Pointe du Bois
Spillway Replacement Project

AQUATIC EFFECTS MONITORING PLAN

DRAFT

Manitoba Hydro

October 2012

POINTE DU BOIS
SPILLWAY REPLACEMENT PROJECT

Aquatic Effects Monitoring Plan

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Report Prepared for

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1.0 OVERVIEW

This document describes the Aquatic Effects Monitoring Plan (AEMP) for the Pointe du Bois Spillway Replacement Project (the Project) at the Pointe du Bois Generating Station (GS) on the Winnipeg River in southeastern Manitoba.

1.1 Project Description

The Project, which will be constructed and operated by Manitoba Hydro, involves replacing the existing spillway and sluiceway with a new 7-bay spillway located in an excavated channel located east of the existing spillway. A new earth fill dam will be constructed mid-way across the existing spillway rock shelf connecting the new spillway structure to the center island (west main dam). A new permanent earth fill dam (south dam) will be constructed downstream of the existing east gravity dam and tied into the existing powerhouse with a new concrete gravity wall. Construction and decommissioning of existing facilities and restoration of the Project site will occur over a period of approximately three years. The predicted environmental effects of the Project were described in the Pointe du Bois Spillway Replacement Project Environmental Impact Statement (Manitoba Hydro 2011) (the EIS) and the Manitoba Hydro Pointe du Bois Spillway Replacement Alteration notice (August 2012).

1.2 Environmental Protection Program and the AEMP

The AEMP is one part of an integrated Environmental Protection Program (EPP) developed for the Project. Implementation of the EPP is an application of Manitoba Hydro's Corporate Environmental Management Policy under the company's ISO14001-certified Environmental Management System. The EPP for the Project will assist Manitoba Hydro and its contractors to be compliant with the corporate environmental policy and regulatory requirements. Additionally, it will provide an opportunity for adaptive management to mitigate unexpected adverse effects should they be detected during monitoring.

The Environmental Protection Program for the Project includes the following:

- Environmental Protection Plans (EnvPP), which provide detailed, site-specific directions to contractors to minimize environmental impact. For the Pointe du Bois Spillway Replacement Project, the EnvPPs are organized by construction component, highlighting measures to reduce the impacts of specific work activities, such as tree clearing and erosion and sediment control;
- Environmental Management Plans, which are focused documents that address a specific environmental issue. For the Pointe du Bois Spillway Replacement Project they include an Sediment Management Plan (SMP) and a Fish Habitat Compensation Plan; and
- Environmental Monitoring Plans, which provide instructions for monitoring the effects of construction and operational activities on the biophysical, physical and socio-economic environments. For the Pointe du Bois Spillway Replacement Project they include individual plans for the monitoring of Aquatic Effects, Terrestrial Effects, Physical Effects and Socio-economic Effects.

The AEMP is comprised of the following components: (1) Water Quality (Section 3.0); (2) Aquatic Habitat (Section 4.0); (3) Aquatic Macroinvertebrates (Section 5.0); (4) Lake Sturgeon (Section 6.0); and (5) Fish Community (Section 7.0). Within each of these components, monitoring plans are presented for the construction (including decommissioning of existing facilities) and operation phases of the Project. This document also describes the overall objectives and approach to monitoring and reporting of monitoring results (Section 8.0). Monitoring related to sediment and erosion is described in the Physical Environment Monitoring Plan (PEMP). Monitoring related to environmental protection (e.g., measurement of effluent quality prior to release to a receiving environment) will be described in EnvPPs. Monitoring of real time suspended sediment levels immediately downstream of construction activities to provide the basis for an adaptive approach to manage sediment inputs during instream construction is described in the SMP. Fish habitat compensation monitoring is described in the Pointe du Bois Spillway Replacement Project Fish Habitat Compensation Plan.

Sampling programs have been developed on the basis of available information. As construction plans evolve, in particular after the award of contracts for various components of the construction phase, programs may need to be modified so that collected information will meet the AEMP objectives.

The monitoring approach is adaptive in that results of the programs will be evaluated on an on-going basis to confirm that plan objectives are being met in an effective and efficient manner.

1.3 Overall Objectives, Approach and Monitoring Schedule

1.3.1 Objectives and Approach

The AEMP for the Pointe du Bois Spillway Replacement Project is intended to document conditions over time for certain Valued Environmental Components (VECs) and other environmental parameters to:

- verify effects assessment predictions detailed in the EIS;
- identify unexpected effects related to the Project;
- monitor effectiveness of mitigation measures;
- identify the need for additional mitigation or remedial actions and then, subsequently, monitor the new mitigation measures that are implemented; and
- confirm compliance with regulatory requirements including Project approvals and environmental regulations.

The AEMP focuses on the primary effects to key components of the environment rather than addressing all potential changes to the aquatic environment as described in the EIS. The EIS provides an overview of the major linkages between the Project and the aquatic environment, proposed mitigation measures, and predicted residual effects. In brief, effects of construction (including decommissioning of existing facilities) are primarily related to changes to surface water quality as a result of inputs from instream construction (e.g., blast mattress placement and removal and commissioning of spillway) although some other activities may also affect the aquatic environment (e.g., blasting). Potential effects during the operation phase arise primarily due to changes in flow pattern downstream of the proposed new spillway. Because effects will differ depending on location, the AEMP has been structured to incorporate monitoring in several study area reaches.

The AEMP will be adaptive in that results of monitoring will be used to modify the plan on an on-going basis. Monitoring during the construction phase has been designed to respond to observed results, both to adjust the temporal and spatial scope of sampling as well as to provide feedback to Project personnel if alterations to mitigation measures are required. Monitoring results during the operation phase will also be examined regularly to provide for both modifications to sampling plans (e.g., reduction if no effects observed, design modifications if program improvements are required) and the implementation of additional mitigation measures, if required. Preparation of a synthesis report, to form the basis for decisions about long-term monitoring plans, is scheduled after several cycles of the AEMP have been completed (see Section 8.2).

The AEMP consists of several inter-related components addressing various parts of the aquatic environment. In general, the AEMP builds on the assessment studies conducted for the EIS, using established monitoring sites and sampling protocols that will be maintained through the construction and operation of the Project. Determination of the overall effect of the Project will be based on interpretation of the integrated results of all these monitoring components in relation to assessments in the EIS; monitoring components will not be considered in isolation.

1.3.2 Monitoring Schedule

As many aquatic environment components experience wide ranges of seasonal and year-to-year variation, and as some effects of the Project may only be detectable after a period of several years, the AEMP has been designed to be long-term. Conversely, certain activities are short-term and require only short-term monitoring. Some monitoring activities have been scheduled within an ongoing plan, while others will be conducted on an 'as required' basis (e.g., focused monitoring for specific construction activities).

The current monitoring schedule (Table 2-1) is as follows:

- Construction (including decommissioning of existing facilities) (2012 to 2014) – Most monitoring during construction is closely linked to specific activities, but some broader-based monitoring is planned to provide continuity with pre-Project conditions for components that will be targeted in the operation phase monitoring. Some monitoring will be conducted during this period to supplement baseline data.
- Operation phase I (2015 to 2019) – More intensive monitoring will be conducted during the first five years of operation, when many of the operation-related effects could occur. Sampling will occur during the first and third year only for water quality and aquatic macroinvertebrates, and every year for all five years for the fish community and lake sturgeon. Aquatic habitat monitoring will occur in 2013 (if a no-spill event occurs) and on two occasions from 2015 to 2019. Supplemental water quality, aquatic habitat

and benthic macroinvertebrate monitoring also would be conducted during phase I should extremely high flow events occur.

- Operation phase I review (2019/2020) – Following completion of five years of post-Project monitoring, an evaluation of results will be conducted to determine whether: (i) unexpected effects are occurring; (ii) mitigation measures need to be modified; and (iii) monitoring should be continued and, if so, the appropriate approach.
- Operation phase II (2020 to 2029) – The operation phase I review of the AEMP will determine the nature and timing of further monitoring. At present it is proposed that there would be annual monitoring of Lake Sturgeon recruitment through to 2029. However, the need for and frequency of this monitoring will be evaluated during the 2019/2020 review.
- Operation phase II review (2030) – A final evaluation of the effects of the Pointe du Bois Spillway Replacement Project and assessment of need for any further monitoring would be conducted in 2030, fifteen years following commissioning of the primary spillway.

It should be noted that although key milestones have been identified above for assessing monitoring program results (e.g., after 2019 and 2029), monitoring results will be reviewed on an annual basis to assess program outputs and to determine whether the program or adaptive management measures require adjustment.

1.3.3 AEMP Monitoring Components and Schedule Synopsis

The AEMP covers the following aspects of the aquatic environment of the Project, which are outlined in sections 3.0-7.0.

Water Quality

During the construction phase, water quality will be measured at sites immediately upstream and downstream of the construction site before, during and after major instream construction activities. Additional samples will be collected at sites farther downstream to establish the spatial extent of effects to water quality. Targeted sampling will also occur in the immediate receiving environment where effluent is discharged or other site-specific effects may occur. Annual monitoring in late summer and late winter will occur when there is no major instream work. Annual monitoring in late summer and late winter will continue during years 1 and 3 of operation. In addition, a targeted sampling program will be implemented in relation to high flow events that may mobilize sediments during operation.

Aquatic Habitat

Aquatic habitat monitoring will be conducted during the construction phase in 2013, (if low or no-spill conditions occur) and in two years from 2015-2019 during low or no-spill conditions subsequent to use of the spillway. Subsequent monitoring will be considered following high spill events in the future.

Aquatic Macroinvertebrates

Macroinvertebrate sampling will be conducted during each year of the construction phase and in years 1 and 3 of operation. During the construction phase, drifting invertebrates will be sampled in Reaches 1 and 3. During the operation phase, drifting invertebrates will be collected from Reaches 1 and 3; and benthic invertebrate grab samples will be collected from Reaches 1 and 4.

Lake Sturgeon

Lake Sturgeon egg deposition, larval drift and small mesh gillnetting studies will begin in 2012 and continue until the decision framework (see Section 6) indicates further sampling is not merited. Sampling will systematically monitor egg deposition and water velocity in the water column at selected sampling sites on a daily basis during the Lake Sturgeon spawning period. A DIDSON camera will be used, where possible, to observe substrate type at higher resolutions than observed in the preceding studies and to observe sturgeon use of the tailrace area and sites of specific interest. Drift of larval sturgeon from the spawning area below the powerhouse and spillway will be monitored during each year that egg deposition monitoring is conducted to provide a relative measure of hatch success. Juvenile Lake Sturgeon survival and recruitment studies will begin in 2012 and continue through the operation phase I and II stages. The first three years will be used as baseline data. The deepest portions of Reaches 3 and 4 will be sampled during the first two weeks of October each year to target juvenile Lake Sturgeon.

Fish Community

Blasting events that are not expected to meet the criteria within the DFO guidelines will be monitored for fish mortality. General fish community monitoring of Reaches 1, 3 and 4, including newly created habitats, will occur four times beginning in the first year following construction, and then three times thereafter until year 10 (i.e., years 1, 4, 7, and 10).

2.0 STUDY AREA

2.1 Project Effects Study Area

The AEMP encompasses the study area defined within the EIS, and incorporates the following reaches (Figure 2-1):

- Pointe du Bois Reservoir – Reach 1: upstream end of the Project study area, encompassing the Winnipeg River from Lamprey Rapids at the upstream end to the existing Pointe du Bois GS at the downstream end (12 km). The Project will maintain the existing water level and flow regime in this reach;
- Pointe du Bois Spillway Rapids – Reach 2: the 300 m portion of the Winnipeg River between the existing Pointe du Bois main dam and spillway and the base of the spillway rapids. This area will be split in half by the new main dam inundating the upper portion and eliminating flows to the lower portion;Pointe du Bois GS to Eight Foot Falls – Reach 3: the 1.5 km section of the Winnipeg River from the Pointe du Bois GS and base of the Spillway Rapids to Eight Foot Falls, which will remain the area immediately downstream of the new spillway facilities and existing Pointe du Bois GS; and
- Slave Falls Reservoir from Eight Foot Falls to Slave Falls GS – Reach 4: the 7.8 km section of the Winnipeg River downstream of Eight Foot Falls to the Slave Falls GS and including one small tributary on the west side of the river (Moose Creek).
- Slave Falls GS to Scotts Rapids – Reach 5: the 6.2 km section of the Winnipeg River between Slave Falls GS and Numao Lake (water quality only).
- Numao Lake and Nutimik Lake – Reach 6: (water quality only).

Effects of both construction (including decommissioning of existing facilities) and operation of the Project vary in their spatial scale, as some activities will be confined to a specific site while others will be regional in scope; therefore, monitoring components will also vary in their spatial scales. In particular, sites downstream of Eight Foot Falls are generally only considered with respect to water quality and the Lake Sturgeon survival and recruitment monitoring.

2.2 Reference Sampling Sites

Reference (control) sites are typically used in monitoring plans to account for effects or changes in a given parameter that are not related to the impact/stressor under study. Therefore, choosing a reference area that is "as similar as possible to the exposure area is essential in order to interpret differences between the areas" (Environment Canada 2002). Ideally, reference sampling sites would be similar in all attributes except for the development; however, in practice, this ideal situation seldom occurs in natural waters. With respect to the study area, external environmental factors that could affect the aquatic environment include: inter-annual variations in flow and water quality in the Winnipeg River; seasonal run-off in the local watershed; other events in the local watershed (e.g., forest fires); inter-annual variations in weather (e.g., spring temperature, severe wind events with effects to erosion); recreational and domestic fisheries; development and recreational use of the Winnipeg River and its shorelines (e.g., cottage development and use); and climate change. In addition, ideal reference areas would be subject to the same non-Project related stressors as the 'exposure area' (e.g., recreational and domestic fishing).

For the Project AEMP, all reference sites are located in the Winnipeg River either upstream of the Project or downstream of Slave Falls GS. Attributes of these sites are summarized as follows:

Pointe du Bois Reservoir (main channel):

- Mainstream Winnipeg River immediately upstream of the Project with no significant tributary inflow;
- Mainstream Winnipeg River upstream of the Project near Big Island with no significant tributary inflow; and
- Mainstream Winnipeg River immediately downstream of Slave Falls GS (reference site for egg deposition monitoring during operation – in Reach 5 [Figure 2.1]).

3.0 WATER QUALITY

The following section provides details of the water quality monitoring activities for the construction (Section 3.1) and operation (Section 3.2) periods. Monitoring during construction and operation will involve comparison of data to upstream reference sampling sites (e.g., upstream-downstream comparisons in relation to relatively site-specific construction activities), to pre-Project data (i.e., baseline data), and to Manitoba Water Quality Standards, Objectives and Guidelines (MWQSOGs; Manitoba Water Stewardship 2011).

3.1 Monitoring During Construction

As described in the EIS, the Project is predicted to cause increases in total suspended solids (TSS) and related variables (e.g., total phosphorus, iron) during short-term construction activities. Water quality monitoring during construction is therefore focused upon activities that are predicted to cause increases in TSS and related variables. The primary tool for monitoring effects on TSS during construction will involve deployment of turbidity loggers upstream and downstream of construction activities, as described in the SMP. Additional TSS/turbidity monitoring will be conducted, as required, in association with activities that may have more localized effects (e.g., concrete batch plant discharge). In general, monitoring will be conducted along a gradient (i.e., increasing distance from the construction site) and in relation to an upstream reference point, where feasible. More detailed plans cannot be provided at this time as specific construction plans for these small works have not been developed.

In addition, the immediate receiving environment for point source discharges identified in the EnvPP (e.g., runoff from the work areas) will be monitored to document effects related to these inputs. Information is currently not available to identify the location of all point and non-point sources, but in general, monitoring will involve sample collection upstream and downstream of the input and/or before, during and after the release of effluents.

The following describes the core water quality monitoring plan for construction, the overall objective of which is to monitor the net effect of various construction activities on a suite of water quality parameters in the mainstem of the Winnipeg River.

3.1.1 Core Water Quality Monitoring

Monitoring Area

The water quality monitoring area extends from near Lamprey Rapids at the head of the Pointe du Bois reservoir (upstream of the anticipated effects of the Project), through the existing and planned facilities at Pointe du Bois, and potentially as far downstream as Nutimik Lake (Figure 3-1).

Pathways of Effect and Key Questions

Construction and commissioning of the new spillway facilities are expected to result in short-term increases in TSS in the Winnipeg River. The largest effects during construction are associated with: construction of the cofferdam adjacent to the powerhouse to allow construction of the powerhouse east abutment; construction of the cofferdam between the rockfill dam and spillway structure (Stage II cofferdam); construction of the approach channel guide berm; and commissioning of the new spillway. As the estimated increases in TSS during construction are within MWQSOG for the Protection of Aquatic Life (PAL), the magnitude of these increases was ranked as small. Nutrients may increase during Project construction in relation to increases in TSS. Increases in TSS during construction may also increase the concentrations of metals (notably aluminum, iron, and manganese) and may contribute to exceedances of MWQSOG for PAL during short-term construction activities.

The key questions for the core water quality monitoring during construction are:

- Are downstream concentrations of TSS, total Kjeldahl nitrogen (TKN), total phosphorus (TP), manganese, iron, and aluminum significantly elevated during construction activities in comparison to either upstream or pre-Project conditions?
- What is the downstream extent to which the above parameters remain markedly elevated in comparison to either upstream or pre-Project conditions?
- Is there an increase in the frequency of MWQSOG for PAL exceedances of water quality parameters measured downstream of the Project that may be related to construction activities?
- Are there any unexpected effects on the water quality parameters (i.e., those not listed above) measured downstream of the Project that may be related to construction activities?

Sampling Design

The sampling design for the core water quality monitoring is a hybrid design incorporating elements of both the before-after-control-impact (BACI) and gradient designs. A BACI design consists of one or more control (or reference) locations to which an exposure (or reference) area is compared, both before and after an impact is deemed to have occurred. A gradient design refers to a series of sampling locations extending away from a potential source of effect (e.g., increase in TSS due to instream work), to a sufficient distance downstream that allows use of the farthest location as a reference (i.e., an effect is no longer detected). Sampling locations along the gradient should represent different exposure levels (e.g., within the mixing zone vs. fully mixed river condition). The hybrid design allows for the statistical testing for effects in the area immediately downstream of construction activities and it also provides an estimate of the spatial extent of potential effects.

Potential Project-related effects will be evaluated through statistical comparisons of key parameters between reference and exposure locations during each sampling event and to pre-Project baseline data, and comparisons of parameters measured to MWQSOG for PAL and any regulatory requirements specified in environmental approvals for the Project.

Parameters

Surface water samples would be collected and submitted to an accredited analytical laboratory for analysis of the following:

- Ammonia;
- Nitrate/nitrite;
- TP;
- Total Dissolved Phosphorus (DP);
- Phosphate (PO4);
- TKN;
- Total and Dissolved Organic Carbon (TOC and DOC);
- TSS;
- Turbidity;
- True colour;
- Conductivity;
- Total Dissolved Solids (TDS);
- Hardness;
- pH;
- Alkalinity;
- Chloride and sulphate (dissolved);
- Total and dissolved metals;
- Chlorophyll *a*; and,
- Benzene, toluene, ethylbenzene, and xylene (BTEX) (only at sites immediately upstream and downstream of the construction site); and
- Petroleum hydrocarbon fractions (PHC fractions) F1 (C6-C10), F2 (>C10-C16), F3 (C16-C34), F4 (C34-C50) (only at sites immediately upstream and downstream of the construction site).

In situ measurements of pH, temperature, specific conductance/conductivity, turbidity, dissolved oxygen (DO), water depth, and Secchi disk depths would be collected from each site.

Sampling Sites

Sampling will be conducted along the Winnipeg River, starting at sites upstream of construction activities and potentially continuing downstream to Nutimik Lake; the number and location of sites downstream of the fully mixed zone (i.e., approximately 1 km downstream of Eight Foot Falls) will be guided by results of the initial construction monitoring, which will define the downstream extent of detectable effects. Proposed sampling locations are illustrated in Figure 3-1; specific locations will be chosen to minimize physical variation among sites to the extent possible. It is anticipated that replicate samples will be collected at four sites:

- Upstream of the GS;
- Within the mixing zone;
- Immediately downstream of Eight Foot Falls; and
- The Slave Falls forebay.

If monitoring indicates that detectable results extend to the Slave Falls forebay, then replicate samples will be collected at sites further downstream.

An *priori* power analysis was conducted for key water quality parameters to determine the appropriate level of sampling effort (i.e., the number of sites per area) required for the conduct of a reasonably statistically robust sampling design (see Appendix 1). A range of effects thresholds was examined, including 10%, 25%, 50%, and 100% changes relative to the baseline means and using thresholds equivalent to MWQSOGs for PAL for TP, DO, TSS, copper, iron, lead, and nitrate using baseline data collected downstream of the GS where effects of the Project would occur. Based on the results of this power analysis, a sample size of four (i.e., four replicates) is proposed for each sampling site/area.

Safety considerations permitting, sampling would be conducted across the Winnipeg River (i.e., transect) within the mixing zone between the construction activities and Eight Foot Falls, to monitor effects before inputs at the construction site are fully mixed across the river. *In situ* measurements of turbidity would be made within the mixing zone to delineate the area of maximum turbidity for sampling.

Sampling Frequency and Schedule

Core water quality monitoring will be conducted prior to, during, and following major instream construction activities, most notably those that are predicted to result in measureable changes in TSS at the end of the mixing zone. As the construction schedule has not been finalized, the precise timing and frequency of monitoring cannot be identified at this time.

Although the effects of the Project on water quality are expected to be negligible outside of these major in-stream construction activities, periodic focused monitoring would be conducted in the immediate vicinity of the construction activities in addition to the core monitoring described above. This monitoring is intended to provide information regarding potential unforeseen effects and would be restricted to the sampling sites immediately downstream of construction activities (i.e., mixing zone area) and sites upstream in the Pointe du Bois forebay (i.e., upstream reference area) and occur once in late summer and late winter of years when there is no instream work. Should unforeseen effects on water quality that indicate a source of contaminants and/or sediments be observed, additional follow-up monitoring would be conducted to confirm results and to identify the spatial extent of effects. Appropriate action to modify construction activities would also be taken (e.g., if hydrocarbons are detected and above MWQSOGs downstream of construction activities, the source of the hydrocarbons would be identified and corrective action would be taken).

Methods

In situ measurements will be collected using calibrated field meters; incremental depth profiles of *in situ* parameters will be obtained at all sites where velocities facilitate accurate measurements. Samples of water would be collected by directly filling sample bottles (provided by the analytical laboratory) at approximately 30 cm below the surface at all sites, except at sites located within the plume downstream of construction activities. At the sites within the mixing zone, it is proposed to collect samples near the surface, mid-depth, and near the sediment-water interface using a Kemmerer or van Dorn sampler. Methods related to delineating the extent of the mixing zone are described in the PEMP.

A quality assurance/quality control (QA/QC) plan will be developed prior to program implementation and will outline the planning, implementation, and assessment procedures to be used in order to apply specific QA/QC activities and criteria to the AEMP.

3.2 Monitoring During Operation

Predicted effects of Project operation are expected to be restricted to increases in TSS downstream of the GS under high flow events and to changes in water quality (specifically DO) in Spillway Pond 2. As such, the following monitoring is proposed: core water quality monitoring will be conducted at mainstem sites from near Lamprey Rapids, upstream of any anticipated effects, and downstream as far as Nutimik Lake; and, water quality monitoring will be conducted in Spillway Pond 2. The following provides a description of the monitoring program proposed for each of these areas during operation.

3.2.1 Core Monitoring at Mainstem Sites: Reaches 1-6

Monitoring Area

The monitoring area extends from near Lamprey Rapids at the head of the Pointe du Bois reservoir (upstream of the anticipated effects of the Project), through the existing and planned facilities at Pointe du Bois, and downstream as far as Nutimik Lake (Figure 3-1).

Pathways of Effect and Key Questions

Effects to water quality along the main flow of the Winnipeg River are expected to be negligible during Project operation, with the possible exception of extreme high flow events. Residual effects during operation are related to the potential for re-suspension of sediments upstream of the approach channel during high flow events. As the estimated increases in TSS during operation are within MWQSOGs for PAL, the magnitude of these increases is ranked as small. Nutrients may increase during Project operation in relation to increases in TSS. Increases in TSS during operation may also increase the concentrations of metals (notably aluminum, iron, and manganese) and may contribute to exceedances of MWQSOG for PAL during short-term construction activities.

The key questions for the core water quality monitoring during operation are:

- Are downstream concentrations of measured water quality parameters significantly different in comparison to either upstream or pre-Project conditions during routine sampling periods?
- Are downstream concentrations of TSS, nutrients (TKN, TP), manganese, iron, and aluminum significantly different in comparison to either upstream or pre-Project conditions during high flow events?
- What is the downstream extent to which the above parameters remain significantly elevated in comparison to either upstream or pre-Project conditions during high flow events?
- Is there an increase in the frequency of MWQSOG for PAL exceedances of water quality parameters measured downstream of the Project during high flow events?
- Are there any unexpected effects on the water quality parameters measured downstream of the Project that may be related to operation?

Sampling Design

Refer to Section 3.1.1 for a description of sampling design, the approach for evaluation of potential Project-related effects, and the assessment of water quality data to characterize existing variability in measured parameters.

Parameters

Surface water samples would be collected and submitted to an accredited analytical laboratory for analysis of the following:

- Ammonia;
- Nitrate/nitrite;
- TP;
- DP;

- TKN;
- Phosphate
- TOC and DOC;
- TSS;
- Turbidity;
- True colour;
- Conductivity;
- TDS;
- Hardness;
- pH;
- Alkalinity;
- Total and dissolved metals;
- Chloride and sulphate; and
- Chlorophyll *a*.

In situ measurements of pH, temperature, specific conductance/conductivity, turbidity, DO, water depth, and Secchi disk depths would be collected from each site.

Sample Sites

It is anticipated that the locations of sampling sites will be the same as selected for the core sampling program during the construction period (Figure 3-1).

Sampling Frequency and Schedule

As effects of Project operation on water quality are predicted to be negligible along the mainstem of the Winnipeg River, with the possible exception of extreme high flow events, water quality monitoring would be conducted in late summer and later winter of years 1 and 3 of operation and during high flow events when feasible. Evaluation of results and structure of the monitoring program is proposed for 2015/16 after completion of Year 1 operation monitoring; the plan may then be revised prior to implementation of monitoring during Year 3 of operation.

Methods

In situ measurements will be collected using a calibrated field meter; incremental depth profiles of *in situ* parameters will be obtained where feasible (i.e., where velocities facilitate accurate measurements). Samples of water would be collected by directly filling sample bottles (provided by the analytical laboratory) at approximately 30 cm below the surface at all sites. Should *in situ* depth profiles indicate notable differences in water quality across water depth, samples will also be collected near the sediment-water interface using a Kemmerer or van Dorn sampler. A QA/QC plan will be developed prior to program implementation.

3.2.2 Spillway Pond Monitoring: Reach 2

Monitoring Area

The monitoring area includes Pond 2 on the spillway shelf.

Pathways of Effect and Key Questions

Water quality may be affected in Spillway Pond 2 due to changes in hydrology (i.e., elimination of inflows and outflows under most conditions). Dissolved oxygen depletion is expected within this pond on the spillway shelf, notably under ice cover, due to elimination of inflows during operation. Dissolved oxygen may decrease to concentrations below the MWQSOGs for PAL in this pond, notably at depth near the end of the ice-cover season.

The key question for the spillway pond monitoring during operation is:

- Are water quality conditions, notably DO concentrations, in Spillway Pond 2 inadequate to support post-Project fish use?

Sampling Design

Baseline water quality data for the Spillway Ponds are very limited due to issues associated with safe access to the area over the baseline field studies program. A single sampling event was successfully completed in September 2011, which was the first opportunity to access the ponds since the baseline studies program was initiated. Therefore, there are insufficient baseline data to apply statistical comparisons between pre- and post-Project water quality conditions for these areas. As a result, the approach taken for these areas will be a comparison to the MWQSOGs for PAL. Results will also be interpreted in relation to observed fish usage of these areas.

Parameters

Surface water samples would be collected and submitted to an accredited analytical laboratory for analysis of the following:

- Ammonia;
- Nitrate/nitrite;
- TP;
- DP;
- Phosphate;

- TKN;
- TOC and DOC;
- TSS;
- Turbidity;
- True colour;
- Conductivity;
- TDS;
- Hardness;
- pH;
- Alkalinity;
- Total and dissolved metals;
- Chloride and sulphate; and
- Chlorophyll *a*.

In situ measurements of pH, temperature, specific conductance/conductivity, turbidity, DO, water depth, and Secchi disk depths would be collected from each site.

Sample Sites

Given the small size of the pond, four samples will be collected and combined to form a single composite. Additional *in situ* depth profile measurements also may be undertaken should oxygen depletion be observed, to provide more detailed information on the spatial extent of effects.

Sampling Frequency and Schedule

Monitoring frequency and timing would be consistent with the core water quality monitoring during operation described in Section 3.2.1.

Methods

In situ measurements will be collected using a calibrated field meter; incremental depth profiles of *in situ* parameters will be obtained at each site. Samples of water would be collected by directly filling sample bottles (provided by the analytical laboratory) at approximately 30 cm below the surface at all sites. Should *in situ* depth profiles indicate notable differences in water quality across water depth, samples will also be collected near the sediment-water interface using a Kemmerer or van Dorn sampler. *In situ* measurements across multiple sites would likely be used to evaluate the spatial extent of thermal stratification and/or DO depletion during each sampling period. A QA/QC plan will be developed prior to program implementation as per Section 3.1.1.

4.0 AQUATIC HABITAT MONITORING

Aquatic habitat mapping of the existing environment was conducted during the environmental assessment studies to provide the basis for predicting the effects of Project-related changes in flow pattern on aquatic biota. Mapping focused on physical habitat (water depth, velocity and substrate type) and the presence or absence of cover (e.g., aquatic macrophytes). Monitoring of potential sediment deposition in habitats downstream of the immediate vicinity of the project is described in the PEMP.

4.1 Monitoring of Substratum in Lake Sturgeon Spawning Habitats in Reach 3

Sampling of substrate composition in Reach 3 will be used to evaluate effects of new flow patterns on substratum composition during both construction and operation of the Project. The efficacy of the plan will in part depend on the magnitude of flows released from the spillway.

4.1.1 Monitoring Area

The study area to examine the potential effects of changed flow pattern on substrate composition in Reach 3 is located immediately downstream of the Pointe du Bois spillway shelf (Figure 2-1).

4.1.2 Pathways of Effects and Key Questions

Substratum characteristics in Lake Sturgeon spawning habitat found immediately below the Pointe du Bois spillway shelf may be altered by introductions of sediment to the water column during construction and operation and by changes to river hydraulics (e.g., concentration of flows into the primary spillway).

The key questions for the Lake Sturgeon spawning habitat substrate monitoring are as follows:

- Are cobble deposits proximate to the spillway outflow being scoured down to bedrock and, if so, are the cobbles, or other fine textured materials, settling in adjacent areas?
- What is the extent to which gravels that could be introduced during construction and operation are being deposited in the Lake Sturgeon spawning habitat downstream of the spillway ledge?

4.1.3 Sampling Design

The environment of Reach 3 is characterized by a heterogeneous mixture of materials of different coarseness. In many areas the bed materials rest on top of bedrock. Of particular interest with respect to Lake Sturgeon spawning are those areas comprised predominantly of cobble materials. The composition of substratum in Reach 3 will be evaluated using SCUBA video transects before and after construction. Effort will be stratified with emphasis placed on the eastern 1/3 of the study area where spillway flows will originate.

4.1.4 Parameters of Concern

Measurements along the transects will provide a record of the relative amount of fine and coarse substratum (%), according to the Wentworth material size classification, and any changes in these relative amounts pre- and post-construction (Strahler and Strahler 2006).

4.1.5 Sampling Sites

Effort will be stratified along the length of the spillway shelf and eastern shoreline with emphasis in areas proximate to water releases from the spillway (Figure 4-1). The SCUBA video transect start and stop locations will be permanently marked for repeated access over time. In all remaining areas, the transects will be spaced 10- 30 m apart and extend approximately 150-200 m downstream. Where possible, the SCUBA transects will be located along axes that have already been captured with video during the EIS studies.

4.1.6 Sampling Frequency and Schedule

Substratum characterization of Reach 3 will be conducted during construction in 2013 (during low or no-spill conditions) and, again, after operation of the spillway in 2016 and 2018 (again, measurements to be taken during low or no-spill conditions subsequent to use of the spillway). Results of the surveys during the period of operation would be most conclusive if high magnitude flow events have passed through the spillway.

4.1.7 Methods

Video recordings will be matched to distance from the spillway shelf or shoreline and depth by means of visible markers on a transect line (5 m apart) laid on the river bottom with GPS coordinates taken at 25 m intervals along the line. Substrates will be classified in the office and mapped. Pre- and post-Project maps will be compared to determine changes in substrate distributions.

5.0 AQUATIC MACROINVERTEBRATES

The following section provides details of the aquatic macroinvertebrate monitoring activities for the construction (Section 5.3) and operation (Section 5.4) periods. The AEMP will utilize measurements of drifting and benthic invertebrates to monitor both the construction and operation phases of the Project (Table 2-1). The aquatic macroinvertebrate monitoring program addresses potential environmental changes that may occur as a result of both the construction and operation phases of the Project. Sampling locations during the construction phase generally have been selected such that continued sampling of these sites during the operating phase would monitor for environmental changes as a result of Project operation. The AEMP for aquatic invertebrates relies upon a combination of statistical comparisons and professional judgment. Monitoring during construction and operation will involve comparison of data to upstream reference sampling sites (e.g., upstream-downstream comparisons in relation to site-specific construction activities) and to pre-Project data (i.e., baseline data) (Figure 5-1).

5.1 Background

Lower trophic level communities characterized as part of the baseline studies for the EIS included phytoplankton, attached algae (i.e., periphyton), drifting aquatic macrophytes, zooplankton, drifting invertebrates, and benthic invertebrates. During development of the AEMP, the need to include these communities in the monitoring program was assessed based on effects predicted in the EIS and limitations of their use in a monitoring program. Phytoplankton and zooplankton were not included in the AEMP as detectable effects are not expected to these groups. Although many attempts were made, adequate periphyton and invertebrate baseline sampling within Reach 2 was not possible because high flow conditions precluded access during pre- Project. Since an intensive, repeatable program is required to obtain sufficient data to support a statistical analysis of effects, the uncertainty and irregularity of the flow conditions make it problematic to sample periphyton and invertebrates successfully within Reach 2. Furthermore, visual encounter surveys of the Corpulent Ramshorn snail conducted during baseline studies indicated snails were not present in the spillway ponds of Reach 2, as such surveys for the snail will not be included in the AEMP. Detailed information regarding the lower trophic baseline data can be found in the following technical documents: Gill and Wyn 2008; Gill et al. 2008; Gill 2009; Gill 2011; and Mandzy and Hnatiuk 2012.

Sampling of drifting invertebrates provides a repeatable approach to measure changes in invertebrate drift density and composition that may be linked to effects from construction and/or operation of the Project by comparing upstream and downstream surface and bottom drift community metrics to those collected pre-Project (Figure 5-1). It is recognized that invertebrate drift samples in large rivers may not reflect local conditions well and the species composition of the drift can be different from that of the benthos and, as such, drift may not be a density-dependent function of the bottom fauna. The rationale for using this sampling method was largely dictated by the limitations posed by flow conditions in the portion of the Winnipeg River under assessment. Hard substrate and high velocities preclude benthic grab sampling in Reach 3. Under high flow and spill conditions, the river water flows through the spillway, scours the spillway shelf and flushes through the spillway pools. During these flow events, it was expected that the biota that exists in the area of Reach 2 would contribute to the downstream drift community. Drift traps were determined to be the most reliable sampling method to estimate the density of biota likely originating from Reach 2 and compare it to that of the upstream environment. During baseline data collection, the overall scope of the project changed considerably, and the drifting invertebrate program had been revised accordingly. Additional data using the AEMP study design were collected in 2012 to improve the baseline dataset for comparison to construction and operation monitoring program results; 2006-2008 and 2010 baseline data will be used to aid in describing any potential Project-related effects, where appropriate.

The baseline benthic invertebrate community data were summarized by reach for technical data reporting purposes. During baseline data collection, the overall scope of the project changed considerably, and the benthic invertebrate program has been revised accordingly. Additional data using the AEMP study design were collected in 2012 to improve the baseline dataset for comparison to construction and operation monitoring program results; 2006 and 2007 baseline data will be used to aid in describing any potential Project-related effects, where appropriate.

5.2 Study Design

During AEMP development, the baseline aquatic macroinvertebrate program was reviewed to identify limitations of the current study design. From an *a priori* power analysis of baseline benthic invertebrate data (NSC unpublished data), it was determined that there was considerable variability in calculated benthic community metrics among samples and sites within aquatic habitat types defined by water depth (i.e., shallow water and deep water sites). Factors contributing to the variability of the calculated metrics include: potential variability in water depth, substrate, water velocity, etc. within and among sites. Due to this high variability, large numbers of samples would be required to observe significant changes at a site either in comparison to another site or over time at the same site.

The AEMP was refined in order to reduce the inherent variability within the benthic invertebrate data. These modifications were intended to increase the statistical power of the data, but not the sampling effort or analytical costs in comparison to the baseline data collection program. The modified study design gives consideration to Environment Canada's Environmental Effects Monitoring (EEM) program.

The EEM program (Environment Canada 2011) recommends that the benthic invertebrate community survey should minimally have sufficient power to detect a critical effect size (CES) of ±2 standard deviations (SD) and this may be accomplished by initially setting α and β to 0.1. This implies that the sampling effort would require a sample size of 5 replicate stations per aquatic habitat type. It should be noted that the minimum detectable difference that ±2 SD corresponds to depends on the variability among replicate stations (e.g., an *a priori* power analysis of benthic invertebrate baseline data indicated that the minimum detectable difference may range between a 10 and 300% change in a selected metric at ±2 SD). To determine how many field sub-samples (i.e., grabs) per replicate station will provide an estimate with 20% precision, previous data for benthic invertebrate abundance and taxa richness (at the family level) were used to determine the mean and variance and, thus, the appropriate number of field sub-samples. However, due to the high variability in baseline data, this determination for specific metrics varied notably from area to area (e.g., may range between 1 and 31 sub-samples). Without *a priori* information on invertebrate density and variability within a station for the revised study design, the number of field sub-samples required to accurately reflect the true density at each replicate station is set at 5 (EEM recommends 3) for the first year of monitoring under the AEMP; the number of sub-samples will be reviewed for subsequent years.

5.3 Monitoring During Construction

A variety of construction-related activities have the potential to result in the release of suspended sediments into the Winnipeg River, resulting in increases in TSS in the Winnipeg River to Eight Foot Falls and possibly further downstream (Figure 5-1). To assist in the interpretation of expected increases in TSS, drifting invertebrates will be collected from Reaches 1 and 3 in connection with the Lake Sturgeon larval fish drift sampling (Section 6.2).

5.3.1 Monitoring Area

The monitoring area includes the immediate forebay of the Pointe du Bois Reservoir, the Project footprint and downstream to Eight Foot Falls (Reaches 1, 2 and 3), where effects, should they be detectable, would be the greatest (Figure 5-1).

5.3.2 Pathways of Effect and Key Questions

The primary potential effect(s) on aquatic macroinvertebrates during construction is related to inputs affecting water quality, such as increases in TSS concentrations due to instream activities in the Winnipeg River. Invertebrate drift net sampling specifically assesses the biological effects of predicted increases in TSS on benthic and drifting invertebrates as a result of instream work on the Winnipeg River, and is intended to complement the water quality monitoring described in Section 3.1.1.

The key question for the monitoring during construction is:

- Is downstream invertebrate drift density and/or community composition significantly changed during construction activities in comparison to either upstream or pre-Project conditions?

5.3.3 Sampling Design

Monitoring during construction will be based on a BACI design. Potential Project-related effects will be evaluated through statistical comparisons of aquatic invertebrate community descriptors (i.e., metrics) between reference (upstream) and exposure (downstream) locations during each sampling event and to pre-Project baseline data.

5.3.4 Parameters

Aquatic macroinvertebrate community descriptors (i.e., metrics) calculated for each sample and included in statistical analyses will include the following:

Abundance and Compositional Measures

- Total invertebrate density;
- Taxon density (for Amphipoda, Oligochaeta, Chironomidae, Ephemeroptera; Trichoptera, Bivalvia, Gastropoda, and Plecoptera);
- Proportion of EPT (% of total for Ephemeroptera, Plecoptera, and Trichoptera); and,
- Ratio of EPT taxa to Chironomidae (EPT:C).

Richness Measures

- Taxa richness (family);
- Hill's effective richness;
- Simpson's Diversity Index; and,
- Simpson's Evenness Index.

5.3.5 Sample Sites

To the extent possible, sampling locations have been selected such that sampling conducted pre-Project and during construction will be comparable. Invertebrate drift will be assessed in Reaches 1 and 3 (Figure 5-1). An assessment of the spatial variability in baseline drifting invertebrate data upstream and downstream of the existing GS would be used to determine the number and placement of sites required to estimate aquatic macroinvertebrate parameters in Reaches 1 and 3 during construction.

5.3.6 Sampling Frequency and Schedule

During each year of construction, invertebrate drift will be collected in conjunction with Lake Sturgeon larval drift sampling during June. If significant increases in TSS concentrations do not occur during construction, drifting invertebrate sampling may be reduced or removed from construction monitoring (Table 2-1).

5.3.7 Methods

Drifting invertebrates will be sampled upstream and downstream of the Project in Reaches 1 and 3 using both floating and sinking drift nets (opening of 43 x 85 cm, with an attached 300 cm long, 950 µm Nitex® screen bag, tapered to a 9 cm diameter removable ABS pipe 'cod-end'). Drift nets would be set for approximately 24 hours. During each year of construction, a total of 60 floating and sinking drift invertebrate samples will be collected (30 samples from Reach 1; and 30 samples from Reach 3).

5.4 <u>Monitoring During Operation</u>

Predicted effects of Project operation are expected to be restricted to increases in TSS and subsequent deposition of sediments downstream of the GS under high flow events. As effects of Project operation on aquatic invertebrates are expected to be minimal, monitoring during the operation phase of the Project is limited to the first and third year of operation, and after high flow events as described for water quality. To assist in the interpretation of potential increases in TSS downstream of the GS, drifting invertebrates will be collected from Reaches 1 and 3 in connection with Lake Sturgeon larval fish drift sampling, and benthic invertebrate grab samples will be collected from shallow and deep habitats in Reaches 1 and 4 (Figure 5-1).

5.4.1 Monitoring Area

The operation monitoring area includes the Pointe du Bois Reservoir (upstream of any potential effects of the Project), through the existing and planned facilities at Pointe du Bois, and downstream as far as Mayos Bay in Reach 4 (Figure 5-1). Drifting invertebrates will be collected from Reaches 1 and 3 and intended to assess estimate biotic changes from Reach 2, and benthic grab samples will be collected in Reaches 1 and 4 .

5.4.2 Pathways of Effect and Key Questions

Potential effects on aquatic macroinvertebrates are related to the deposition of sediments downstream of the GS following high flow events and increases in TSS. Benthic invertebrate sampling will assess the biological effects of potential increases in TSS and subsequent sedimentation during high flow events on benthic invertebrates, and is intended to complement the water quality monitoring described in Section 3.2.1.

The key questions for the monitoring during operation are:

- Is downstream invertebrate drift density and composition significantly altered in comparison to either upstream or pre-Project conditions?
- Is downstream benthic invertebrate community composition significantly changed during and/or after high flow events with a corresponding increase in TSS in comparison to either upstream or pre-Project conditions?

5.4.3 Sampling Design

Monitoring during operation will be based on a BACI design. Refer to Section 5.3.3 for a description of sampling design, the approach for evaluation of potential Project-related effects, and the assessment of aquatic macroinvertebrate data to characterize existing variability in calculated metrics.

5.4.4 Parameters

Refer to Section 5.3.4 for a description of the aquatic macroinvertebrate community descriptors (i.e., metrics) that would be calculated for each sample and included in statistical analyses.

5.4.5 Sample Sites

Sampling conducted for the EIS studies found that invertebrate sample collection was not possible in many parts of Reaches 2 and 3, particularly on and close to the spillway rapids during spill events (Figure 5-1). To the extent possible, sampling locations have been selected such that sampling conducted pre-Project and during construction will be comparable. Invertebrate drift will be assessed in Reaches 1 and 3 and benthic invertebrates will be sampled from shallow and deep habitat in Reaches 1 and 4; specific locations will be chosen to minimize physical variation among sites to the extent possible. An assessment of the spatial variability in baseline drifting invertebrate and benthic macroinvertebrate data upstream and downstream of the existing GS would be used to determine the number and placement of sites required to estimate aquatic macroinvertebrate parameters in Reaches 1, 3, and 4 during operation (Figure 5-1).

5.4.6 Sampling Frequency and Schedule

Invertebrate drift will be collected in conjunction with Lake Sturgeon larval drift sampling during June of the first and third year of operation (Table 2-1). Benthic invertebrates will be sampled in late-September/early-October of the first and third year of operation. If significant increases in TSS concentrations do not occur during high flow events, invertebrate sampling may be reduced.

5.4.7 Methods

Drifting invertebrates will be sampled upstream and downstream of the Project in Reaches 1 and 3 using both floating and sinking drift nets (opening of 43 x 85 cm, with an attached 300 cm long, 950 µm Nitex® screen bag, tapered to a 9 cm diameter removable ABS pipe ‘cod-end’). Drift nets would be set for approximately 24 hours. In years 1 and 3 of Operation, a total of 60 floating and sinking drift invertebrate samples will be collected (30 samples from Reach 1; and 30 samples from Reach 3).

Benthic invertebrates will be sampled from shallow and deep habitats in Reaches 1 and 4 using a petite Ponar dredge (0.023 m^2 opening) and sieved through a 500 µm sieve bucket. In years 1 and 3 of Operation, a total of 100 benthic invertebrate sub-samples will be collected; five sub-samples from five replicate stations at shallow and deep water sites in each Reach. Twenty benthic sediment samples (one sediment grab sample per replicate station) will also be collected for particle size and total organic carbon analyses.

6.0 LAKE STURGEON

The following section provides details of a plan to monitor Project-related effects to Lake Sturgeon in the study area. Monitoring will begin before the construction phase and continue at various levels of effort through the first 15 years of operation. The monitoring program includes egg deposition, larval drift and small mesh gillnetting mark and recapture components to provide measures of spawning, hatch and recruitment. Monitoring results will provide a means for evaluating potential effects to the Slave Falls Reservoir Lake Sturgeon population and the need for implementation of adaptive management strategies.

6.1 Lake Sturgeon Egg Deposition

6.1.1 Background

A Habitat Suitability Index (HSI) model was developed from the literature and with local observation of egg deposition to estimate and compare patterns of egg deposition habitat before and after the Pointe du Bois Spillway Replacement Project (NSC 2011a). Sampling in 2007-2008 was conducted spatially to cover the majority of the available habitat and adapted to account for changes arising from spillway flows. Sampling in the first year was conducted within 354 m of the powerhouse and spillway and included lotic and lentic habitat. Some of the areas sampled were large back-eddies, and were not expected to provide suitable habitat. In 2009-2010, sampling effort ranged as far as 415 m from the station, in response to larger inflows; however, most effort was placed in lotic habitat within 120 m of the powerhouse and spillway, where most eggs were being observed. After four spawning periods, approximately 95% of the eggs were observed within 100 m of the principal structures. Eggs were not observed farther than 360 m from the station. In 2012, in consultation with Fisheries and Oceans Canada, sampling was extended up to 400 m from the station and the same pattern of deposition was observed.

Agreement between the literature and observed data was excellent for the velocity Suitability Index (SI). The depth SI was not expected to influence habitat availability at depths greater than the body height of mature Lake Sturgeon. Eggs were found on a wide range of substrate types below the powerhouse and spillway. The addition of a constraint variable, ‘Direction’ of flow, formed a four variable model that accounted for some of the discrepancy by excluding flows that are more than 40 degrees off the downstream axis. While the ‘Direction’ of flow variable improved the estimate of suitable habitat, the model continued to overestimate the habitat occupied by eggs. Addition of a second constraint variable, referred to as ‘Distance’, which models the observed decrease in egg abundance from the dam and spillway formed a five variable model that was consistent with the observed pattern of egg deposition. Distance is measured in the downstream direction relative to the powerhouse which is an impassable barrier, or in the case of the spillway shelf, is an energetic barrier. Both areas create hydraulic habitat that acts as an origin of attractant flow that entrains air and develops vertical and/or horizontal current shears.

Studies of egg deposition from 2007-2010 show that Lake Sturgeon demonstrate an adaptive behavior to opportunistically select sites based on availability of hydraulic habitat. Sites of attractant flow varied markedly between years with and without spill. In the tailrace, sturgeon egg deposition patterns differed among years and appeared to relate closely to the main origins of attractant flow arising from the configuration of operating turbines, which varied among years. Below the spillway shelf, sturgeon used small and narrow leakage channels when the spillway gates were not open. During spills, eggs were deposited in new areas below the origin of flow along several current shears found at the edge of large plumes of fast water. Results suggests that not only do the number and paths of flow change below the spillway as flows increase, but also below the powerhouse in relation to the number and location of turbines operating. It is for these reasons the sampling design provided below is habitat specific, where ‘like’ hydraulic habitat is sampled, as opposed to being location specific.

6.1.2 HSI Model

Review of the HSI model by DFO during early 2012 resulted in a request for additional egg deposition sampling over a greater range in Distance (up to 400 m downstream). This change in scope, referred to as the “extended sampling program”, complemented the “core” AEMP program described above. Preliminary analysis of the “extended” program results show an egg deposition pattern similar to that observed from 2007-2010. Consequently, egg deposition sampling will generally take a “habitat specific” approach. The only exception will be in the first year of operation when the core program will be modified to incorporate the “extended” program. .

6.1.3 Lake Sturgeon Egg Deposition Monitoring Program

The "core" Lake Sturgeon egg deposition monitoring program requires information that does not exist in the literature. Due to the paucity of egg deposition data from other locations and considering that the monitoring site at Pointe du Bois has marked changes in the pattern and magnitude of flows over space and time, there is some uncertainty as to whether the proposed baseline monitoring data will result in a quantitative or qualitative assessment method (see Section 6.2.6). In either case the approach to Adaptive Management would be the same (see Section 6.2.7).

Monitoring Area

Monitoring during construction and operation will be conducted in Reach 3 with effort placed mainly within 250 m of the powerhouse and spillway shelf. Existing data suggest most effort will be within 150 m.

During operation, monitoring will continue to sample the powerhouse tailrace, but will also focus on physical and hydraulic habitat and egg deposition on the alignment originating from the new spillway discharge channel (contingent on flow availability). Sampling will be extended to 400 m downstream of the station in the first year of operation to confirm the pattern of egg deposition. An additional Key Site will be added at Slave Falls during the first year of operation to provide a control for results from Pointe du Bois.

Pathways of effect and key questions

Potential effects on Lake Sturgeon egg deposition due to the operation of the new spillway will occur as a result of flow concentration and realignment of flows in the upper two-thirds of Reach 3. Leakage will no longer occur when the spillway is not in use.

The key question for the monitoring during construction and operation is:

- Is the pattern of egg deposition, as defined by a relationship and/or count statistics that describe the change in egg abundance vs. Distance, the same before and after the Project?

The objectives of the egg deposition monitoring program are based on two principal assumptions learned from the development of the HSI Model for the Pointe du Bois Spillway Replacement Project: 1) Hydraulic cues appear to be the dominant habitat variable that sturgeon respond to when spawning is initiated on this spawning ground; and 2) The slope of the Egg abundance vs. Distance relationship adequately describes how sturgeon ascend an attractant flow, spawn, deposit eggs and recognizes that egg drift contributes to the observed pattern. Specific objectives of the monitoring program include:

1) Establish monitoring sites below the powerhouse and spillway from which to systematically monitor egg deposition.
   - **a.** Establish a baseline and attempt to assess inter-annual variation in egg deposition from samples collected at a relatively high spatial and temporal resolution.

   b. Assessment of variation and change before and after the Project would be based on relative change (i.e., not absolute).
   c. "Like habitat" will be sampled as the basis of comparison in response to changes in hydraulic conditions. Changes in hydraulic habitat arise due to turbine failure/maintenance or lack of or amount of spill (e.g., if the location or alignment of a current shear varies under different flow regimes the sites will shift to capture the same hydraulic feature[s]).
2) Improve the understanding of the Distance and Direction constraint variables.
   a. Sample egg deposition with more consistent spatial and temporal effort to ensure the current form of the Distance model is not notably biased.
3) Capture habitat information at resolutions higher than that modelled for the habitat suitability analyses.
4) Integrate the ongoing study of egg deposition by Lake Sturgeon at newly created rock shoals below the powerhouse with the current monitoring plan.
5) Subsample a relatively small fraction of eggs each year to confirm fertilization occurred.
6) Confirm the area around Eight Foot Falls, which appears to be the only other suitable spawning habitat in the Slave Falls Reservoir, is not an area of egg deposition.
7) Monitor egg deposition below Slave Falls at the onset of Operation as a reference.

Sampling Design

Egg counts yield non-normal data that is not suitable for *a priori* power analysis for an effect size determination. The following study is intended to detect spatial pattern changes that are catastrophic or high magnitude.

Parameters

The primary indicator metrics targeted by the egg trap sampling program will be:

- The slope of a relationship between egg count and Distance. This metric describes the general pattern of egg distribution observed. The slope, and potentially intercept, of the egg abundance pattern will be monitored to determine if the sturgeon ascend, spawn, and deposit eggs in a manner similar to what has been observed.
- Mean and cumulative egg counts over time summarized by 20 m distance bin by the following variables: Key Site, Year, and Pre-/Post-.

Sampling Sites

The indicator metrics will be investigated at the scale of Key Sites. Key Sites are defined as swaths of physical and hydraulic habitat that extend from the origin of attractant flow to the 95th percentile egg count Distance.

Key Sites will be approximately 30 m wide and extend to the 95th egg deposition percentile distance[1]. The width of a Key Site equates to approximately three turbine flows below the powerhouse or, below the spillway, encompasses flows to sample the edge of the fast flow, shear zone, and slower water found farther away from the current shear.

Sampling Frequency and Schedule

Egg deposition will be monitored in May and June each spring during construction and through the operation phase I stage, upon which the available results will be reviewed and indicate the approach to any further sampling in operation phase II (Table 2-1). In phase II the need to sample when spill does not occur would be considered annually.

Methods

Each Key Site will have three series of egg mats deployed in a downstream direction at approximately 6-10 m intervals (Figure 6-1). Single egg mats will be deployed along the edges of the shear zone and in eddies, where possible. Sampling at the same interval will take place below the 95th percentile egg deposition distance at select locations to confirm the state of the present Distance model. Select Key Sites will overlap with constructed rock shoals when hydraulic conditions permit.

During the first year of operation, the “extended” sampling program will be conducted by evenly placing egg mats across the velocity gradient for a distance of 400 m downstream. Egg traps also will be placed in the area of Eight Foot Falls to continue to confirm spawning does not occur there. During operation, the area below Slave Falls GS will also be monitored for egg deposition to provide a reference for the program conducted downstream of Pointe du Bois GS.

Water velocity in the study area, including all egg traps at Key Sites, will be observed using Acoustic Doppler Current Profilers (ADCP) throughout the water column. Substrate and use of substrate by Lake Sturgeon would be captured with a side scan and/or DIDSON camera, where possible.

6.1.4 Approach for Assessing Monitoring Results

The results of the egg deposition monitoring program may produce two expected outcomes:

Case 1: Monitoring Data are Markedly Variable

The assessment method is based on the available data and is expected to be determined by an AEMP monitoring committee (proponent, regulator, invited members).

The expected outcome is a qualitative (i.e., visual) assessment that indicates if changes are/are not apparent in the data.

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[1] The 95th percentile egg deposition distance may change as new data are analyzed.

Case 2: Monitoring Data are Considered Relatively Stable

Slope of the Egg Abundance vs. Distance Relationship

General Linear Models may be considered to test for differences in the slope of the noted relationship. If merited, differences in the intercept (i.e., the mean number of eggs sampled) can be compared using least squares means (LS Means) at the distance from the station that is the grand mean of the Key Site pooled dataset. Use of statistical inference does not necessarily dictate formal conclusion. Other more simple approaches could be adopted where the data in question are visually compared to the range in observed Key Site data.

The expected outcome is a quantitative assessment that indicates that changes are/are not apparent based on statistical inference and group consensus by an AEMP committee. It is expected that the Egg Abundance vs. Distance relationship will be similar to that observed during the EIS studies (2007-2010).

Appendix II provides an example of the analytical approach to assess changes in egg deposition using a subset of the available data collected at Pointe du Bois from 2007 – 2010.

6.1.5 Decision Framework for Adaptive Management

The draft decision framework illustrated in Figure 6-2 will guide sampling and assessment workflows for the AEMP adaptive management aspect of the Project. The design of the framework is scalable over space and time in that the framework can apply to comparing the results of Key Sites in a single year, multiple Key Sites over multiple years, or all data before and after the Project.

Decisions on a sample, set of samples, or all samples pooled occur at steps A-F on Figure 6-2. Each step is described in brief below.

All decisions regarding the review of data, evaluation or revision of sampling design, assessment for completeness of sampling, changes in methods, and testing of assumptions of the monitoring program occurs at the Analyze/Assess Step.

A: Is the pattern of observation consistent with the expected results learned from the EIS studies? This benchmarks our current understanding of sample distributions to which all monitoring data is compared until a sufficient amount of monitoring data are available to support or refute the EIS data.

B: If the patterns agree with expected results (A) and the sample size is considered sufficiently large (i.e., Yes) from which to base conclusion the monitoring program has been completed. This is the pathway that a "no effect" result of the project would take, likely after several iterations through the flow diagram after several years of data collection. If the sample size is considered small (i.e., No), despite supporting expected results, more sampling is required.

C: If the patterns of observed data do not agree with expected results (A) and the sample size is not considered sufficiently large (i.e., No) then more sampling is required.

D: If the patterns of observed data do not agree with expected results (A) and the sample size is considered sufficiently large (C) (i.e., Yes) and the pattern of observed data is outside the range of inter-site or inter-annual variation (D) a Project effect may be considered.

E: If a Project effect is under consideration (E) but is unclear (i.e., No or Uncertain) the unexpected result may have resulted from site, event, or habitat specific interactions (or other unknown environmental or biological attributes). One possible outcome of this step is that complete understanding of the unexpected but large sample result (A + C) may not be possible. Results from the reference site at Slave Falls may help to choose the relevant pathway.

F: If the apparent Project effect (E) is under consideration but is not attributable to Site, Event, or Habitat specific interactions (F) meaning the environmental/biological interactions can be excluded as a source of change (i.e., No), then the state of knowledge must be reconsidered and potentially a new sampling plan designed to accommodate the new knowledge. If the apparent Project effect (E) is attributable to Site, Event, or Habitat specific interactions (F) then new information is available that dictates a new state of knowledge. If this is expected to occur very infrequently, for example, it may be excluded. Alternatively a new range in the data has been found. Return to D from A.

The study team will develop reports on the data each year and distribute them to the Monitoring Committee. The reports provide preliminary summaries of the state of data with respect to the anticipated flow of work in the following year. Each report would contain the data from previous years, and provide a synthesis and recommendations for sampling in the following spawning period.

6.2 Lake Sturgeon Larval Drift

A larval drift program will be conducted in conjunction with the egg deposition program each year to provide a relative measure of larval emergence (not quantitative). Monitoring will commence in the construction period and will continue through the operational phase.

6.2.1 Monitoring Area

The study area for Lake Sturgeon larval drift monitoring encompasses the area of the Winnipeg River from the base of the Pointe du Bois spillway rapids and GS downstream to Eight-Foot Falls (Figure 2-1). Lake Sturgeon spawning is known to occur in Reach 3 both in the Pointe du Bois GS powerhouse tailrace and near the base of the spillway rapids.

6.2.2 Pathways of Effect and Key Questions

Changes to aquatic habitat downstream of the Pointe du Bois GS due to hydraulic modifications and alteration of substrates could affect hatch of Lake Sturgeon eggs.

The key questions for monitoring Lake Sturgeon larvae include:

- Will emergence and drift of Lake Sturgeon larvae occur following deposition of eggs during operation of the new spillway?
- What is the relative strength of the larval drift in relation to the egg deposition?

6.2.3 Sampling Design

Larval drift from the Lake Sturgeon spawning grounds located below the Pointe du Bois GS will be monitored by setting drift traps on the bottom of the river.

6.2.4 Parameters

Material collected in drift traps will be sorted and all lake sturgeon larvae will be enumerated and measured to the nearest mm. Catches will be expressed in number of larvae captured per trap per 24 hour sampling period.

6.2.5 Sampling Sites

Larval drift nets will be set in similar locations to drift nets set from 2006-2012 All sets will be located between the Pointe du Bois GS and Eight-Foot Falls.

6.2.6 Sampling Frequency and Schedule

Larval drift sampling will be conducted annually in conjunction with the egg deposition monitoring program (Section 6.1.3). Larval drift netting will commence seven days following the onset of spawning and continue daily for a three week period. The effort will be similar to drift net programs conducted from 2006-2012.

6.2.7 Methods

Sinking drift nets (opening of 43 x 85 cm, with an attached, 300 cm long, 950 µm Nitex® screen bag, tapered to a 9 cm diameter removable ABS pipe 'cod-end') will be set for 24 hour periods in locations and for durations used during baseline monitoring. Annual larval drift data will be compared to pre-Project data to provide a relative measure of hatch success.

6.3 Juvenile Lake Sturgeon Survival and Recruitment

The post-Project abundance of Lake Sturgeon in the Slave Falls Reservoir will ultimately be determined by recruitment of young fish. To understand whether survival and recruitment is affected over the short term post-Project, juvenile Lake Sturgeon survival and recruitment will be monitored. Monitoring will commence immediately post-Project to assess variation and will continue annually for a sufficient number of years to track cohort survival, inter-annual variation in catchability, survival, and recruitment of each age class.

6.3.1 Monitoring Area

Monitoring of juvenile Lake Sturgeon will be conducted in Reaches 3 and 4 between Pointe du Bois GS and Slave Falls GS.

6.3.2 Pathways of Effect and Key Questions

Potential effects to egg deposition and hatch due to changes to hydraulic conditions below Pointe du Bois GS spillway could affect recruitment of lake sturgeon in the Pointe du Bois GS to Slave Falls GS reach of the Winnipeg River.

The key question for monitoring Lake Sturgeon recruitment is:

- Will recruitment of Lake Sturgeon in the Post Project environment change from pre-Project levels?

6.3.3 Sampling Design

A small mesh gillnetting study will be conducted to target young-of-the-year (YOY) and juvenile lake sturgeon. Mark and recapture data will be collected to develop encounter histories to assess annual survival, recruitment, and abundance of Lake Sturgeon in the Pointe du Bois GS to Slave Falls GS reach of the Winnipeg River.

Gillnetting programs such as proposed due not lend themselves to A Priori power analysis. These studies are intended to detect spatial pattern changes that are catastrophic or high magnitude. The proposed approach is evidence based and is comprised of several metrics, of which CPUE is only one. Given that the majority of statistical comparisons will be nonparametric it will be possible to make a post-hoc assessment of the 'power' by simulation. In the same fashion this is done using t-tests and randomizations from normal distributions, it could be adapted to non-normal distributions and Mann-Whitney or other nonparametric tests. The post-hoc approach essentially allows for a likelihood of the observed result to be put into the context of the data distributions, or in this case the specific metric of choice. Because this approach requires an understanding of how the metrics are distributed, it must be post-hoc and therefore used as an adaptive tool to make adjustments to sample size and/or monitoring program in general

6.3.4 Parameters

All Lake Sturgeon captured that are less than 900 mm in length (sub-adults) will be measured for total length, fork length, and weight. A fin ray (for age determination) will be collected from each fish sampled, and a fin clip (for potential future genetics analysis) will be collected from a sub-sample. All fish captured will be examined for previously applied tags.

6.3.5 Sampling Sites

The timing of the sampling program, sampling locations, and gear are selected specifically to target for juvenile Lake Sturgeon. In the Slave Falls Reservoir, juvenile Lake Sturgeon movements are highly restricted to three zones of contiguous deep-water habitat, located between Pointe du Bois and Eight Foot Falls, Eight Foot Falls and the Old Slave Falls narrows, and the Old Slave Falls narrows to the Slave Falls GS. It is assumed that distributions are primarily influenced by patterns of larval drift, which are ultimately influenced by flows. Therefore, netting will be conducted in all three zones as illustrated in Figure 6-3.

6.3.6 Sampling Frequency and Schedule

Monitoring will be conducted annually commencing during construction in 2012 and, depending on results, may continue for 15 years. Monitoring results will be evaluated after 2019 to determine the actual frequency of sampling through to 2029.

6.3.7 Methods

Monitoring will be conducted during the fall when lower water temperatures will reduce potential for mortalities. Gear will include small mesh gill nets with mesh sizes of 1”, 2”, and 3”. Lake Sturgeon will be collected, sampled for the parameters described in Section 6.3.3 and marked with either 8 mm or 12 mm (dependent on size of fish) Passive Integrated Transponder (PIT) tags.

A total of 15 gillnet sets will be conducted annually in each of the three sampling zones. Sampling will focus explicitly on deep-water habitats (> 15m). Due to the exclusivity of deep water habitat use by YOY and juvenile Lake Sturgeon in the Winnipeg River, by-catch is expected to be minimal.

Encounter histories will be developed for all juvenile Lake Sturgeon captured. Population analyses will be run using the industry standard Program Mark using classic Jolly-Seber, Pradel Models, and age-structured models (Figure 6-4) to assess the annual survival, recruitment, and abundance of Lake Sturgeon. Mark-recapture studies, in particular Jolly-Seber models require a minimum of three years of data. The sampling is designed to be adaptive, targeting juvenile Lake Sturgeon of several age classes. In fall 2012, 5” and 6” meshes will also be utilized (in addition to 1”, 2” and 3” meshes) to target larger (older) juvenile/sub-adult size classes, to quantify year-class strength relationships during the pre-Project phase. Monitoring is intended to continue through the construction and into the post-Project phase to provide a continuous dataset on the juvenile Lake Sturgeon in the study area.

7.0 FISH COMMUNITY

The following section provides details of a plan to monitor Project-related effects to the fish community in the Study Area. Monitoring will begin in the construction phase and continue at various levels of effort through the first 15 years of operation. The studies will monitor the effects of blasting, changes to physical conditions in Spillway Pond 2, fish use of newly created habitats and the general fish community upstream and downstream of the Project. All monitoring of the fish community, with the exception of blasting, will occur during Project operation.

7.1 Monitoring During Construction

Blasting will generally be conducted in accordance with DFO guidelines for the use of explosives in or near Canadian fisheries waters (Wright and Hopky 1998) to ensure compliance with the fish and fish habitat protection provisions of the *Fisheries Act* (including provisions to protect against overpressure in fish swim bladders and to protect spawning beds during egg incubation). A potential location where the above criteria may not be achieved is the upstream end of the primary spillway approach channel. Blasting will be monitored to ensure that DFO guidelines are met and that fish mortality deemed unacceptable by regulatory authorities does not occur. Blast monitoring will be described within individual EnvPPs. The following monitoring specifically addresses potential fish mortalities due to blasting events that are not able to meet criteria within the DFO guidelines.

Monitoring Area

Blasting will be conducted to construct the spillway approach and discharge channels and may be used for some activities during decommissioning of existing facilities. This monitoring program will be conducted in any areas where blasting is occurring in or adjacent to fish habitat where blasting guidelines cannot be met.

Pathways of Effect and Key Questions

Blasting will be conducted to excavate the intake and discharge channels of the spillway. Blasting has the potential to cause fish mortalities by increasing pressures in the water column, particularly if blasting guidelines cannot be met.

The key question for monitoring blasting is:

- What is the level of fish mortality when blasting occurs that does not meet DFO guidelines?

Sampling Design

Observational monitoring of fish mortality will be conducted during and after blasts that are not expected to meet the criteria within the DFO guidelines.

Parameters

Observed dead fish will be collected, where possible, enumerated by species and sampled for length and weight. Over pressure meters (e.g., Blastmaid) will be used to determine blast conditions.

Sampling Sites

Monitoring will occur immediately adjacent to and downstream of blasting sites.

Sampling Frequency and Schedule

The above stated monitoring will be conducted during construction for any blasting events that are not expected to meet the criteria within the DFO guidelines.

Methods

Monitoring will include direct observation of the blast site and the area immediately downstream for a period of approximately 30 minutes following the blast. Results of blast monitoring will be reported electronically to appropriate regulatory authorities.

7.2 Monitoring During Operation

7.2.1 Fish Productivity and Habitat Use in Newly Created Forebay Habitat

Construction of the new spillway structure is expected to create and/or modify approximately 100,000 m^2 of aquatic habitat between the new main dam and the existing structure and in the new spillway approach channel. Monitoring of this new or modified habitat will be conducted to determine the nature and extent of use by fish and the productive capacity of this habitat in relation to other habitats in the area.

Monitoring Area

Monitoring will be conducted in approximately 80,000 m^2 of aquatic habitat that will be created between the new Main Dam and the existing spillway structure and in approximately 20,000 m^2 of aquatic habitat that will be created in the new approach channel following construction of the new spillway structure (Figure 7-1).

Pathways of Effect and Key Questions

Construction of the new spillway will create or modify aquatic habitat that will be used by fish.

The key question for monitoring fish use of the newly created/modified habitats is:

- How does fish use of the new/modified habitat compare to fish use of existing habitats in the Pointe du Bois forebay area and downstream of the spillway?

Sampling Design

Gillnetting will be conducted in the newly created/modified habitats to determine use by individual fish species and life stage and to generate catch per unit effort (CPUE) data.

Parameters

All fish captured will be enumerated by species, measured for length and weight, and classified by sexual maturity. Species use will be measured in terms of relative abundance, catch per unit effort, size, and sexual maturity.

Sampling Sites

A minimum of two sampling sites will be selected within each of the newly created/modified habitats.

Sampling Frequency and Schedule

Monitoring will occur during spring, summer, and fall periods during the first and third year of operation.

Methods

Sampling will be conducted with standard index gill nets and boat electrofishing (where suitable). The data collected will be compared to existing CPUE data to determine the relative importance of the newly created habitat in relation to fish productivity.

7.2.2 Spillway Pond Monitoring

Monitoring of Spillway Pond 2 will occur during the operation phase to measure the magnitude of impact associated with the loss of spillway inflows to the pond.

Under existing conditions Pond 2 receives inflow as a result of spillway leakage at all times during the open-water season and higher flows during spill events. During post-Project operations, spillway leakage will be eliminated. As well, during spill events spillway flows will be directed through the new spillway, thereby bypassing the ponds. Cessation of flows into Pond 2 will eliminate fish access and affect water quality in the pond.

Monitoring Area

Sampling will be focused on Ponds 2 on the spillway rock shelf downstream of the spillway structures (Figure 7-1).

Pathways of Effect and Key Questions

Changes to limnological conditions in Pond 2 during operation due to a reduction in inflow frequency as a result of concentration of spills through the new spillway will affect the ability of the pond to support fish.

The key questions for monitoring the fish community in Pond 2 are:

- How will the fish population in Pond 2 change during Project operation compared to current conditions?

Sampling Design

Gillnetting will be conducted in spillway Pond 2 to generate an understanding of catch per unit effort and relative abundance. Data from the operation phase will be compared to pre-Project data.

Parameters

All fish captured will be enumerated by species, measured for length and weight, and classified by sexual maturity. Data will be presented by species and life stage captured and by CPUE.

Sampling Sites

Sampling sites will be situated throughout Pond 2.

Sampling Frequency and Schedule

Monitoring will occur during the first year and third year of operation.

Methods

Monitoring will include standard index and small mesh gillnet sampling. Data will be compared to pre-Project data to determine changes in the fish community.

7.2.3 Reach Monitoring

During Project operation, Reaches 1, 3, and 4 will be monitored to assess fish abundance by way of CPUE and community composition.

Monitoring Area

Monitoring of the fish community will be conducted in Reaches 1, 3, and 4 (Figure 2-1).

Pathways of Effect and Key Questions

Changes to habitats downstream of the new spillway have the potential to affect spawning by fish other than Lake Sturgeon. Effects to spawning could change species abundance in the Winnipeg River between Pointe du Bois GS and Slave Falls GS.

The key question for monitoring the fish community in Reaches 1, 3 and 4 is:

- How will CPUE of species other than Lake Sturgeon change in Reaches 3 and 4 during operation of the Project in relation to CPUE of fish in Reach 1 and in comparison to pre-Project CPUE in Reaches 3 and 4?

Sampling Design

A standard index gillnetting program will be conducted periodically during the operation period to generate relative abundance and CPUE data to determine whether changes in the fish population are occurring.

The inherent variability in gillnet catches and composition require several levels of assessment. Comparisons are restricted to nonparametric statistics as the existing data have been fitted to a negative binomial distribution (Figure 7-2). The probability of CPUE values can be determined using the fitted distribution both individually and in combination to estimate a likelihood of the monitoring results. Additional tests of reliability can be determined *post hoc* by iteration to approximate the nonparametric equivalent of power at observed significance levels. All of the analyses will be run using random deviates from built-in Microsoft Excel distribution functions. All iteration-based analyses will be built using Excel macros written in Visual Basic for Applications.

Community composition will be compared to existing baseline data to determine whether the monitoring data fall within the expected variation. Incidence-abundance curves of existing baseline data (Figure 7-3) will be used to assess the incidence and abundance of fish species during the monitoring period. Annual frequency of occurrence of fish species in the baseline line data will be used to assess annual variation in composition (Figure 7-4) and allow appropriate assessment of the composition during the monitoring period.

Species specific CPUE and variability will be described and analyzed following the Coordinated Aquatic Monitoring Program (CAMP) protocol.

Each specific assessment approach is a piece of the larger evidence-based approach to assessing the fish community. Each specific analysis therefore will be subject to the same process (see Adaptive Management Decision Framework Section 6.1.5) to ensure each analysis and/or metric is treated with the appropriate degree of rigor.

Parameters

Fish will be collected, enumerated by species, and sampled for length and weight. The data will be analyzed to generate CPUE values and frequency of occurrence histograms.

Sampling Sites

Sampling sites will be distributed randomly throughout Reaches 1, 3, and 4.

Sampling Frequency and Schedule

The periodicity of the monitoring is focused on a 3-year interval, which will provide sufficient duration to detect changes in target species of interest such as Walleye and Northern Pike. Monitoring of Reaches 1, 3, and 4 will occur four times beginning in the first year following construction, and every 3 years after until Year 10 (i.e., years 1, 4, 7, and 10). Reach 1 will be covered by CAMP with the addition of 1.5” mesh to remain compliant with baseline gear and target the full range of fish lengths.

Methods

Monitoring will include standard index and small mesh gillnet sampling of Reaches 1, 3, and 4 to determine whether fish species composition and CPUE have changed substantially. Data will be compared to pre-Project data to determine changes in the fish community.

A total of 10 sets in each Reach will be used to define the distribution of CPUE during the monitoring period. This should provide a sufficient number of samples from which to compare CPUE values. No *a priori* power analysis is available for nonparametric tests; *post hoc* assessment of the reliability of the nonparametric tests can be achieved through iteration.

8.0 REPORTING AND FOLLOW-UP FOR REGULATORY AUTHORITIES

A schedule for overall reporting is provided in Table 2-1. During the conduct of specific construction activities for which daily or weekly reporting is required, reports will be submitted electronically (via e-mail) to the appropriate authorities. Annual reports will be provided in digital form (Adobe PDF).

During the construction period, Manitoba Hydro will be responsible to ensure that monitoring and reporting are conducted as described in this AEMP. Manitoba Hydro will oversee the implementation and conduct of the studies by qualified individuals, and oversee the review of reports prior to submission to the regulators. As required, monitoring plans will be modified throughout construction and operation.

An overview of reporting for each of the monitoring plan components during the construction and operation phases is provided below.

8.1 Monitoring During Construction

During the construction period, annual reports integrating the results of all components of the monitoring plan will be prepared in the year following data collection. In addition, reporting of some parameters will occur during specific construction activities on exception and based on water quality results in exceedance of the environmental requirements for the Project. In such cases Manitoba Hydro will submit a report detailing results of monitoring activities during the construction period to the designated agencies.

Reports will include:

- A summary of monitoring activities conducted;
- Results of monitoring (as they are made available[2]), including field observations;
- Observations/results and/or information indicating that limits specified in the *Environment Act* Licence or other authorizations have been exceeded; and
- Information on atypical or unexpected occurrences, with respect to construction activities, that may have resulted in any exceedances of pre-determined thresholds.

Blasting Monitoring Reports

All reasonable measures will be undertaken to avoid exceedance of the blasting guideline criteria. However, if any of the blasting guideline criteria is expected to be exceeded, appropriate regulatory authorities will be notified prior to the blast and the blast monitoring report will be submitted following the blast. Following a blast, if it is determined the blast did not meet the blasting guidelines the blast monitoring report will be

[2] Water chemistry data generated through analyses conducted at an accredited analytical laboratory are generally not available within the same day that samples are collected. In addition, there is a typically an approximate 24-hour delay associated with collection and transport of samples to an accredited laboratory in Winnipeg.

submitted to regulatory authorities shortly after the blast. All blast monitoring reports will be included in the annual report.

Annual Reports

Reports will be prepared in the year following data collection. Reports will describe the monitoring conducted within a given year with reference to specific construction activities, results of the monitoring plans, and comparison to pre-construction conditions, where relevant. The report will include all results of the water quality, aquatic habitat, aquatic macroinvertebrate, Lake Sturgeon, and fish community monitoring conducted in a given year.

8.2 Monitoring During Operation

Results of monitoring during the operating phase will be presented in annual reports in the year following completion of the relevant field work. Reports will include:

- a complete description of sampling methodology;
- a complete record of all data collected;
- notes regarding specific conditions (e.g., water levels and flows) that may have affected monitoring results;
- comparison to guidelines and pre-Project data, where relevant (note that detailed analyses will not be conducted until completion of Phase I of the operations phase of monitoring); and
- a brief summary of the integrated results of monitoring, with preliminary indication of whether: (i) unexpected effects that may need to be addressed through mitigation are occurring; and (ii) recommendations for modifications, if any, to the monitoring plan.

In 2020, a synthesis report providing detailed analysis of data collected to date, with reference to pre-Project and reference site conditions will be prepared. This report will describe:

- the effects of the Pointe du Bois Spillway Replacement Project on the aquatic environment during the operating phase;
- effects that were not anticipated in the EIS;
- effects that are occurring that may need to be addressed through a modification of mitigation measures; and
- a proposed monitoring plan for Phase 2 of the operations monitoring plan.

Similar to the construction phase, the operation phase monitoring reports will include results of the water quality, aquatic habitat, aquatic macroinvertebrate, Lake Sturgeon, and fish community studies within a single report.

9.0 LITERATURE CITED

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TABLES AND FIGURES

Table 2-1. Summary of major field activities planned for the Aquatic Effects Monitoring Plan. Reports for field activities will be provided the year following the activity.

Program	**Construction**			**Operation phase I**					**Operation phase II**									
									Year									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Water quality	○	○	○	○			○											
Aquatic habitat		○			○		○											
Invertebrates	○	○	○	○		○												
Fish community	○	○	○	○	○	○	○	○	○	○?	○?	○	○?	○?	○	○?	○?	○

○= Field activities planned, see individual sections for details.

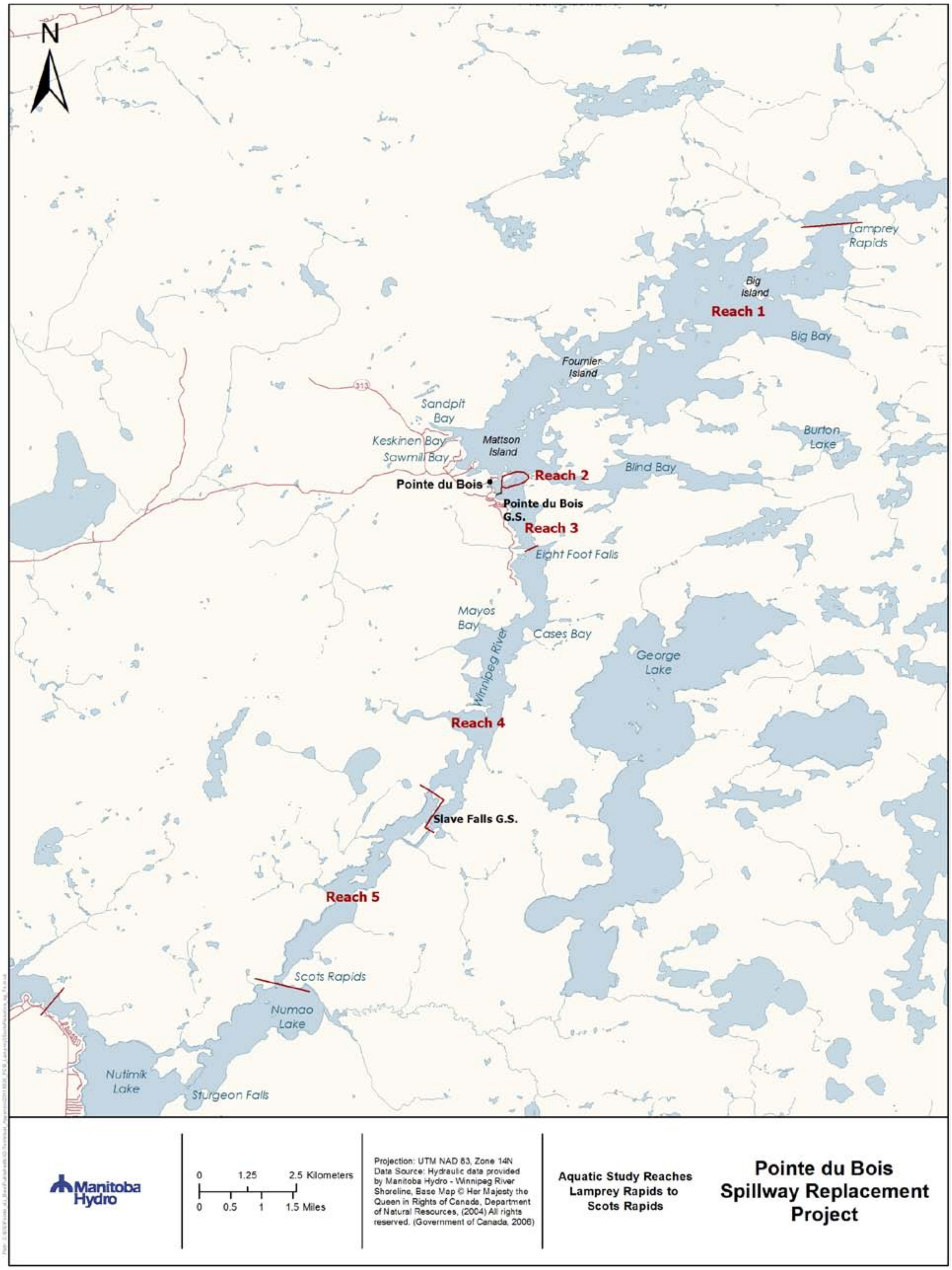

Figure 2-1. The Spillway Replacement Project study area.

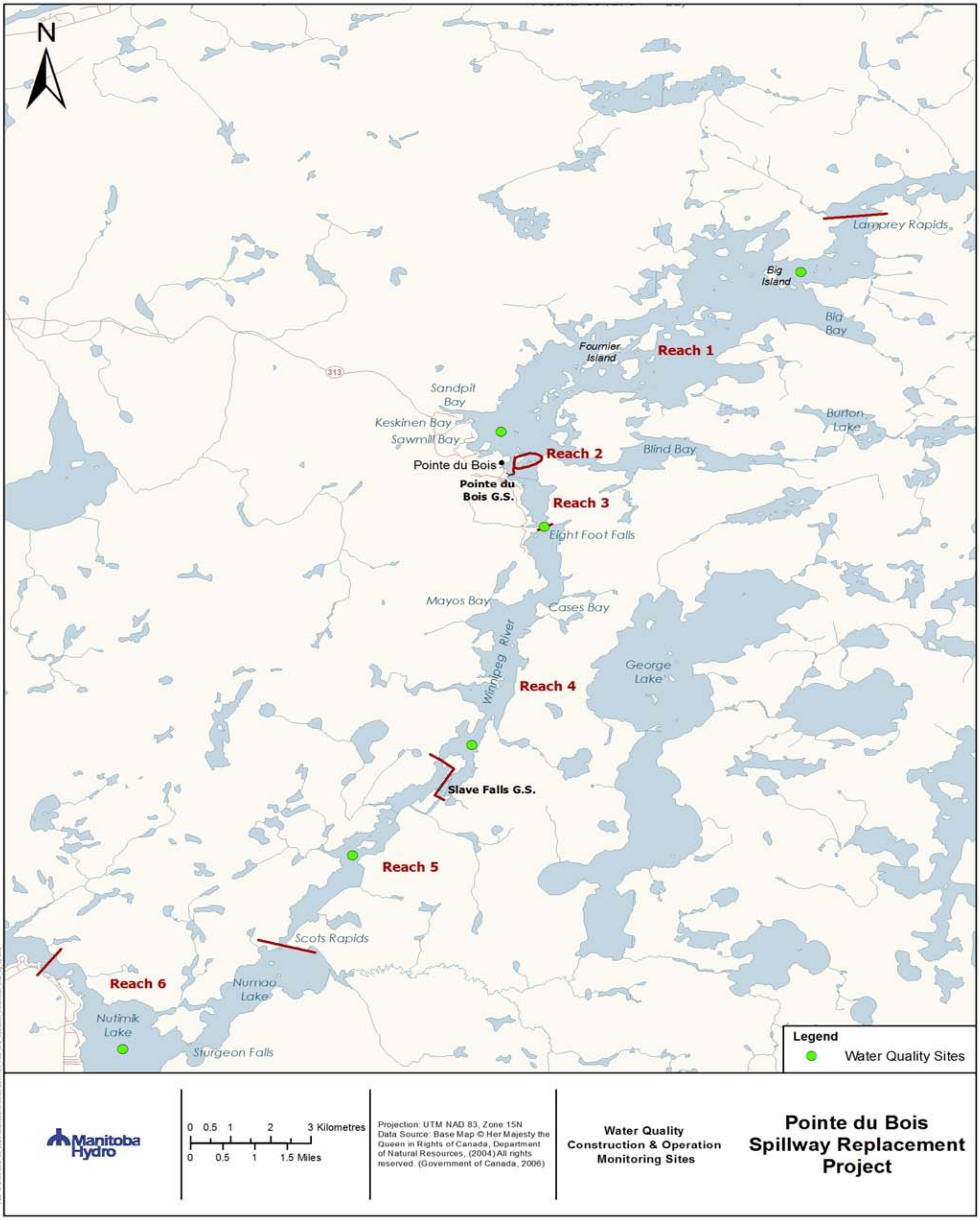

Figure 3-1. Water quality monitoring sites for the construction and operation phases of the Spillway Replacement Project.

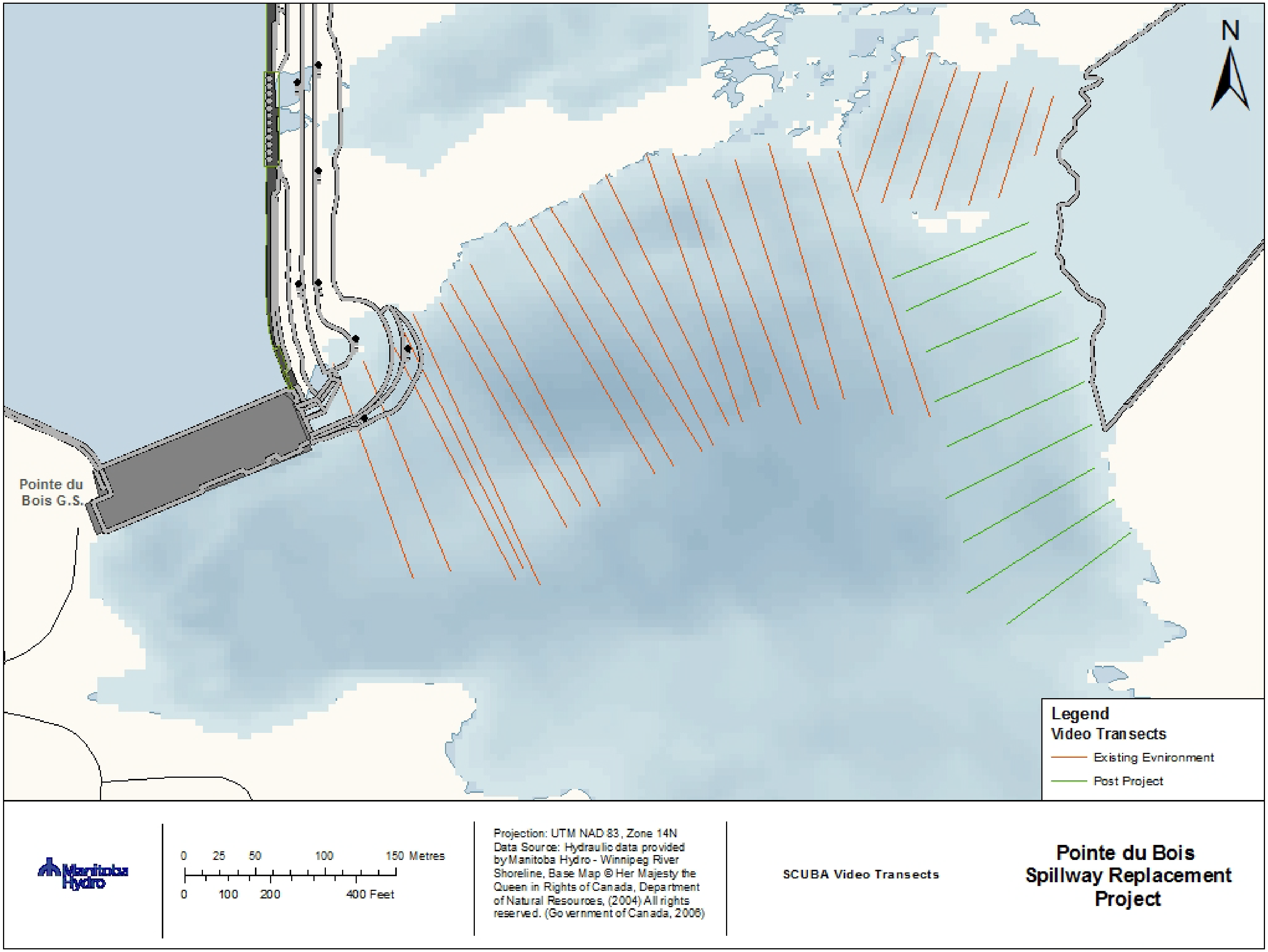

Figure 4-1. Video transect locations below the spillway shelf area.

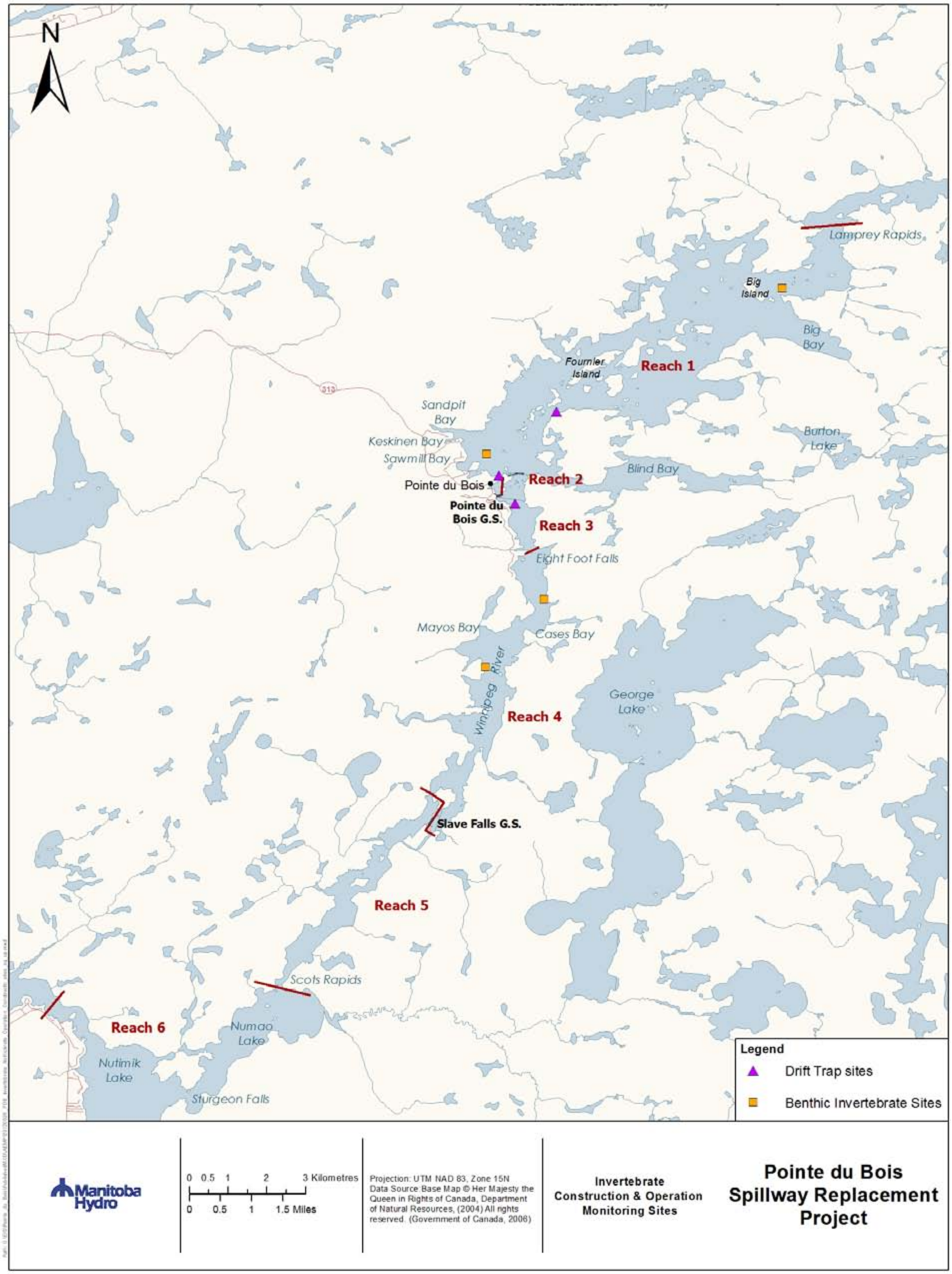

Figure 5-1. Aquatic macroinvertebrate monitoring sites for the construction and operation phase of the Spillway Replacement Project

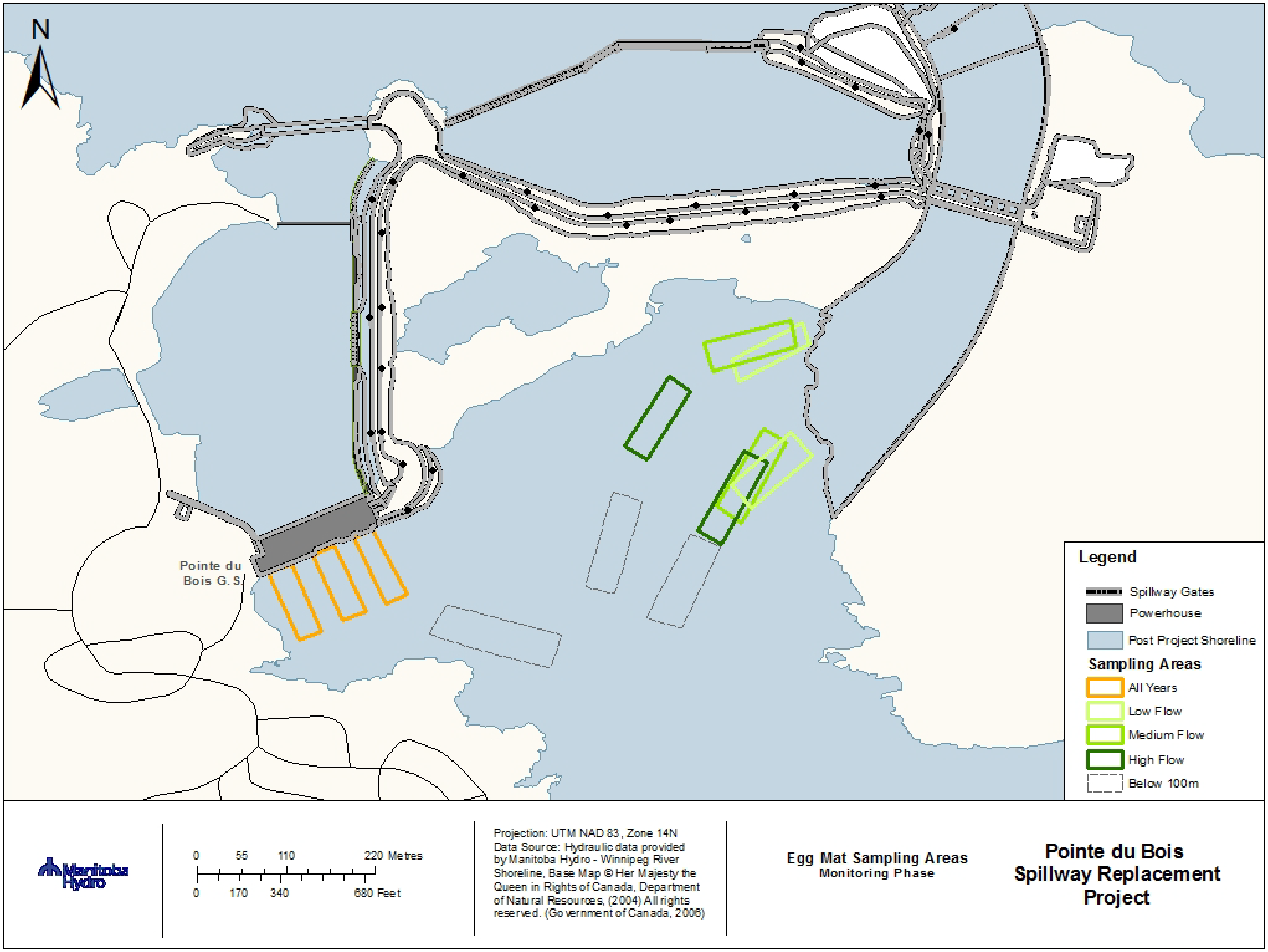

Figure 6-1. Example illustration of Key Sites when spillway flows complement powerhouse flows for the Existing Environment. Actual Key Site selection would be made based on hydraulic conditions evident at the onset of the sturgeon spawning period.

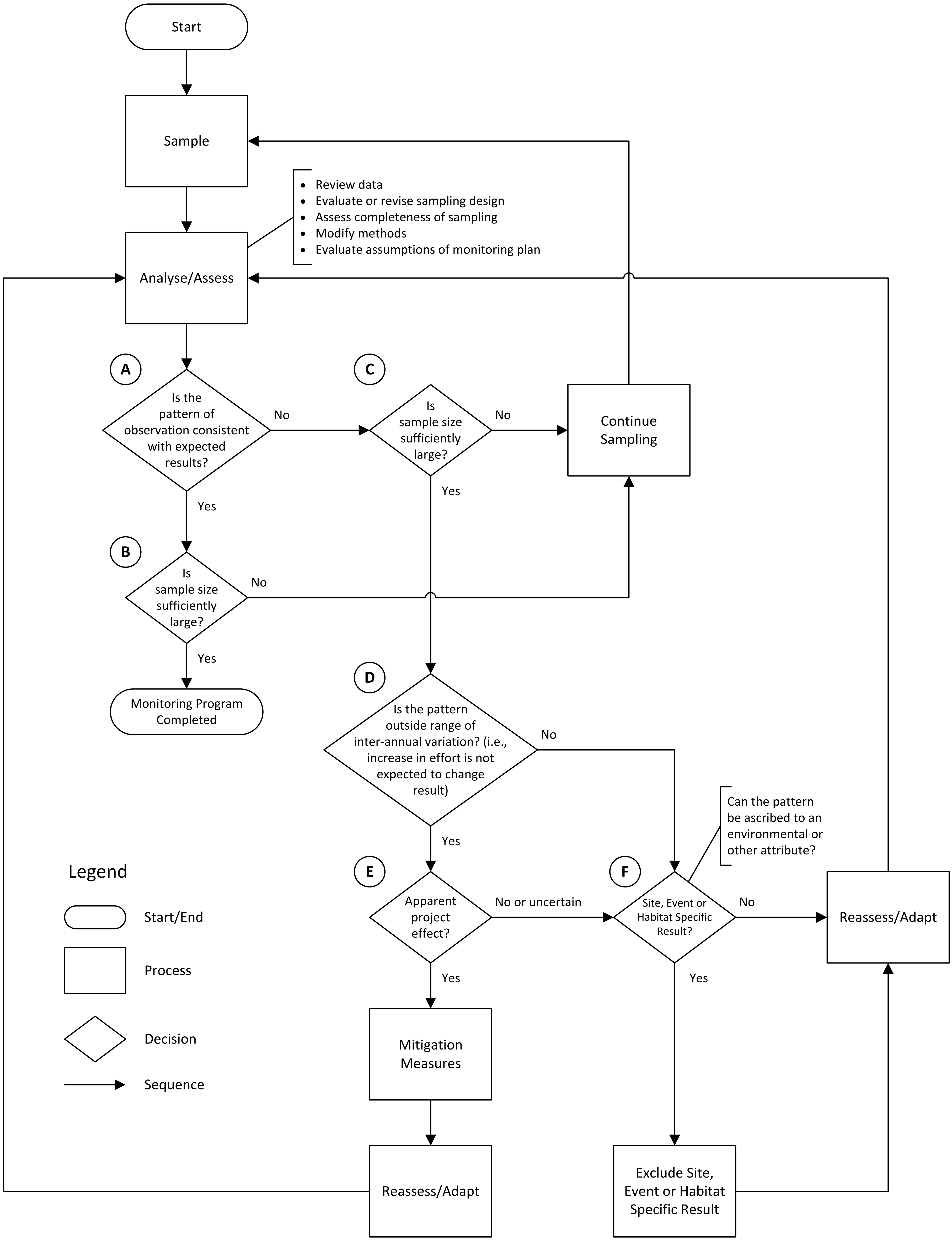

Figure 6-2. Adaptive Management Decision Framework to guide field sampling protocols and assessment workflows.

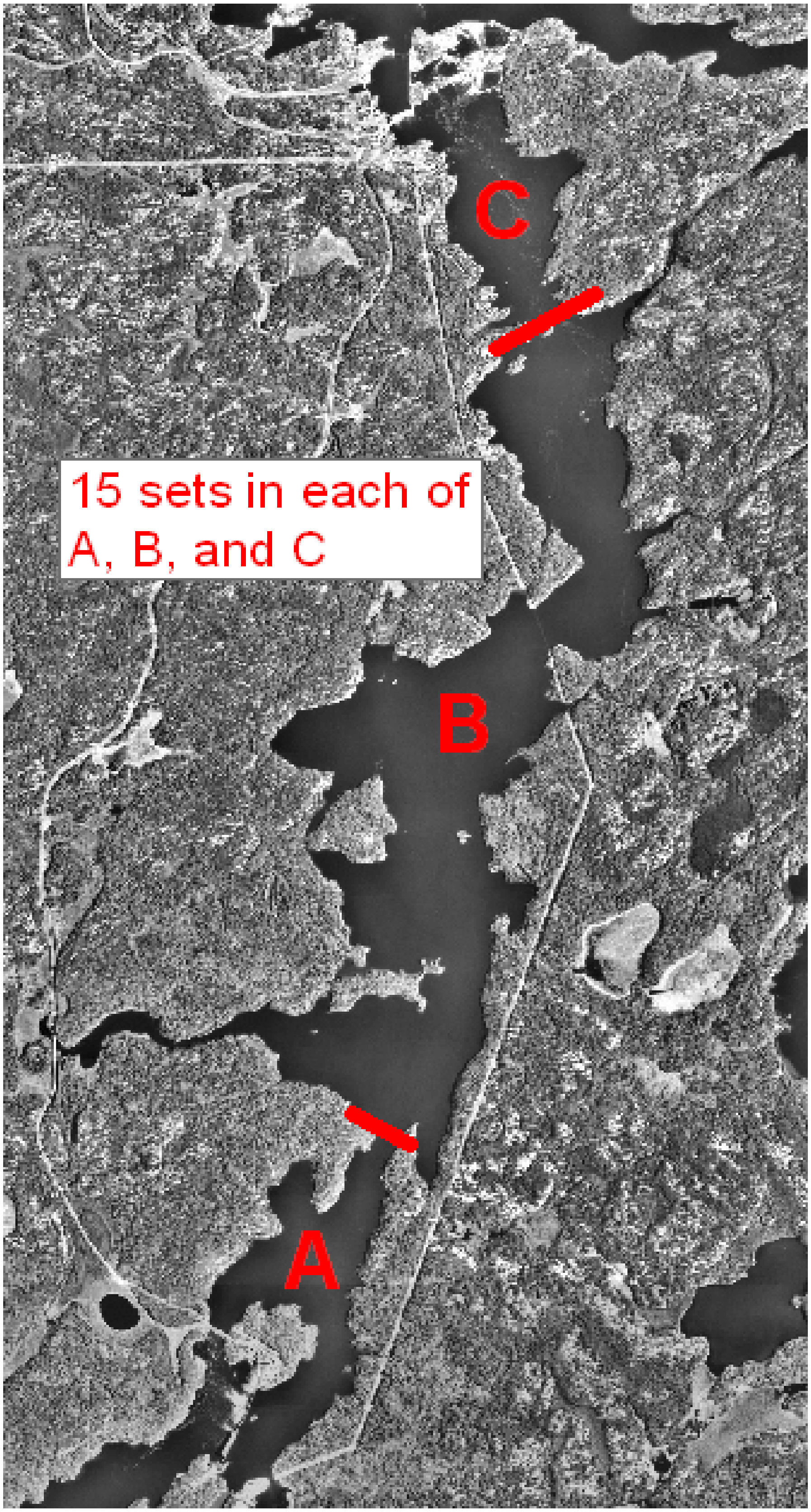

Figure 6-3. Sampling zones and recommendations for number of gillnet sets (100 yd gangs) for proposed juvenile Lake Sturgeon recruitment monitoring.

Targeted Monitoring

Mark-Recapture Data						Covariates	
Fish ID	Year 1	Year 2	Year 3	···	Year *n*	Wild	Sex
000001	1	0	1	...	1	1	0
000002	1	1	0	...	0	1	1
000003	1	0	0	...	1	0	0
000004	1	1	1	...	0	1	1
000005	0	1	0	...	0	0	1
000006	0	1	0	...	0	1	1
000007	0	1	1	...	0	1	1
000008	0	1	0	...	0	0	1
000009	0	0	1	...	1	1	0
000010	0	0	1	...	0	1	0
000011	0	0	1	...	0	1	1
000012	0	0	1	...	0	1	0
...	...	...	...	...	...	...	...
00000*n*	0	0	0	...	1	0	1

Juvenile or adult abundance, survival, recapture across years. For spawning adults Lambda-Burnham or Pradel Models for recruitment → Standard Jolly-Seber

1	2	3	4
	2	3	4
		3	4
			4

Juvenile cohort abundance, survival, recapture through time and across years. Time lag monitoring of spawning success. Age-specific survival and year specific recruitment → Cohort Jolly-Seber

1	2	3	4
	1	2	3
		1	2
			1

Figure 6-4. Example of mark-recapture data for juvenile Lake Sturgeon monitoring. The same datasets can be used for annual cohorts and/or specific age classes.

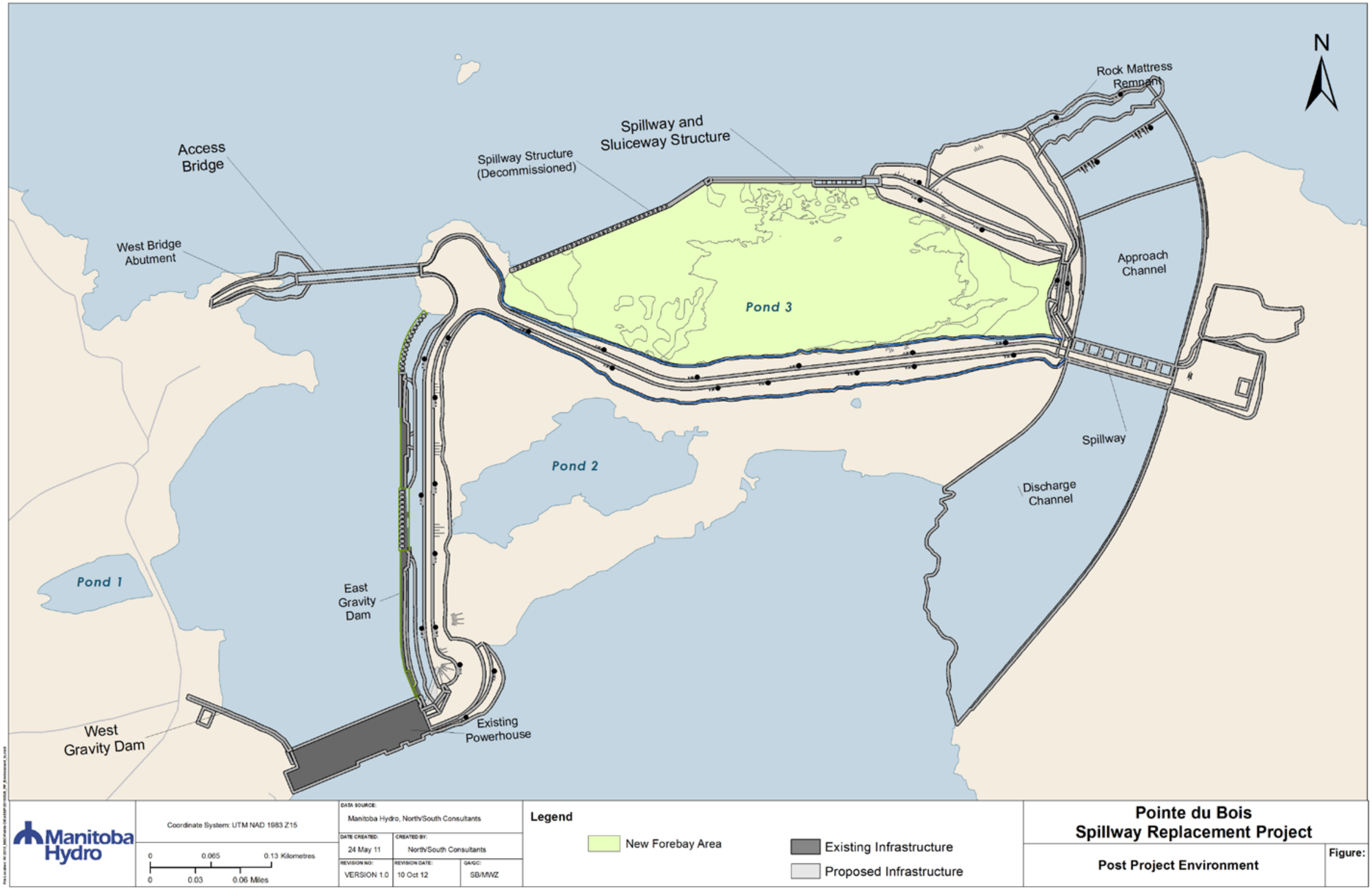

Figure 7-1. Location of upstream areas of newly created fish habitat and Spillway Ponds 2 and 3.

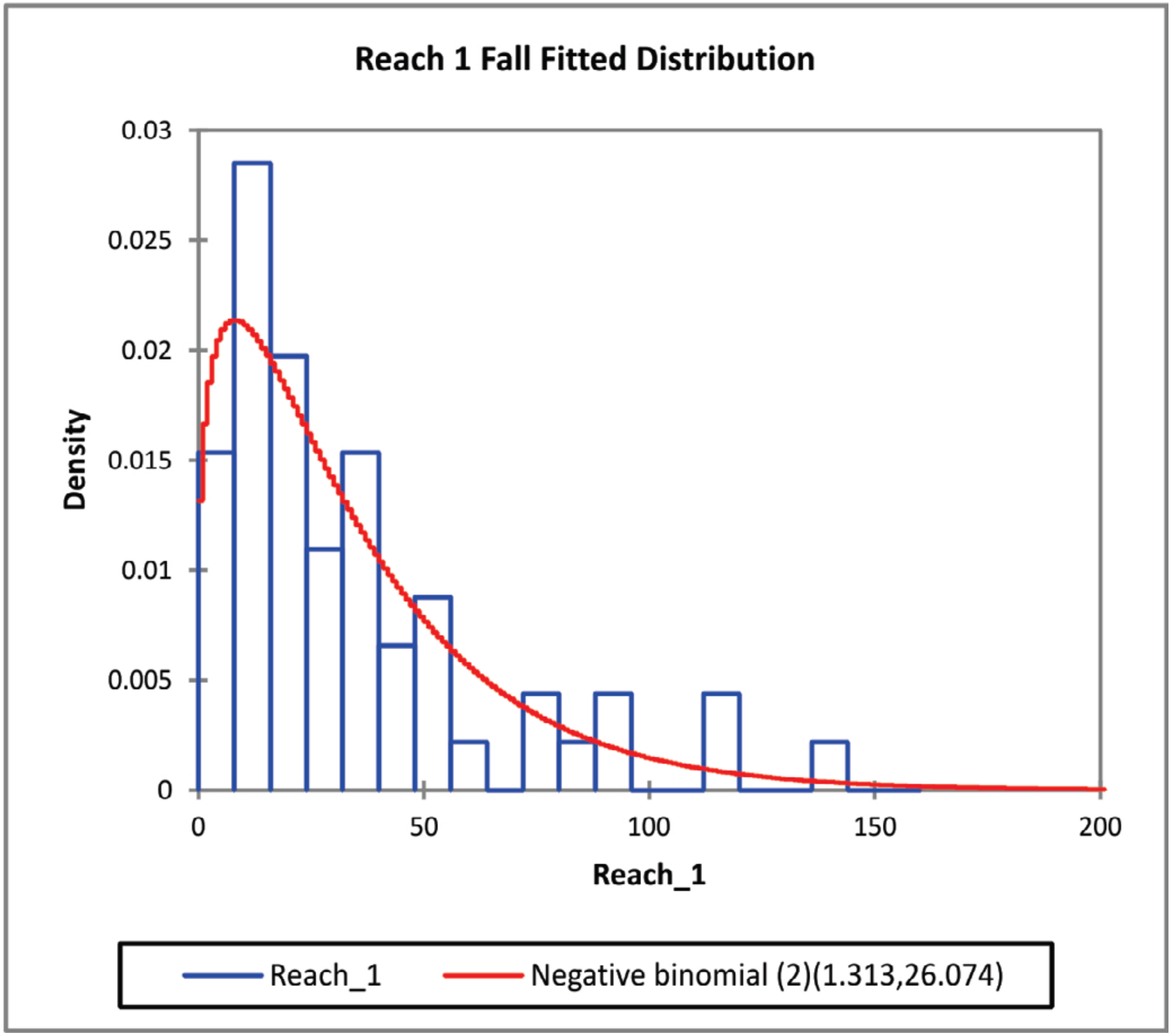

Figure 7-2. Baseline CPUE data from Reach 1, showing a fitted negative binomial distribution.

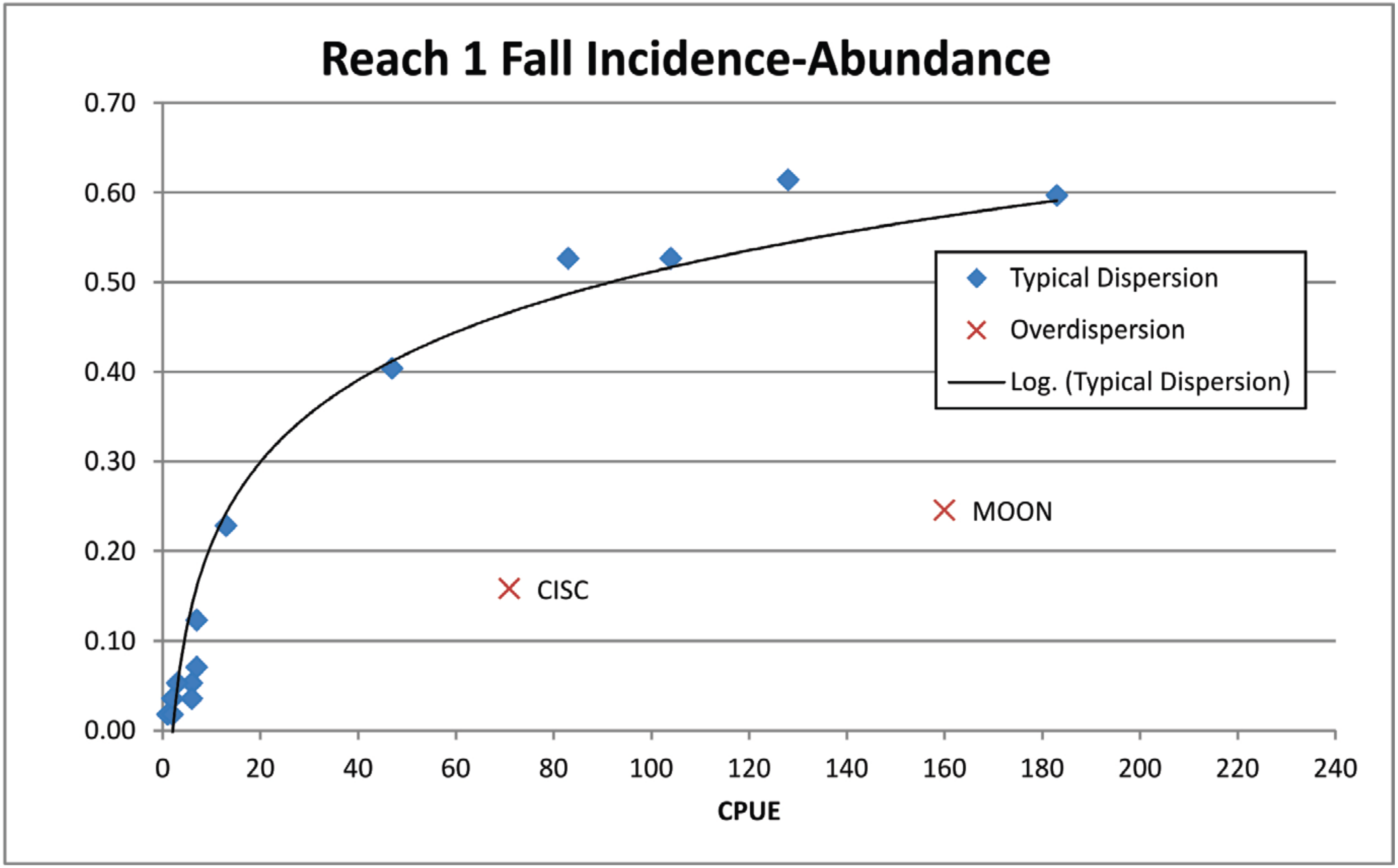

Figure 7-3. Incidence-abundance curve showing typical species dispersion and overdispersed cisco and mooneye.

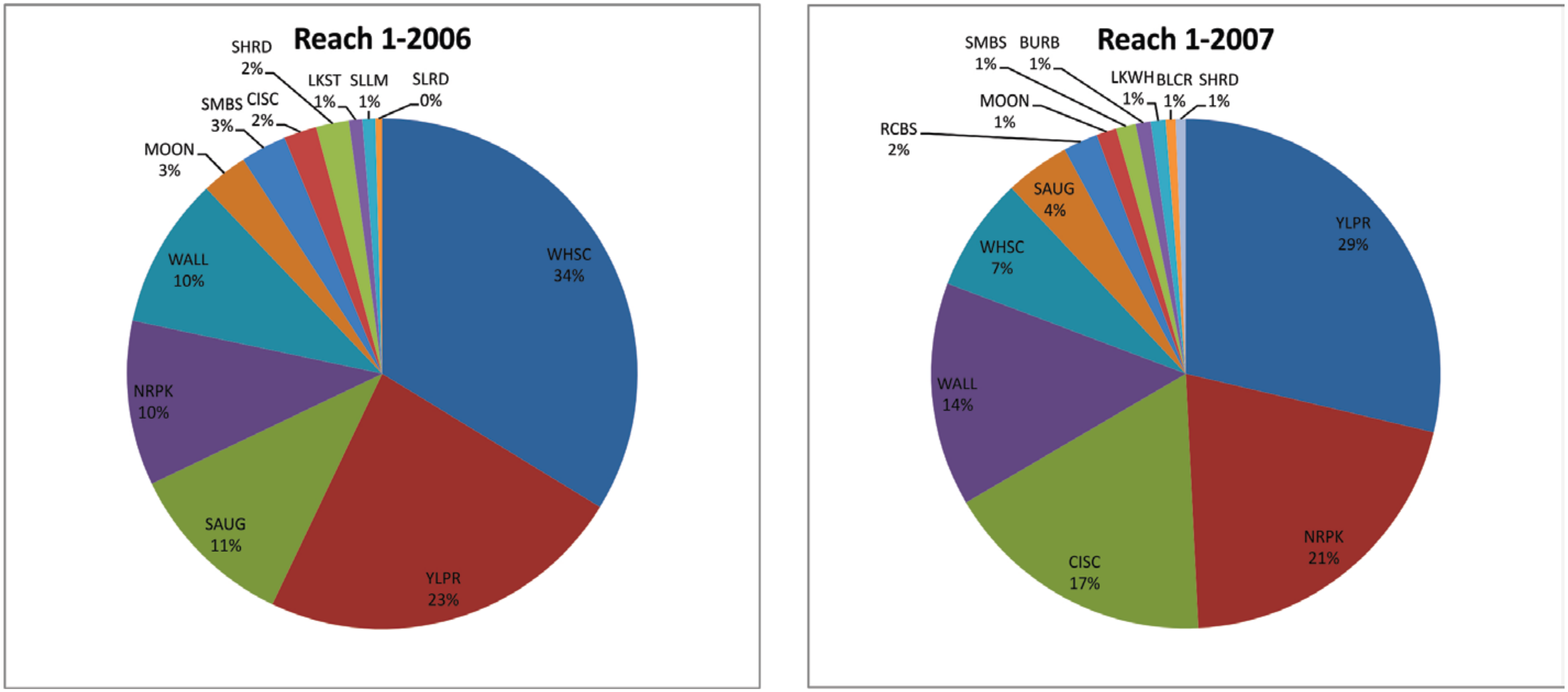

Figure 7-4. Annual variation in species composition comparing fall 2006 with fall 2007 for Reach 1.

APPENDIX 1

WATER QUALITY POWER ANALYSIS

Introduction

An *a priori* power analysis was conducted to determine the appropriate level of sampling effort (i.e., identify sample sizes) for the water quality monitoring program. The following provides an overview of the methods and results of this analysis.

Methods and Approach

Effects of the Project on water quality are predicted to occur downstream of construction activities during short-term construction activities and in Spillway Pond 2 during operation. The general monitoring design, as described in the AEMP, includes comparisons of water quality conditions spatially (i.e., upstream-downstream or "control-impact" comparisons) and temporally (i.e., comparisons to baseline water quality or "before-after" comparisons). To facilitate identification of sample sizes (i.e., number of sampling sites within each sampling area), baseline water quality data were subject to a power analysis.

Baseline sampling conducted downstream (Sites WPG-3 and WPG-4) of the Pointe du Bois GS were subject to analysis for a subset of water quality variables. The subset of water quality variables and the rationale for their inclusion are provided in Table 1.

The first step of the analysis entailed spatial comparisons between the two sites downstream of the GS to determine if baseline data could be pooled for this area. Open-water data collected in 2006-2008 were pooled for each site and analysed using t-tests to assess whether there were significant differences between the two sites within the downstream reach. All analyses were conducted using SYSTAT 10 for Windows, with alpha = 0.10 (as discussed in Environment Canada 2002). Results of this analysis indicated that water quality of sites WPG-3 and WPG-4 was not significantly different. Therefore, data collected from these sites were pooled for the conduct of the power analysis.

There is no standard effects threshold applied for water quality monitoring programs in Canada. For the purposes of exploring the statistical power associated with the baseline water quality data, several effects thresholds (i.e., the minimum detectable difference) were considered including:

- 10% difference;
- 25% difference;
- 50% difference;
- 100% difference;

- For selected variables, thresholds equivalent to the Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs) for the protection of aquatic life (PAL; Manitoba Water Stewardship 2011); and
- The Canadian Council of Ministers of the Environment (CCME) triggers identified in the Canadian guidance framework for the management of phosphorus in freshwater systems (CCME 1999; updated to 2012).

Effects thresholds based on MWQSOGs and the CCME phosphorus management framework triggers are summarized in Table 2. Power analyses were conducted for open-water and ice-cover seasons separately. Power analyses were performed using the Goal Seek function in Excel 2010 using alpha of 0.05 and power of 0.80. Power analyses could not be completed for some parameters (i.e., TSS, lead, selenium, and silver) for the ice-cover season as these parameters were not detected during the baseline studies in that season.

Results

A sample size of four was selected based on the results of the power analyses summarized in Tables 3-5. A sample size of four would be sufficient to detect exceedances of MWQSOGs for PAL for TSS (the key variable predicted to be affected by the Project), nitrate, copper, lead, and the MWQSOG narrative guideline for TP for streams and rivers in the open-water season. This sample size is also sufficient to detect a 100% change in TSS during the open-water season; power analysis could not be completed on this parameter for the ice-cover season due to lack of detection during the baseline studies. This sample size would also be sufficient to detect less than or equal to 100% change for the key variables that are predicted to be potentially affected by the project including TP, TKN, TDS, DO, aluminum, copper, iron, and manganese in the open-water season.

References

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian environmental quality guidelines. CCME, Winnipeg, MB. Updated to 2012.

Environment Canada. 2002. Metal mining guidance document for aquatic environmental effects monitoring. June 2002.

Manitoba Water Stewardship. 2011. Manitoba Water Quality Standards, Objectives, and Guidelines. Water Science and Management Branch, MWS. MWS Report 2011-01, November 28, 2011. 67 p.

Table 1. Water quality variables subject to power analysis.

Water Quality Variable	Rationale
Total suspended solids (TSS)	Primary variable predicted to be affected by the Project; Manitoba water quality objectives (MWQOs) for the protection of aquatic life (PAL).
Total phosphorus (TP)	Correlated to TSS and may be affected by the Project in relation to increases in TSS; Manitoba narrative water quality guideline; CCME Phosphorus Canadian guidance framework for the management of freshwater systems.
Dissolved phosphorus (DP)	Indicator of the biologically available fraction of phosphorus.
Total Kjeldahl nitrogen (TKN)	Correlated to TSS and may be affected by the Project in relation to increases in TSS.
Ammonia	While not expected to be affected by the Project, could be affected by use of Ammonium Nitrate Fuel Oils (ANFOs) during construction. MWQOs for PAL.
Nitrate/nitrite	While not expected to be affected by the Project, could be affected by use of ANFOs during construction. Manitoba Water Quality Guideline (MWQG) for PAL.
Dissolved oxygen (DO)	Critical variable for PAL; May be affected (i.e., reduced) in Spillway Pond 2 during Project operation. MWQOs for PAL.
Total dissolved solids (TDS)	Commonly used general indicator of water quality.
Aluminum	MWQG for PAL; Mean baseline concentrations exceeded the MWQG for PAL; Correlated to TSS and may be affected by the Project in relation to increases in TSS.
Copper	MWQO for PAL; Baseline concentrations occasionally exceeded the MWQO for PAL.
Iron	MWQG for PAL; Baseline concentrations occasionally exceeded the MWQG for PAL; Correlated to TSS and may be affected by the Project in relation to increases in TSS.
Lead	MWQO for PAL; Baseline concentrations occasionally exceeded the MWQO for PAL.
Manganese	Correlated to TSS and may be affected by the Project in relation to increases in TSS.
Selenium	MWQG for PAL; Baseline concentrations occasionally exceeded the MWQG for PAL.
Silver	MWQG for PAL; Baseline concentrations occasionally exceeded the MWQG for PAL.

Table 2. Effects thresholds for power analysis based on water quality objectives or guidelines.

Parameter	Water quality objective or guideline
Total suspended solids (TSS)	short-term MWQO (24-hour averaging duration) for PAL (25 mg/L increase above background); and long-term MWQO (30-day averaging duration) for PAL (5 mg/L increase above background).
Total phosphorus (TP)	Manitoba narrative water quality guideline for lakes, reservoirs and ponds and streams near the point of entry to said waterbodies (0.025 mg/L); Manitoba narrative water quality guideline for streams (0.050 mg/L); and Shift in trophic category, in accordance with CCME phosphorus management framework for freshwater systems.
Dissolved oxygen (DO)	Most stringent MWQO for PAL for cool- and cold-water aquatic life (open-water = 6.5 mg/L and ice-cover season = 9.5 mg/L).
Nitrate	Chronic MWQG for PAL (2.93 mg N/L).
Copper	Chronic MWQO for PAL based on mean water hardness (open-water = 0.00443 mg/L and ice-cover season = 0.00534 mg/L).
Iron	MWQG for PAL (0.3 mg/L).
Lead	Chronic MWQO for PAL based on mean water hardness (open-water = 0.00105 mg/L and ice-cover season = 0.00139 mg/L).

Table 3. Results of power analyses (sites WPG-3 and WPG-4) for the open-water season.

Parameter	Mean	SD	Thresholds						
			10%	25%	50%	100%	MWQSOG PAL[1]	CCME[2]	Comments
TSS	4	2	246	40	11	4	3	-	MWQSOG = 5 mg/L
							2	-	MWQSOG = 25 mg/L
TP	0.022	0.005	74	13	4	3	40	2	MWQSOG = 0.025 mg/L
							2	-	MWQSOG = 0.050 mg/L
Dissolved Orthophosphorus	0.006	0.004	781	126	32	9	-	-	-
Ammonia	0.013	0.008	531	86	22	6	-	-	-
Nitrate/nitrite	0.040	0.049	2389	383	97	25	2	-	MWQSOG = 13 mg N/L
TKN	0.5	0.04	11	3	2	2	-	-	-
TDS	73	10	30	6	3	2	-	-	-
DO	8.77	1.33	37	7	3	2	6	-	MWQSOG = 6.5 mg/L
Al	0.255	0.086	181	30	8	3	-	-	-
Cu	0.001	0.001	259	42	11	4	2	-	MWQSOG = 0.00443 mg/L
Fe	0.231	0.073	156	26	7	3	18	-	MWQSOG = 0.3 mg/L
Pb	0.0003	0.0002	597	96	25	7	3	-	MWQSOG = 0.00105 mg/L
Mn	0.0120	0.0021	48	9	3	2	-	-	-
Se	0.001	0.0003	495	80	21	6	-	-	-
Ag	0.0001	0.0002	495	80	21	6	-	-	-

[1] MWS (2011)

[2] CCME (1999; updated to 2012)

Table 4. Results of power analyses (sites WPG-3 and WPG-4) for the ice-cover season.

Parameter	Mean	SD	Thresholds						Comments
			10%	25%	50%	100%	MWQSOG PAL[1]	CCME[2]	
TSS	<2	-	-	-	-	-	-	-	MWQSOG = 5 mg/L
							-	-	MWQSOG = 25 mg/L
TP	0.020	0.002	13	3	2	2	4	2	MWQSOG = 0.025 mg/L
							1	-	MWQSOG = 0.050 mg/L
Dissolved Orthophosphorus	0.009	0.003	133	22	6	3	-	-	-
Ammonia	0.007	0.004	505	82	21	6	-	-	-
Nitrate/nitrite	0.159	0.004	3	2	2	1	1	-	MWQSOG = 13 mg/L
TKN	0.4	0.1	29	6	3	2	-	-	-
TDS	94	34	209	34	9	4	-	-	-
DO	12.2	1.5	24	5	3	2	6	-	MWQSOG = 9.5 mg/L
Al	0.331	0.093	125	21	6	3	-	-	-
Cu	0.002	0.001	108	18	6	2	3	-	MWQSOG = 0.00534 mg/L
Fe	0.280	0.019	8	3	2	2	15	-	MWQSOG = 0.3 mg/L
Pb	<0.00005	-	-	-	-	-	-	-	MWQSOG = 0.00139 mg/L
Mn	0.0079	0.0009	20	4	3	2	-	-	-
Se	<0.001	-	-	-	-	-	-	-	-
Ag	<0.0001	-	-	-	-	-	-	-	-

[1] MWS (2011)

[2] CCME (1999; updated to 2012)

Table 5. Summary of the level of significant differences detectable with a sample size of four.

Parameter	Level of Change Detectable	
	Open-water	Ice-cover
TSS	100%	NA
TP	50%	10-25%
Dissolved Orthophosphorus	>100%	50-100%
Ammonia	>100%	>100%
Nitrate/nitrite	>100%	<10%
TKN	10-25%	25-50%
TDS	25-50%	100%
DO	25-50%	25-50%
Al	50-100%	50-100%
Cu	50%	50-100%
Fe	50-100%	10-25%
Pb	>100%	NA
Mn	25-50%	25%
Se	>100%	NA
Ag	>100%	NA

APPENDIX 2

Patterns of Egg Abundance in the Available Egg Trap Data

To demonstrate the patterns of egg abundance vs. distance in the existing data, sturgeon egg data were extracted from four select areas (n = 155 trap pulls with eggs present) at a size consistent with the approach of "Key Sites" located within 120 m of the powerhouse and spillway (Figure A1-1). The data pooled for the spillway and tailrace are shown in Figure A1-2.

The available data for the selected sites (Figure A1-3) in the spillway do not have samples at all 20 m bins (Table A1-1) given flow occurs less often at these sites, and results in smaller sample sizes relative to the tailrace area. These data are not well suited for comparison at the level consistent with the approach of "Key Sites". When pooled at the level of spillway and tailrace the observations for both groups occupy a similar range in X and Y (Figure A1-4) and have visually similar regression slopes (Figure A1-5). This may suggest that sturgeon use (i.e., ascend, spawn, and deposit eggs) the habitat in both areas in similar ways. Note: In this example the difference in intercept (Y axis) may have resulted from differences in sample size.

Summary

Comparison at the level of Key Sites may be more likely with the AEMP than was possible with the available data given sample distributions in the future are expected to be more systematic over distance. The available data show, however, that even after a four-year period of study the sample sizes below the spillway will likely be smaller than that below the powerhouse given the reduced frequency of spill events. Further, the location of flow paths can change notably below the spillway among years with different inflows, and as such, some Key Sites may not replicate and have unbalanced sample distributions. The available data suggest that while comparisons of Key Sites below the powerhouse may be successful within and among years, the use of Key Site data below the spillway may need to be pooled.

Future comparisons between the tailrace and spillway are merited. The tailrace habitat can be considered a reference site given it will not be changed by the Project.

Table A1-1. Count and mean Egg Abundance (transformed) for four select sites in the tailrace and spillway collected 2007-2010.

		Distance (m)											
		20 m		40 m		60 m		80 m		100 m		120 m	
		Total Eggs (Sqrt)		Total Eggs (Sqrt)		Total Eggs (Sqrt)		Total Eggs (Sqrt)		Total Eggs (Sqrt)		Total Eggs (Sqrt)	
		Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean
Site Name	chute	2	6.244563	7	8.265141	2	7.499925	0	.	0	.	0	.
	main flow	0	.	6	11.537738	8	8.245552	5	5.888504	5	5.111399	4	2.824331
	side chute	3	6.945583	10	3.278050	2	1.707107	4	2.333960	0	.	0	.
	turbines 234	39	7.256834	15	3.648480	16	3.866093	19	3.318424	10	3.203240	6	2.845979

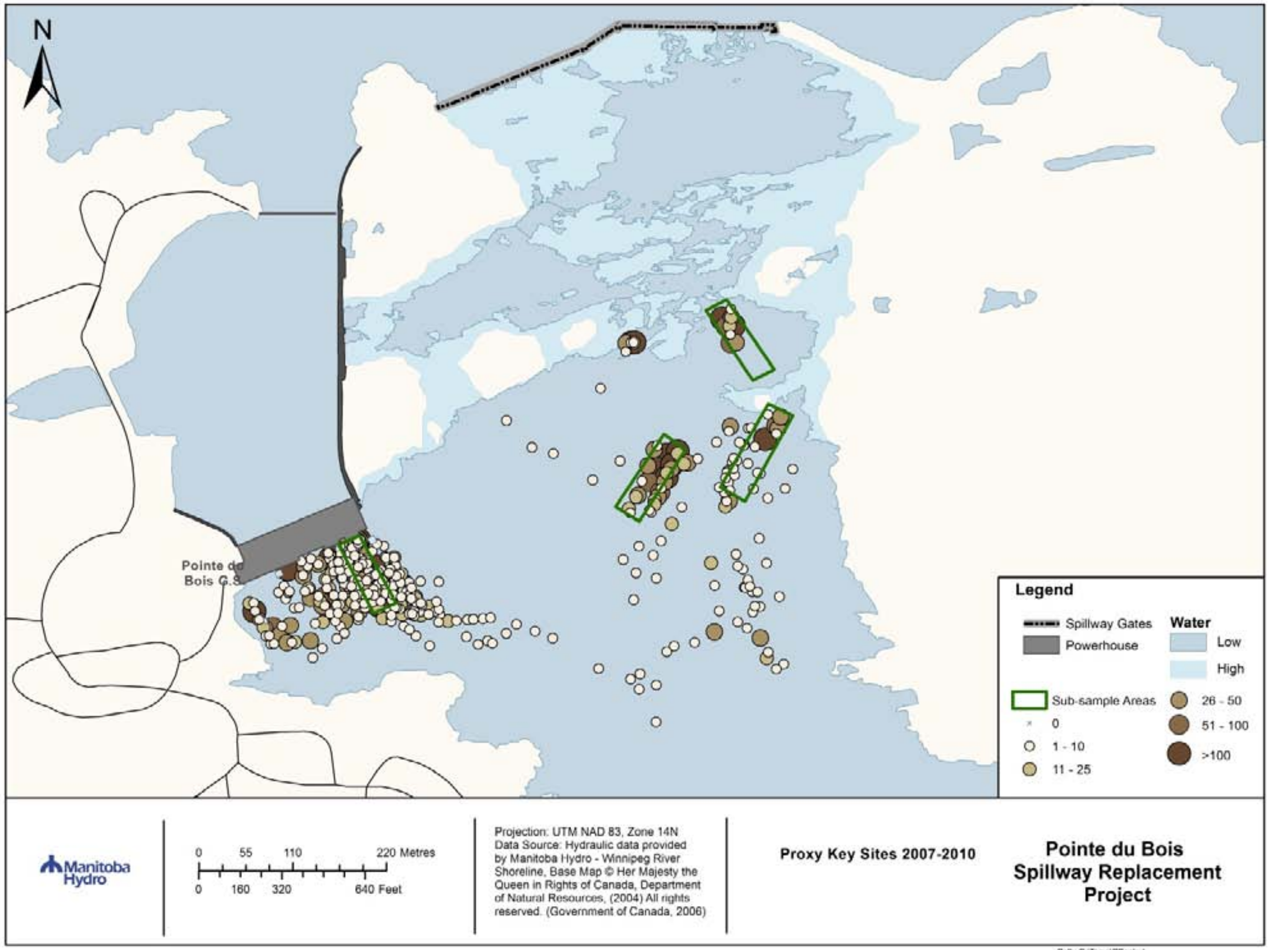

Figure A1-1. Location of sites where egg presence data have been extracted to demonstrate pattern in abundance at a scale similar to Key Sites.

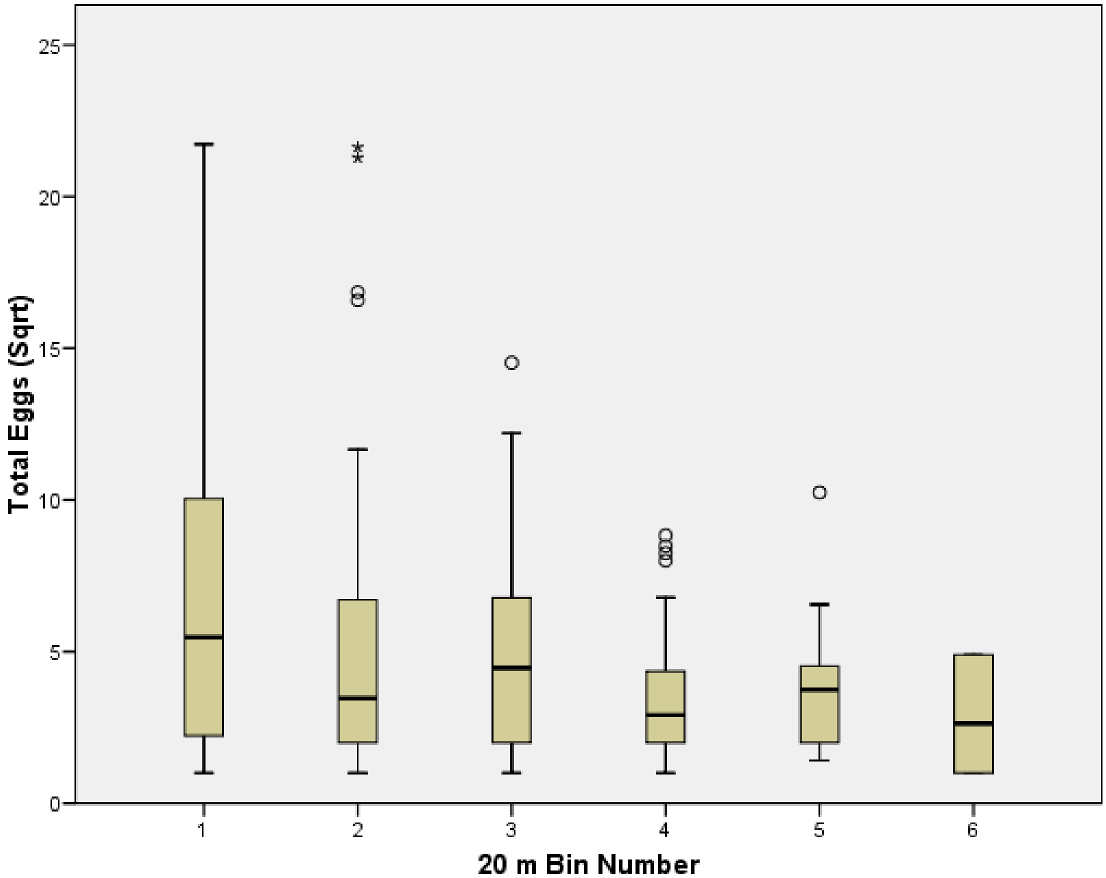

Figure A1-2. Boxplots of Egg Abundance with Distance for all samples pooled (n = 155 trap pulls) from the tailrace and spillway for four select areas at a scale similar to Key Sites.

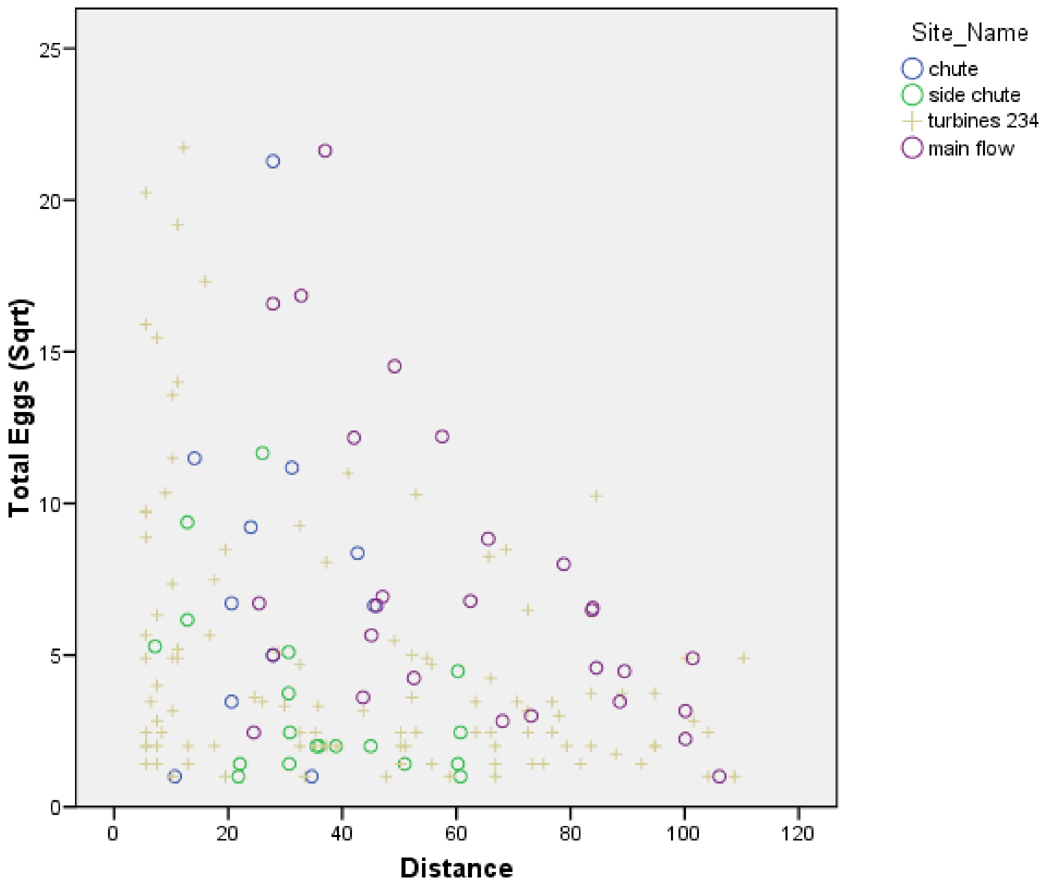

Figure A1-3. Egg Abundance with Distance for four select areas with eggs present at a scale similar to Key Sites. All sites are located in the spillway except "turbines 234" which is found in the tailrace.

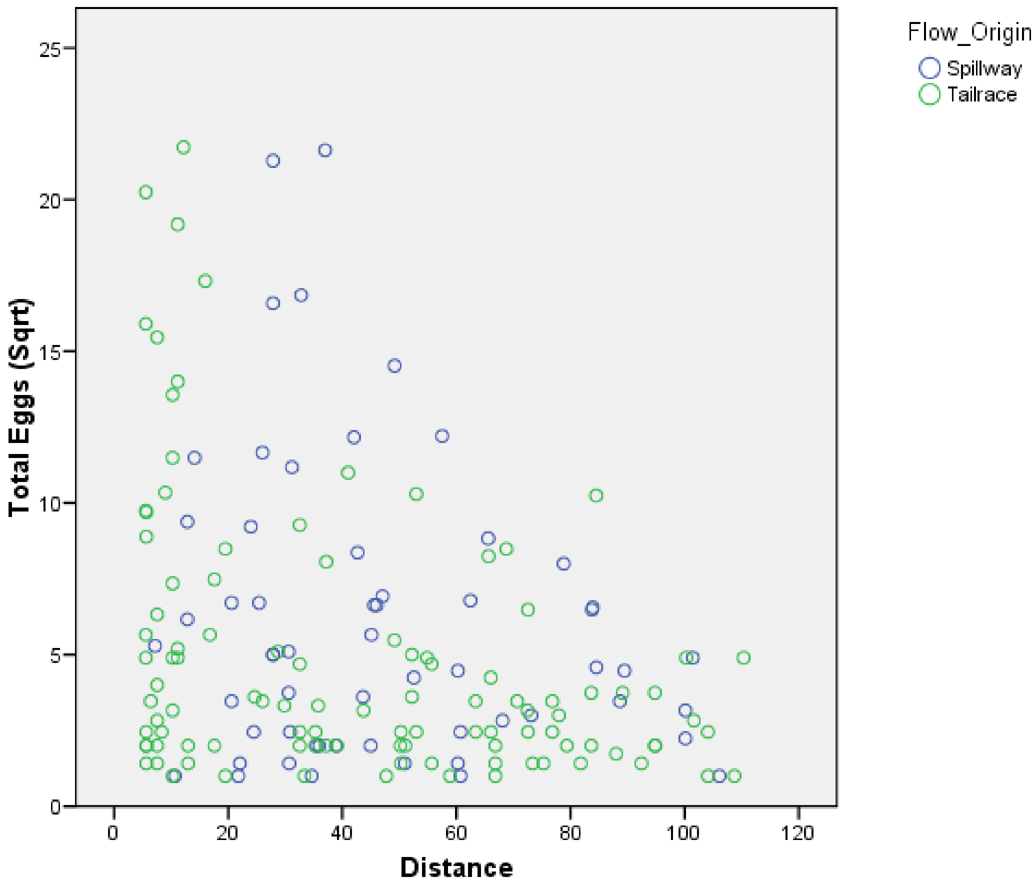

Figure A1-4. Egg Abundance with Distance for four select areas with eggs present at a scale similar to Key Sites. All sites have been pooled at the level of spillway and tailrace.

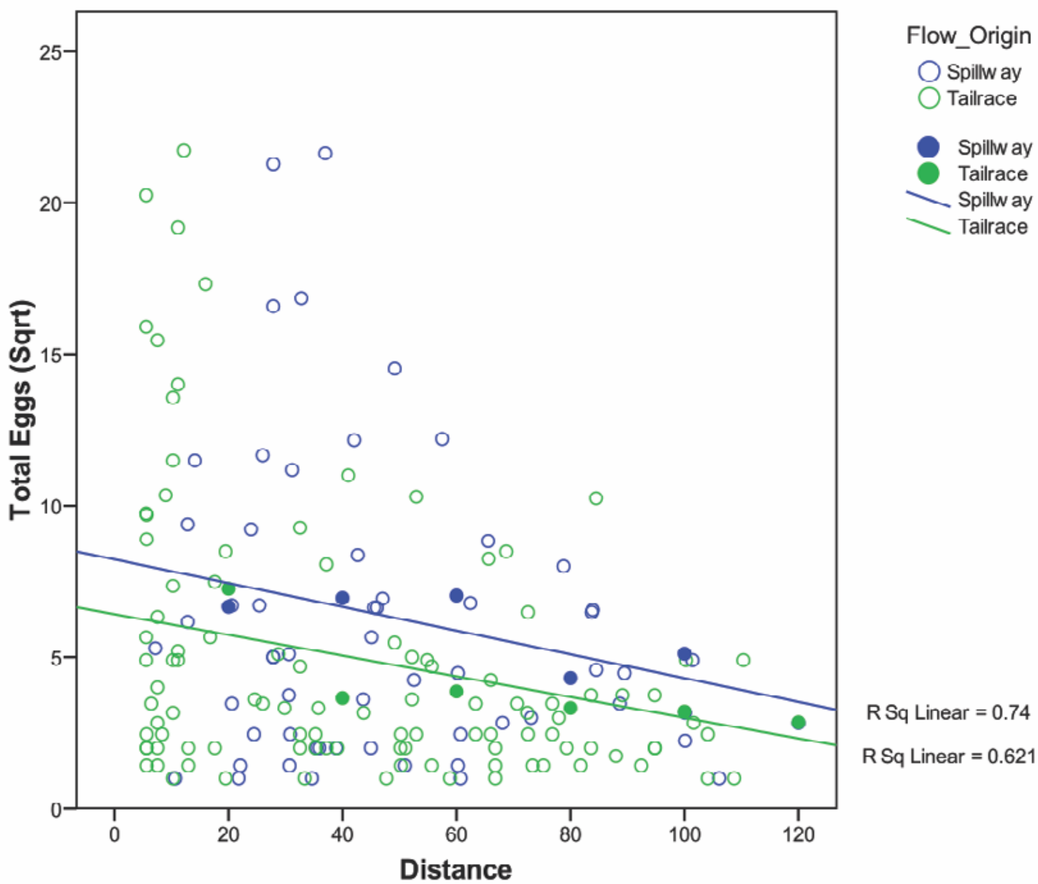

Figure A1-5. Egg Abundance with Distance observations (hollow symbols) with regressions on the average number of total eggs (solid symbols) for each 20 m bin.