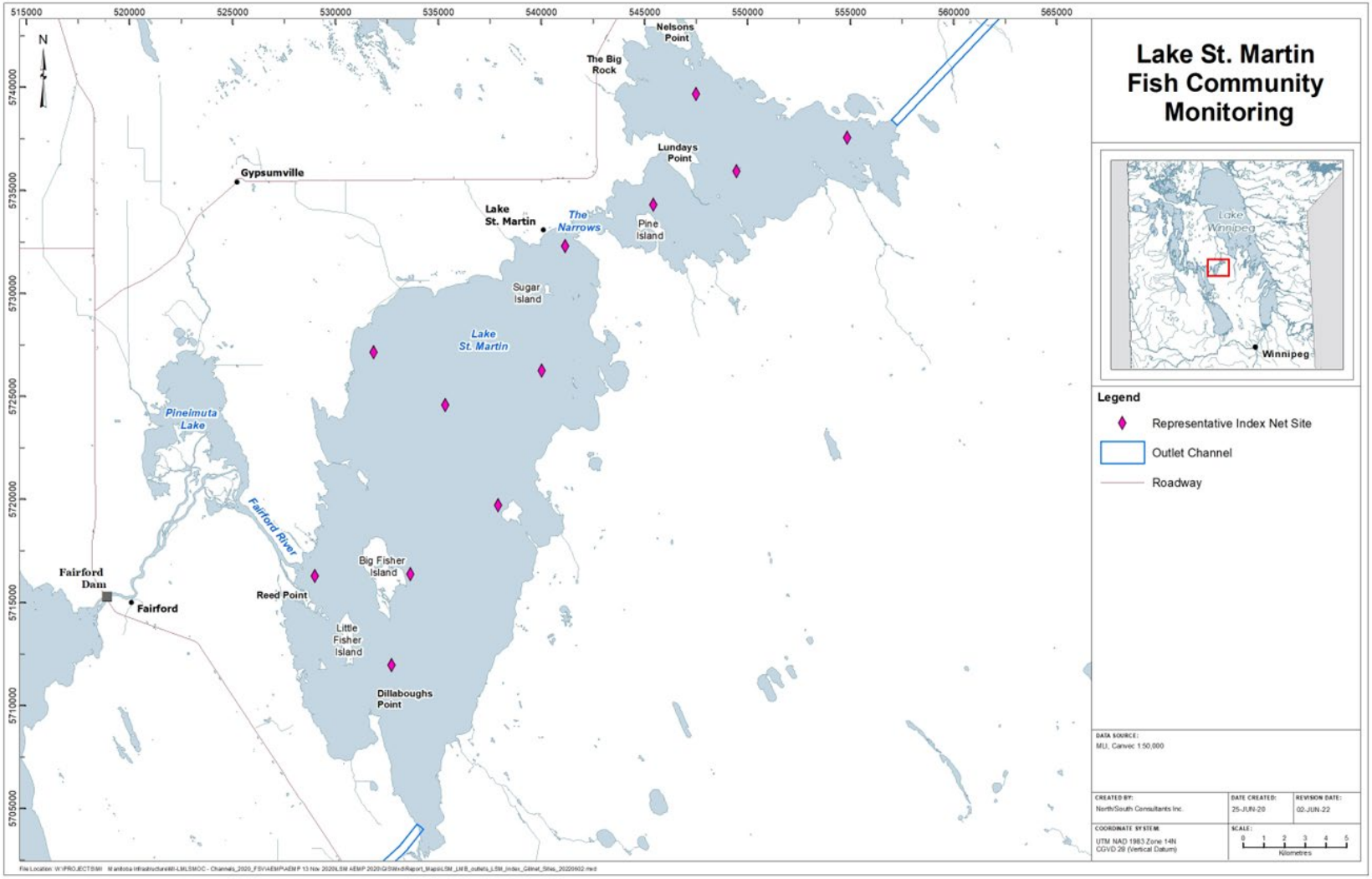


Figure 1-5: Representative standard experimental gill net sites for Lake St. Martin fish community sampling

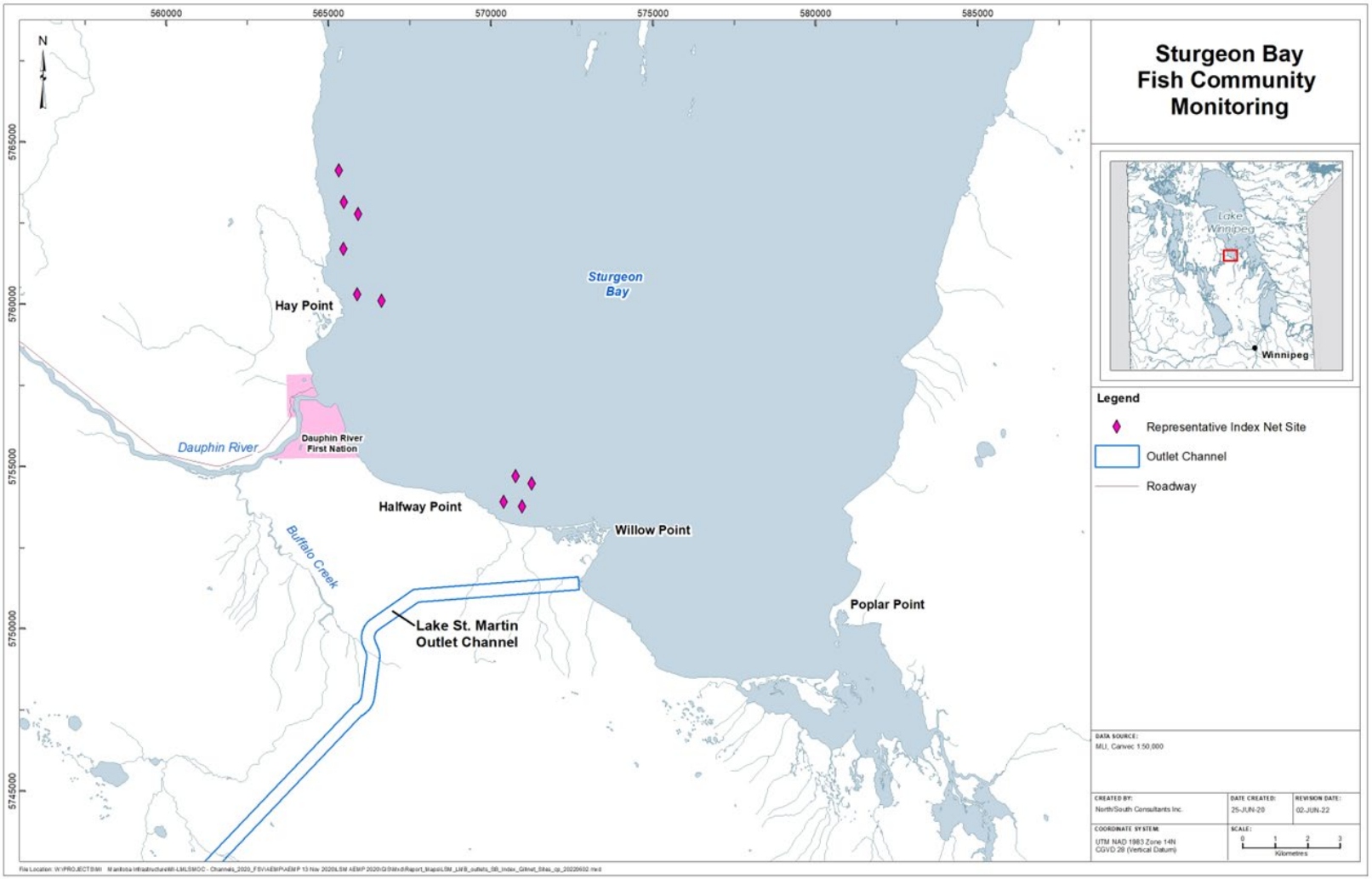


Figure 1-6: Representative index net sites for Sturgeon Bay fish community sampling as part of the CAMP. Sites may be added near the proposed LSMOC outlet.

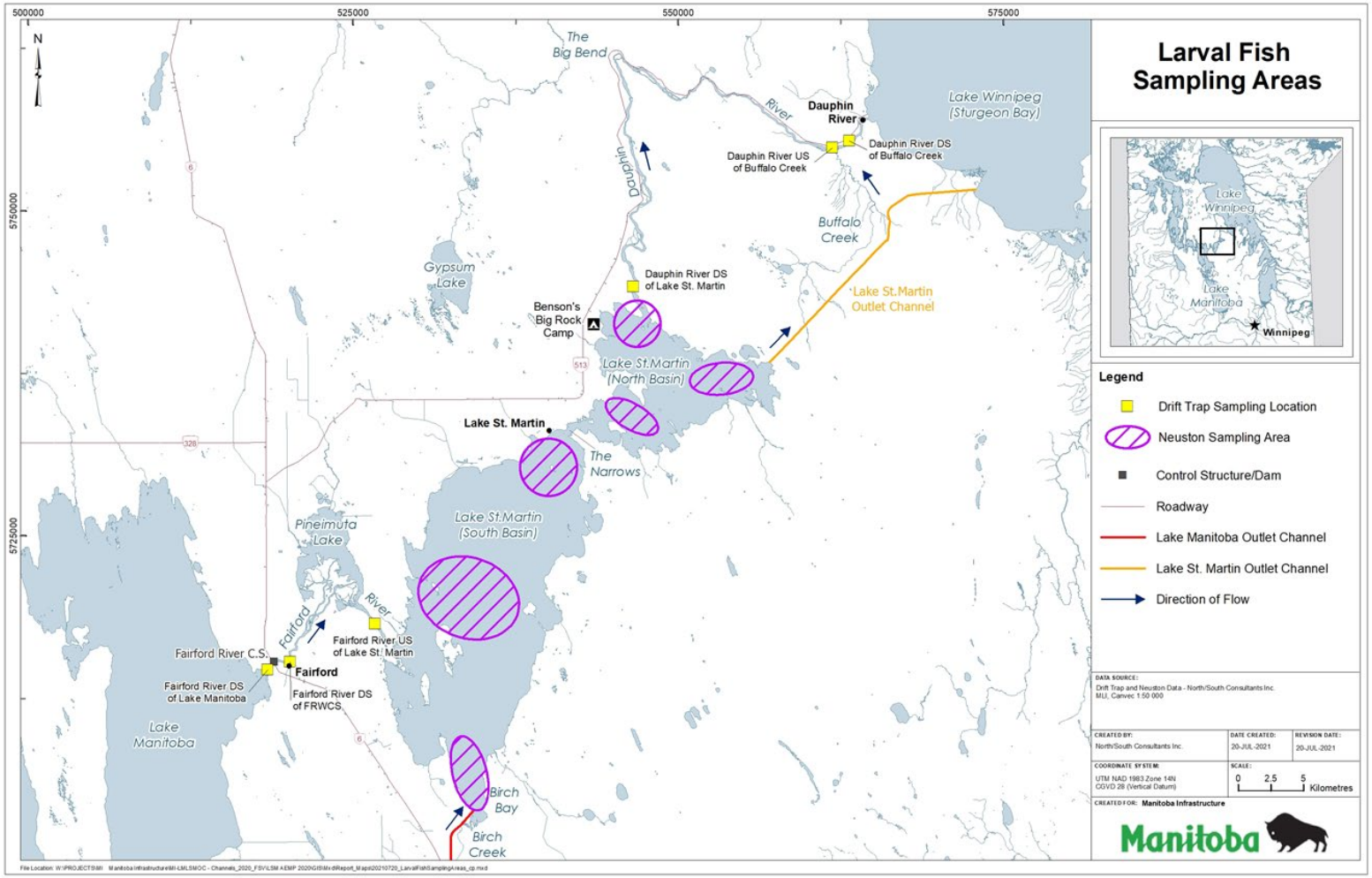


Figure 1-7: Larval lake whitefish sampling sites on Lake St. Martin and larval drift trap sites on the Dauphin and Fairford rivers.

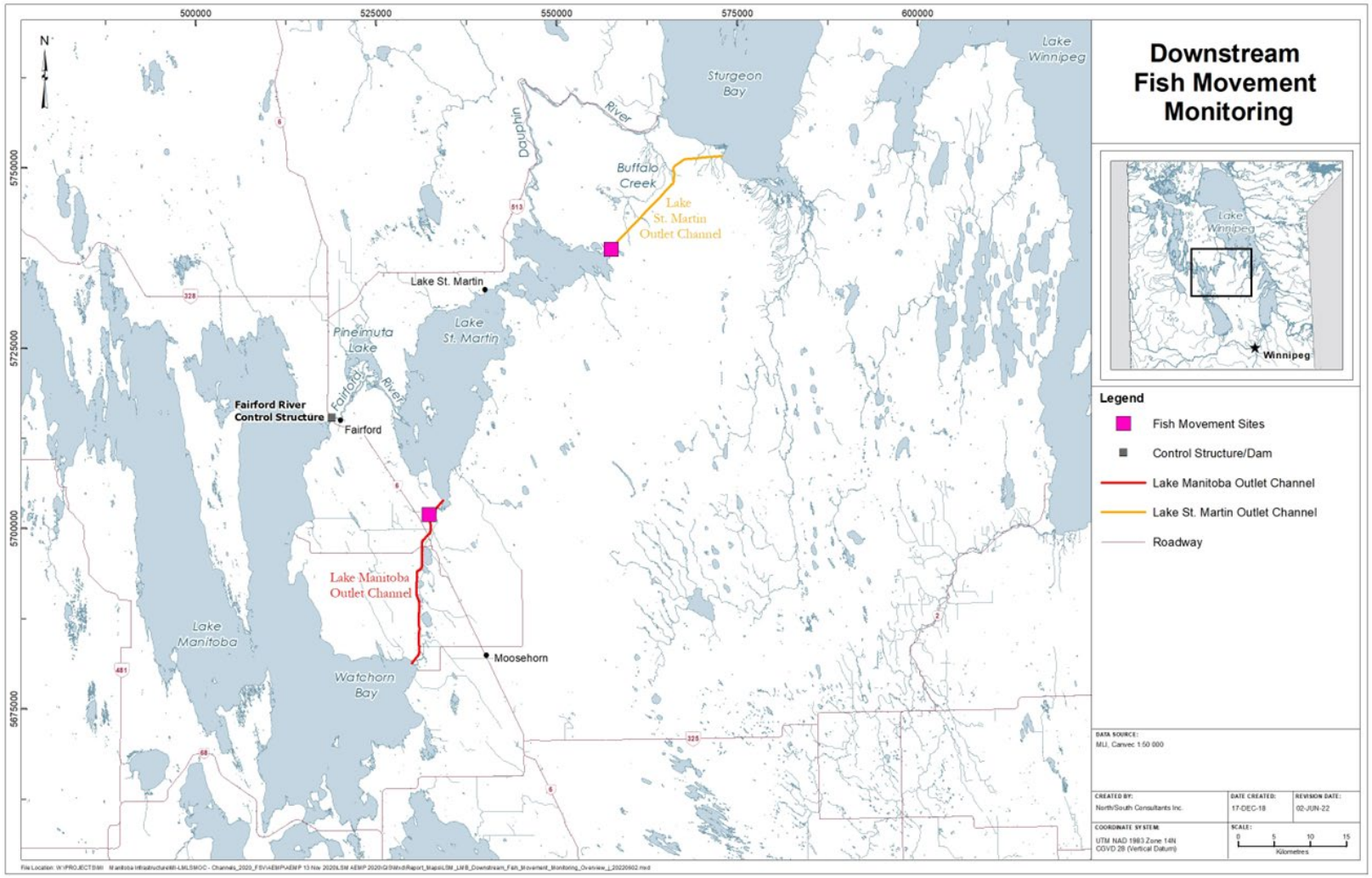


Figure 1-8: Location of hydroacoustic receiver stations to document downstream fish movements during POC operation.

# APPENDIX 2

## Tables

Table 2-1: Definition of Project phases and states used in the AEMP

| Project phase | Phase definition |
|---|---|
| **Supplemental Data Collection** | The period prior to commissioning; construction activities that are occurring are not expected to affect the aquatic environment components being studied.<br>Supplemental studies conducted to provide information to address additional data requirements identified during AEMP development. |
| **Commissioning and immediate post-commissioning** | Construction is complete and operation of channels is being tested during commissioning.<br>Data collected when flow is passing through the channels and when the channels are watered but there is no flow for one year after the WCSs are first opened. |
| **Operational Period** | Construction and commissioning are complete, channels have been watered.<br>The operational phase consists of three states described below. |
| **State of Operation** | **State definition** |
| **Water Control Structures Closed = non-operation state** | Water control structures are closed, and water is not being diverted for flood mitigation.<br>Monitoring studies conducted to determine whether conditions in the POCs are suitable for the survival of fish that are present. Studies may also be conducted in Birch and Buffalo creeks where adverse affects are more likely under natural low flow conditions. |
| **Water Control Structures Open = operation state** | Water control structures are open and water is being diverted to alleviate flood conditions.<br>Monitoring studies to describe effects related to water diversion through channels. |
| **Post-closure of Water Control Structures = post-operation state** | The immediate year following diversion of water through channels. Monitoring studies to determine effects of operation that may only be evident following operation. E.g., egg hatch of fall spawning fish in spring following operation. |

Table 2-2: Supplemental studies conducted prior to commissioning.

| Supplemental Studies | Study Objective | AEMP Section |
|---|---|---|
| **Surface water quality** | Provide additional water quality data at sites throughout study area, collected concurrently to allow assessment of spatial variation among sites. Data collection late summer 2020 – late fall 2021. An additional year of data collection will occur prior to commissioning of the POCs. | 3.3 |
| **Sediment quality in Lake St. Martin and Sturgeon Bay** | Provide pre-Project data on sediment quality at selected locations in the study area. Data collection fall 2020, supplemented by additional sites in 2021. | 3.5 |
| **Substrate composition at sites in Lake St. Martin and Sturgeon Bay** | Provide pre-Project substrate composition at sites where modelling has indicated that fine sediments may be deposited over coarse substrates during commissioning. Data collection 2021 (Lake St. Martin) and 2022 (Sturgeon Bay). | 4.4 |
| **Substrate composition at sites in Lake Winnipeg, including the nearshore off McBeth Point.** | Provide pre-Project substrate composition at sites where Fisher River Cree Nation indicated that sediments accumulated after operation of the EOC to provide the basis for comparison after commissioning of the POCs. Data collection summer 2022. Need for additional pre-commissioning data will be determined based on results. | 4.5 |
| **Fish community monitoring in Lake St. Martin** | Fish community composition data from Lake St. Martin to provide additional data against which potential changes related to channel operation will be assessed. Data collection 2018, 2021, and an additional year prior to commissioning. | 5.3 |
| **Fish use of Birch Creek and Buffalo Creek** | Investigations were conducted to determine the extent to which fish currently use habitat in the Birch and Buffalo creeks. Habitat information was also recorded during surveys. Data collection in 2021 (low flow) and 2022 (high flow). | 5.5 |
| **Spring fish spawning in Fairford and Dauphin rivers** | Determine the presence of adult fish during spring in the Dauphin and Fairford rivers. Data collection in 2021 and an additional year prior to commissioning. | 6.3 |

| Supplemental Studies | Study Objective | AEMP Section |
|---|---|---|
| **Fall Fish Use of the Dauphin and Fairford Rivers** | The magnitude and timing of fall fish movements, with emphasis on the lake whitefish, were documented in the Dauphin and Fairford rivers. Data collection in 2020 and 2021. These studies were conducted under extreme drought conditions to supplement studies conducted during the operation of the EOC under flood conditions. The need to collect additional data under conditions other than drought or flood will be assessed. | 6.4 |
| **Larval Lake Whitefish in Lake St. Martin** | The abundance and distribution of larval lake whitefish in Lake St. Martin were documented during early spring to determine the location of successful egg hatch in the lake. Data collection in 2021 and 2022. An additional year of data collection will occur prior to commissioning of the POCs. | 6.5 |
| **Larval fish drift in Fairford and Dauphin rivers** | Larval fish drift along the Fairford and Dauphin rivers provides the species composition and numbers of larval fish currently drifting through the system. Studies target both fall and spring spawners. Data collection in 2021 and 2022. An additional year of data collection will occur prior to commissioning of the POCs. | 6.6 |

Table 2-3: Water quality parameters to be sampled.

| Parameter Groups | | |
|---|---|---|
| **Routine Parameters** | **Metals (Total and Dissolved) and Major Ions** | |
| Routine Chemistry | Aluminum (Al) | Nickel (Ni) |
| Total alkalinity, as CaCO3 | Antimony (Sb) | Phosphorus (P) |
| Bicarbonate alkalinity as HCO3 | Arsenic (As) | Potassium (K) |
| Carbonate alkalinity, as CO3 | Barium (Ba) | Rubidium (Rb) |
| Hydroxide alkalinity, as OH | Beryllium (Be) | Selenium (Se) |
| pH | Bismuth (Bi) | Silicon (Si) |
| Conductivity | Boron (B) | Silver (Ag) |
| Total Dissolved Solids | Cadmium (Cd) | Sodium (Na) |
| Hardness, as CaCO3 | Calcium (Ca) | Strontium (Sr) |
| Nutrients | Cesium (Cs) | Sulphate (dissolved) |
| Total Ammonia (as N) | Chloride (dissolved) | Sulfur (S) |
| Nitrate (as N) | Chromium (Cr) | Tellurium (Te) |
| Nitrite (as N) | Cobalt (Co) | Thallium (Tl) |
| Nitrate and Nitrite (as N) | Copper (Cu) | Thorium (Th) |
| Total Kjeldahl Nitrogen | Iron (Fe) | Tin (Sn) |
| Total Nitrogen | Lead (Pb) | Titanium (Ti) |
| Dissolved Phosphorus | Lithium (Li) | Tungsten (W) |
| Total Particulate Phosphorus | Magnesium (Mg) | Uranium (U) |
| Total Phosphorus | Manganese (Mn) | Vanadium (V) |
| Total Inorganic Carbon | Mercury (Hg) | Zinc (Zn) |
| Total Organic Carbon | Molybdenum (Mo) | Zirconium (Zr) |
| Dissolved Organic Carbon | | |
| Total Carbon | | |
| Water Clarity | | |
| Total Suspended Solids | | |
| Turbidity | | |
| True Colour | | |
| Algal Pigments | | |
| Chlorophyll a | | |
| Phaeophytin a | | |

Table 2-4: Hydrocarbon and pesticide parameters measured at selected water quality sampling sites.

| Parameter Group | | | |
|---|---|---|---|
| Hydrocarbon Parameters | | Pesticide Parameters | |
| Benzene | Indeno(1,2,3-cd)pyrene | Aldrin | Oxychlordane |
| Ethyl benzene | 1-Methyl Naphthalene | alpha-BHC | Pentachloronitrobenzene |
| Toluene | 2-Methyl Naphthalene | beta-BHC | AMPA |
| o-Xylene | Naphthalene | gamma-hexachlorocyclohexane | Bromoxynil |
| m+p-Xylenes | Phenanthrene | delta-BHC | Clopyralid |
| Xylenes (Total) | Pyrene | a-chlordane | 2,4-D |
| F1 (C6-C10) | Quinoline | g-chlordane | Dicamba |
| F1-BTEX | B(a)P Total Potency Equivalent | o,p-DDD | 2,4-DB |
| F2-Naphth | | pp-DDD | 2,4-DP |
| F2 (C10-C16) | | o,p-DDE | Dinoseb |
| F3-PAH | | pp-DDE | MCPA |
| F3 (C16-C34) | | op-DDT | MCPB |
| F4 (C34-C50) | | pp-DDT | Mecoprop |
| Total Hydrocarbons (C6-C50) | | Dieldrin | Picloram |
| Acenaphthene | | Endosulfan I | 2,4,5-T |
| Acenaphthylene | | Endosulfan II | 2,4,5-TP |
| Acridine | | Endosulfan Sulfate | Triclopyr |
| Anthracene | | Endrin | Atrazine |
| Benzo(a)anthracene | | Endrin Aldehyde | Atrazine+N-Dealkylated Metabolites |

| Parameter Group | | | |
|---|---|---|---|
| Hydrocarbon Parameters | | Pesticide Parameters | |
| Benzo(a)pyrene | | Heptachlor | Ethalfluralin |
| Benzo(b&j)fluoranthene | | Heptachlor Epoxide | Atrazine Desethyl |
| Benzo(g,h,i)perylene | | Hexachlorobenzene | Fluazifop-p-butyl |
| Benzo(k)fluoranthene | | Hexachlorobutadiene | Glyphosate |
| Chrysene | | Hexachloroethane | Diclofop-methyl |
| Dibenzo(a,h)anthracene | | Methoxychlor | Triallate |
| Fluoranthene | | Mirex | Trifluralin |
| Fluorene | | trans-Nonachlor | |

Table 2-5: Schedule of monitoring planned to be conducted for the Aquatic Effects Monitoring Program.

| Study | Additional Supplemental Data 2022 + | Commissioning [1] | Post-Construction | | |
|---|---|---|---|---|---|
| | | | Non-Operation | Operation | Post-Operation |
| **Surface Water Quality** | | | | | |
| Core Water Quality | X | X | | X | X |
| DO | | X | X | | X |
| TSS | | X | | X | X |
| **Aquatic Habitat** | | | | | |
| Habitat at the POCs | | X | X | | X |
| Lake St. Martin and Sturgeon Bay Substrate | X | X | | | X |
| McBeth Point | X | X | | | X |
| **Fish - Community Studies** | | | | | |
| Lake St. Martin [2] | X | | X | | X |
| Sturgeon Bay [3] | X | X | X | X | X |
| Commercial Fishing Records | X | | X | | X |
| Birch and Buffalo Creeks | X | X | X | | |
| **Fish - Spawning** | | | | | |
| Spring Use of Dauphin and Fairford Rivers | X | | | X | |
| Fall Use of Dauphin and Fairford Rivers | | | | X | |
| Larval Lake Whitefish in Lake St. Martin | X | X | | | X |
| Larval Fish Movements in Rivers | X | | | X | X |

| Study | Additional Supplemental Data 2022 + | Commissioning [1] | Post-Construction | | |
|---|---|---|---|---|---|
| | | | Non-Operation | Operation | Post-Operation |
| **Fish - Effects at the POCs** | | | | | |
| Adult Fish Movements in POCs | | | | X | |
| Larval Fish Movements in POCs | | | | X | |
| Fish Use of the Outlets | | | | X | |
| Fish Stranding after Closure | | X | | | X |
| Fish Use of POCs | | X | X | | X |
| Fish Mortality due to DO Depletion [4] | | TBD | | | TBD |
| **Fish - Mercury** | | | | | |
| Mercury in Fish Flesh [5] | | X | | | TBD |

Notes:
Supplemental data collection to be completed prior to commissioning. Operation refers to the period when the WCs are open for flood mitigation; post operation is the period of monitoring immediately after WCS closure to address effects of operation. Non-operation is a period when the WCSs have been closed for more than a year. Note the monitoring of construction effects to water quality is presented in the Surface Water Management Plan.

1 The commissioning period begins when POCs are initially watered and extends for one year thereafter.
2 Monitoring will occur after POC operation and on an approximately 3 year cycle if POC operation does not occur
3 Sturgeon Bay fish community will be monitored annually as part of CAMP, results will be utilized by AEMP.
4 Monitoring will be conducted if DO levels decline to critically low concentrations.
5 Mercury samples will be collected for up to five years after channel commissioning