Emergency Reduction of Lake Manitoba & Lake St. Martin Water Levels

Existing Aquatic Environment, Potential Impacts, and Work Plan

DRAFT REPORT

Prepared for Manitoba Infrastructure and Transportation · December 2012

By North/South Consultants Inc. · 83 Scurfield Blvd. · Winnipeg, MB · R3Y 1G4

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EXECUTIVE SUMMARY

Background

Due to widespread record flooding throughout southern Manitoba in 2011, water levels in Lake Manitoba and Lake St. Martin are several feet higher than desirable, resulting in significant damage to hundreds of properties, restricted road access to several communities, and long-term evacuation of four First Nations. If no action is taken, it is expected that high water levels and associated negative impacts will persist into 2012.

The Province of Manitoba has retained KGS Group and AECOM to investigate options to provide an emergency reduction of water levels in the two lakes. Water flows out of Lake Manitoba through the Fairford River and Lake Pineimuta to Lake St. Martin, and then through the Dauphin River to Lake Winnipeg. Currently, drainage through the Dauphin River to Lake Winnipeg is not sufficient to rapidly reduce the flood stage water levels on Lake Manitoba and Lake St. Martin. After reviewing numerous strategies, it was recommended that an emergency channel (Reach 1 Emergency Outlet Channel or simply Reach 1) be constructed to reduce the hydraulic flow restrictions out of Lake St. Martin to Lake Winnipeg (AECOM and KGS 2011). Reach 1 will include the excavation of a channel from Lake St. Martin to Big Buffalo Lake, a small lake located about 7 km northeast of Lake St. Martin. From Big Buffalo Lake, water will flow down Buffalo Creek and enter the Dauphin River about 4 km upstream of Lake Winnipeg. The entire pathway from Lake St. Martin to Lake Winnipeg is hereafter referred to as the “diversion route”. In addition to construction of Reach 1, the review recommends allowing unrestricted maximum flow of water through the Fairford River Water Control Structure (FRWCS) to enhance flow out of Lake Manitoba.

Construction and operation of Reach 1 and alteration of flows through the FRWCS has the potential to impact the aquatic habitat and biotic community of several waterbodies within the region. North/South Consultants Inc. has been retained KGS and AECOM to assist in assessing the potential project-related effects to aquatic environments that may be affected by the project. The objectives of this report are to:

- summarize existing information related to local aquatic habitat and biotic communities;
- describe potential impacts to the aquatic environment resulting from completion of Reach 1and maintenance of a high flows through the winter at FRWCS;
- identify any potential information gaps that need to be addressed to better understand aquatic impacts related to these developments and plan appropriate mitigation strategies;
- identify information requirements to measure impacts to the aquatic environment post-project; and,
- identify potential studies to address those information requirements.

Existing Environment

Waterbodies affected by flooding in 2011 include Lake Manitoba, the Fairford River and Pineimuta Lake, Lake St. Martin, and the Dauphin River. Water flows from Lake Manitoba through the Fairford River and Lake Pineimuta to Lake St. Martin, and then down the Dauphin River to enter Lake Winnipeg at Sturgeon Bay. Water inputs into Lake Manitoba are primarily from the Waterhen and Whitemud rivers, and, during times of flood-level flows on the Assiniboine River, from the Portage Diversion. Water flow out of Lake Manitoba is regulated at the Fairford River by operation of the Fairford Dam. When water flow into Lake St. Martin is high, the drainage capacity of the Dauphin River is exceeded, and water level on Lake St. Martin increases.

Although biological information specific to each of these waterbodies is not available for many species occurring in the area, a basic understanding of fish communities exists and movement patterns and habitat usage are understood for several of the commercially important species. Fish communities in each water body are diverse and are comprised of many species of fish (e.g., at least 37 species occur in Lake Manitoba). Of relevance to the project, the Dauphin River is used as a migratory route by spawning Walleye and Lake Whitefish moving from feeding areas in Sturgeon Bay to spawning locations in upstream areas of the river and in Lake St. Martin. Further, a commercial fisherman has indicated that Walleye and Lake Whitefish spawn in nearshore areas of Sturgeon Bay north and south of the Dauphin River mouth. Commercial fisheries occurring in Lake Manitoba, Lake St. Martin and Sturgeon Bay target species such Walleye, Lake Whitefish, Carp, suckers, and Northern Pike and are an important part of the local economies.

Big Buffalo Lake and Buffalo Creek, collectively the Buffalo Creek Drainage System, are not part of the drainage affected by high water levels on Lake Manitoba, but will be the initial receiving environments for water diverted from Lake St. Martin via Reach 1. The Buffalo Creek Drainage System will form part of the diversion route and will convey water from Buffalo Lake to the Dauphin River. A brief field investigation conducted in August, 2011 provided fish community and habitat information required to assess effects related to operation of the diversion channel. Big Buffalo Lake is shallow (~2 m deep), surrounded by wetlands and supports a fish community that includes Yellow Perch, Northern Pike, juvenile White Suckers, Golden Shiners, and at least one more species of minnow. Buffalo Creek originates at Big Buffalo Lake and flows through wetland and bog habitat before entering into an area characterized by better drained soil and a slightly greater gradient. The creek enters into the Dauphin River at a location about 4 km upstream of Sturgeon Bay. Fish species found in the creek included Northern Pike, White Suckers, Yellow Perch, Central Mudminnows, Logperch, several dace species, and sculpins. A local fisherman suggested that Northern Pike and White Suckers may move into the lower reaches of the creek during spring to spawn. There is also a possibility that a relatively small number of Lake Whitefish could use the lower reach of the creek for spawning during fall.

Summary of Anticipated Effects

Construction, operation, and closure of Reach 1 will affect the aquatic ecosystems along and downstream of the diversion route. Through the process of scoping potential project-related effects, physical linkages from construction, operation and closure of the project were considered in relation to water quality, aquatic habitat, and fish resources.

We have provided a summary of the nature and magnitude of anticipated effects based on the most current information regarding the project. The nature and magnitude of potential changes identified here may change as additional information regarding the project becomes available and as mitigation strategies are developed.

Water Quality

The potential linkages between the Project and water quality impacts are complex but relate primarily to three main physical effects pathways:

- Alterations in the rate and seasonality of flow discharged to Sturgeon Bay and other waterbodies in the study area;
- Effects of flooding along the whole diversion route; and,
- Potential for erosion and/or mobilization of sediments due to the diversion.

A substantial change in water quality is expected to occur in the Buffalo Creek Drainage System due to diversion of flows, and/or flooding, and/or increases in TSS related to erosion and sediment re-suspension. Due to the lack of existing information on this system, the nature and magnitude of these effects cannot be identified at this time. Effects to water quality in the Buffalo Creek Drainage System and the mouth of the Dauphin River are expected to be short term and will not persist long after the life span of the project.

Impacts to water quality in Sturgeon Bay are related to alterations in the rate and seasonality of inflows and to potential erosion and/or mobilization of sediments from the diversion route. The effects may include increased TSS and related variables, reductions in DO concentrations, and an increase in the spatial extent of the Dauphin River plume in Sturgeon Bay over the period of the Project. The effects will generally be short term with the exception of effects on DO in Sturgeon Bay related to introduction and deposition of organic materials.

Effects of the Project on water quality in the north basin of Lake Winnipeg as a whole are expected to be negligible:

- due to an expected low magnitude of change in the basin volume related to the increased inputs over winter; and,

- because the flows would eventually drain to Lake Winnipeg without the Project and the residence time of the north basin has been estimated to range from approximately 2 to 6 years (based on the period of 1999-2007, MWS and EC 2011).

Aquatic Habitat

Potential linkages between aquatic habitat and the proposed emergency channel and operation of the FRWCS relate primarily to the following effects pathways:

- Direct loss of habitat due to the footprint of structures;
- Alteration of habitat due to increased flow and flooding along the diversion route; and,
- Alteration of habitat due to erosion and sedimentation.

Increased flows along the diversion route are expected to affect habitat in the Buffalo Creek Drainage System and the Dauphin River downstream of its confluence with Buffalo Creek. Habitat effects related to increased flows will be short term, lasting only for the duration of the diversion flows. Lake and channel geometry and cross-sectional morphometry will change significantly and a decrease in riparian vegetation is expected to occur post-project. Aquatic habitat within t the Buffalo Creek Drainage System is considered resilient and is not expected to suffer a significant decrease in productive capacity post-project.

Shorelines and substrates at the mouth of the Dauphin River downstream of the confluence of Buffalo Creek are expected to suffer site-specific increases in erosion due to changes in flow patterns. The most significant effects will occur in the vicinity of the confluence with Buffalo Creek.

Deposition of sediments in Sturgeon Bay has the potential to affect substrate composition and the suitability of foraging, overwintering, spawning and incubation habitat. It is not possible to determine the extent of the effect without an estimate of the material that will be mobilized from Reach 1 and the Buffalo Creek Drainage System.

Fish Resources

The potential linkages between the Project and fish resource impacts relate primarily to three main physical effects pathways:

- Habitat change due to altered flow, resulting in potential impacts to spawning behaviour and timing, egg deposition and incubation, rearing success, overwintering, general movements, and metal concentrations in muscle tissue;
- Altered access to habitat due to increased flow, creating possible attraction flows and/or velocity barriers during operation; and,

- Re-distribution of fish species in all affected waterbodies resulting directly from changes to flow patterns.

The introduction of flows through the Buffalo Creek Drainage System is expected to have short-term effects on the resident fish communities. Species composition is expected to change as water velocities increase and fish are introduced to the system from Lake St. Martin and fish migrate out of the system to Lake Winnipeg. There is also the possibility that mercury concentrations will increase in the system post-project due to transfer of methylmercury from Lake St. Martin. The fish populations in the Buffalo Creek Drainage System are considered resilient and are expected to re-establish rapidly post-project. There may be a small reduction in post-project productivity in Buffalo Creek for a number of years until sediments are redistributed and riparian cover is re-established.

Increased flows from Buffalo Creek have the potential to attract fall and spring spawning fish from the Dauphin River. Depending on timing, termination of flow has the potential to strand fish and dewater eggs. Increased flows from Buffalo Creek also have the potential to modify habitats at the mouth of the Dauphin River. The majority of Lake Whitefish and Walleye spawning habitat in the Dauphin River system is expected to occur upstream of the confluence with Buffalo Creek and in Lake St. Martin. Consequently, habitat effects at the mouth of the Dauphin River would not be expected to have measureable effects on regional fish stocks.

Deposition of mineral and organic material discharged from the diversion route has the potential to affect spawning, rearing and overwintering habitats for fish in Sturgeon Bay. Increases in sediment transport may also contribute to oxygen depletion and increases in mercury methylation rates. Methyl mercury may also be transported downstream from the Buffalo Creek Drainage System. Potential effects are difficult to quantify without an estimate of the magnitude and distribution of sediment deposition and a better understanding of fish habitat within the bay. However, it is expected that impacts would be local and would not be measurable in a regional context (i.e., Lake Winnipeg).

Work Plan

Two approaches were taken to develop a work plan for assessing the environmental effects of the project. The first was to identify studies that would provide information to fill data gaps to better understand aquatic impacts and plan appropriate mitigation strategies. The second approach was to collect information to provide a background against which post-project changes can be measured. Where possible, studies were designed to provide information to help assess aquatic impacts, as well as provide a baseline against which post-project changes could be measured.

Proposed studies that would provide information to assist in predicting project-related impacts and mitigation planning include:

- Habitat mapping (water depth and substrate mapping) in the Dauphin River from its confluence with Buffalo Creek downstream to Sturgeon Bay to help understand fish usage of the area (emphasis on identifying potential spawning habitat for Lake Whitefish and Walleye);
- Fish utilization studies in the Dauphin River from its confluence with Buffalo Creek downstream to Sturgeon Bay to help understand fish usage of the area (emphasis on documenting fish use of the Dauphin River and nearshore areas of Sturgeon Bay; including Lake Whitefish fall spawning movements into the Dauphin River and whether Lake Whitefish spawn in the Dauphin River from Buffalo Creek downstream to Sturgeon Bay);
- Fish utilization studies and habitat assessments in the Buffalo Creek Drainage System (these investigations have been completed); and,
- Collection of local knowledge regarding fish and fish habitat use in the study area.

Proposed studies that would provide information necessary to measure post-project effects include:

- A water quality sampling program across selected waterbodies within the study area (Lake Manitoba, Fairford River, Pineimuta Lake, Lake St. Martin, Big Buffalo Lake, Buffalo Creek, Dauphin River and Sturgeon Bay) to provide a data set that is sufficient for evaluating spatial differences and for monitoring project impacts. This program would build upon existing water quality monitoring programs;
- Collection of high resolution satellite imagery of the diversion route (Reach 1, Big Buffalo Lake, Buffalo Creek, and Dauphin River to Sturgeon Bay) to provide the background from which the spatial extent of post-project effects to terrestrial and aquatic habitat may be determined;
- Habitat mapping (water depth included, but emphasis on substrate mapping) in nearshore and offshore Sturgeon Bay to 1) document existing conditions against which post-project changes can be determined, and 2) provide information to identify potential Walleye and Lake Whitefish spawning habitat in nearshore Sturgeon Bay;
- Collection of information to document incremental bed load and suspended sediment inputs into Sturgeon Bay from the Dauphin River and the diversion route;
- Fish use and habitat assessment studies in the diversion route during operation and after closure;
- A fisheries investigation to determine fish abundance in Lake St. Martin following closure of Reach 1 (existing information held by the Province of Manitoba will be used to provide the baseline pre-diversion conditions); and,
- Collection of muscle tissue samples from Lake Whitefish, Northern Pike, and Walleye prior to operation and following closure of Reach 1. Fish from Lake St. Martin and Sturgeon Bay would be purchased from commercial fishermen.

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1.0 INTRODUCTION

Due to widespread, record flooding throughout southern Manitoba in 2011, water levels in Lake Manitoba and Lake St. Martin are several feet higher than desirable, resulting in significant damage to hundreds of properties, restricted road access to several communities, and long-term evacuation of four First Nations. If no action is taken, it is expected that high water levels and associated negative impacts will persist into 2012.

The Province of Manitoba (the Province) has retained KGS Group and AECOM to investigate options to provide an emergency reduction of water levels in the two lakes. Water flows out of Lake Manitoba through the Fairford River and Lake Pineimuta to Lake St. Martin, and then through the Dauphin River to Lake Winnipeg (Figure 1). Currently, drainage through the Dauphin River to Lake Winnipeg is not sufficient to rapidly reduce the flood stage water levels on Lake Manitoba and Lake St. Martin. After reviewing numerous strategies, it was recommended that an emergency channel (Reach 1 Emergency Outlet Channel or simply Reach 1) be constructed to reduce the hydraulic flow restrictions out of Lake St. Martin to Lake Winnipeg (KGS and AECOM 2011).

Reach 1 will include the excavation of a channel from Lake St. Martin to Big Buffalo Lake, a small lake located about 7 km northeast of Lake St. Martin (Figure 2). From Big Buffalo Lake, water will flow down Buffalo Creek and enter the Dauphin River about 4 km upstream of Lake Winnipeg. For the remainder if this report, this route will be referred to as the “diversion route”. Although the precise location of Reach 1 is currently being refined, it is anticipated that the channel will be approximately 300 feet (91.4 m) wide and up to 25 feet (7.6 m) deep (KGS and AECOM 2011). Design capacity of Reach 1 is 5,000 cfs (141.6 cms) when water level on the lake is at 801 feet (244.1 m) above sea level. If Reach 1 is completed prior to freeze up in fall 2011, it is anticipated that the initial flow will be 9,000 cfs (254.9 cms). Flow down Reach 1 will vary, depending on water level on the lake and the effects of the development of ice cover on the channel (KGS and AECOM 2011).

The review of options also recommends allowing unrestricted maximum flow of water through the Fairford River Water Control Structure (FRWCS) to enhance flow out of Lake Manitoba (KGS and AECOM 2011). The intent is to complete Reach 1 prior to freeze-up during fall 2011; this would reduce water levels prior to spring 2012, when flow into Lake Manitoba and Lake St. Martin would increase again. Supplementary work, subject to the successful completion of Reach 1, may include an additional bypass channel around the north side of the FRWCS to allow increased outflow from Lake Manitoba and expansion of Reach 1 to accommodate the increase with no impact to Lake St. Martin water levels.

Construction and operation of Reach 1 and alteration of flows through the FRWCS have the potential to impact the aquatic habitat and biotic community of several waterbodies within the region. North/South Consultants Inc. has been retained by KGS Group to assist in assessing the potential project-related effects to aquatic environments that may be affected by the project. The objectives of this report are to:

- Summarize existing information related to local aquatic habitat and biotic communities;
- Describe potential impacts to the aquatic environment resulting from completion of Reach 1 and maintenance of a high flows through the winter at FRWCS;
- Identify any potential information gaps that need to be addressed to better understand aquatic impacts related to these developments and plan appropriate mitigation strategies;
- Identify information requirements to measure impacts to the aquatic environment post-project; and,
- Identify potential studies to address those information requirements.

2.0 STUDY AREA

Construction of the Lake St. Martin emergency channel and operation of the FRWCS at full capacity through winter of 2011/2012 has the potential to affect aquatic environments in Lake Manitoba, the Fairford River, Pineimuta Lake, Lake St. Martin, the Dauphin River, Big Buffalo Lake, Buffalo Creek and the Sturgeon Bay area of Lake Winnipeg (Figure 2). Collectively, these waterways will be referred to as the "study area" throughout the remainder of this document.

The main water inflows into Lake Manitoba are from the Whitemud River, the Waterhen River (including Lake Winnipegosis and Dauphin Lake), and the Portage Diversion, which routes excess flows from the Assiniboine River into the south end of Lake Manitoba (Figure 1). Water flows out of Lake Manitoba through the Fairford River and Lake Pineimuta to Lake St. Martin, and then through the Dauphin River to Lake Winnipeg.

Big Buffalo Lake is a small lake (0.55 km^2) located in a large wetland approximately 7 km north east of Lake St. Martin. The lake drains into Buffalo Creek, a small creek that discharges into the Dauphin River approximately 4 km upstream of Lake Winnipeg. Currently, the Buffalo Creek Drainage System does not receive water from the Lake Manitoba/Lake St. Martin watershed.

Construction of the Fairford Dam in 1961 allowed for the regulation of Lake Manitoba levels and in 1984 the Fairford Fishway was incorporated to provide passage of fish between Lake St. Martin, the Dauphin and Fairford rivers and Lake Manitoba. Dam design did not take into account impacts on downstream waterbodies and consequently, the Fairford River, Pineimuta Lake, Lake St. Martin, and the Dauphin River are subject to flooding during periods of high water levels in Lake Manitoba and levels lower than natural during low level periods. Following a study conducted by the Lake Manitoba Regulation Review Advisory Committee, it was decided that Lake Manitoba would be allowed to fluctuate closer to its pre-regulation state in order to sustain aquatic habitat along the lake shore (MWS 2010a). However, downstream waterbodies continue to be impacted in extremely high water level years. Following construction of the Portage Diversion in 1970, water levels on Lake Manitoba rose higher than what was originally projected before the Fairford Dam was constructed. Consequently, its operation compounded the negative effects to downstream habitat that were produced by the Fairford Dam.

Additional descriptions of the physical environment and flow regulation on Lake Manitoba, Fairford River, Pineimuta Lake, Lake St. Martin, Dauphin River and Lake Winnipeg are provided in the following sections.

2.1 LAKE MANITOBA

Lake Manitoba has a surface area of approximately 4,700 km^2 and consists of two basins: a small irregular shaped north basin and larger south basin (Figure 2). The lake is relatively shallow, with a mean depth of about 5 m and a maximum depth of 7 m. Lake Manitoba is fed primarily by the Waterhen River. During flood years on the Assiniboine and/or Red rivers, the Portage Diversion also contributes water to the lake. The diversion was completed in 1970 and connects the Assiniboine River to Lake Manitoba (Figure 2). The Fairford River is the only outlet from Lake Manitoba and drains into the north basin of Lake St. Martin. The Lake Manitoba drainage basin is 79,800 km^2. The mean water level of Lake Manitoba near Steep Rock from 1923-2010 was 247 m (Environment Canada Water Survey 2010).

In 1904, minor channel improvements were undertaken in the Fairford River in order to limit maximum water levels on Lake Manitoba. However, these improvements were unsuccessful (Kuiper 1958; MWC 1973). During the 1920s and early 1930s the lake was subject to a natural range of regulation, which varied from a maximum mean monthly elevation of 248 m above sea level between 1923 and 1925 to a minimum mean monthly elevation of 247 m above sea level in 1932 and 1933 (MWC 1973). As a result of the low levels in the 1930s, a control structure was built in 1934 at the outlet of Lake Manitoba in the Fairford River. However, as no channel improvements were undertaken in the Fairford River, outflows from the lake could not be increased during periods of high inflows. The control works, therefore, could do nothing to reduce the frequency of higher lake levels and the resultant flood damage. As such, an additional study was conducted in 1956 and completed in 1958 by the Lakes Winnipeg and Manitoba Board. As a result of flood damage, the board recommended construction of a new control structure at the outlet of Lake Manitoba in the Fairford River. Subsequently, the Fairford Dam was built in 1961.

For over 40 years, the Fairford Dam was operated frequently in order to maintain Lake Manitoba near a level of 247.5 m (811.9 ft). However, operation of the dam changed following a study conducted by the LMRRAC in 2006 (MWS 2010a). The committee recommended that the lake be allowed to fluctuate closer to its natural state in order to sustain aquatic habitat along the lake shore. It was decided that operation of the dam would occur only when the lake rose above 247.7 m (812.5 ft) or declined below 247.0 m (810.5 ft). As a result, operation of the dam has not occurred in recent years except to prevent flooding on the Dauphin River due to frazil ice jamming near freeze-up (MWS 2010a). Outflows were reduced during the autumn of 2007 and 2008 to prevent or reduce such flooding. Logs were replaced in early winter after the Dauphin River had become frozen over. In recent years two bays in the dam have been left open to facilitate fish passage across the dam (MWS 2010a).

2.2 FAIRFORD RIVER

The Fairford River is 16 km long and conveys water from Lake Manitoba to Lake St. Martin. It has a total drainage area of 79,800 km^2 (i.e., the Lake Manitoba watershed and local drainage). From 1912-2006, mean monthly discharge ranged from a low of 1 cms in December 1964 to a high of 330 cms in June 1979 (Environment Canada 2007a). The annual mean discharge from the Fairford River calculated for the periods 1912-1920 and 1955-2006 is 75 cms. The Fairford River was flowing at 574 cms on June 23, 2011.

The Fairford Dam was constructed in 1961 to regulate water levels on Lake Manitoba (Figure 3). The dam is 73 m long and has eleven 5.9 m wide bays. Discharge is regulated by removing or replacing stop logs in one or more of the bays. When the dam was constructed, two concrete weirs were incorporated in one of the bays to provide passage for fish. Each weir contained a 610 x 760 mm opening, and stop logs could be placed on the upstream weir. However, studies by Derksen (1988) and Katopodis et al. (1991) suggested that the weirs were not effective in passing fish upstream. Subsequently, a Denil fishway was constructed in March of 1984. The fishway was incorporated into the third bay from the south bank under the highway bridge.

2.3 PINEIMUTA LAKE

Pineimuta Lake is a shallow wetland complex situated along the Fairford River between Lake Manitoba and Lake St. Martin. It has a surface area of 39 km^2 (Figure 4). Little information exists for the lake in terms of water flow and depth, though the lake can be negatively affected by extremely variable water levels due to operation of the Fairford Dam. There is no control structure on the outlet of Pineimuta Lake. In 1978, the Manitoba Water Commission (MWC) looked at nine alternatives aimed at improving the wide range of water levels on Lake St. Martin and Pineimuta Lake (LMWSB 2010). It was determined that additional benefits to aquatic resources would be less than the lowest cost alternative to regulate water level, and the project did not move forward.

2.4 LAKE ST. MARTIN

Lake St. Martin is located to the north east of Lake Manitoba and the majority of inflow is from Lake Manitoba via the Fairford River (Stone 1965). The lake also receives water from local surface run off and from a number of small springs in the north east basin (Stone 1965). It has a surface area of approximately 340 km^2 and is comprised of two distinct but connected basins (261 and 79 km^2). At a water level of 242.4 m above sea level, the maximum depths of the larger and smaller basins are 4.11 and 1.52 m, respectively (Stone 1965). Lake St. Martin is drained by the Dauphin River into Sturgeon Bay on Lake Winnipeg. The elevation drop between Lake Manitoba and Lake St. Martin is approximately four metres; the drop between Lake St. Martin and Lake Winnipeg is 27 metres. The rate of land slope in the area is approximately 0.8 m/km and generally in the range of 2% or less. Due to the flat slope of the land adjacent to Lake St. Martin and Pineimuta Lake, small increases in lake levels inundate large areas of land (Mills et al. 1971).

Mean annual precipitation in the area is 483 mm; the average frost-free period is 101 days and the seasonal moisture deficit between May and September is 200 to 250 mm (Environment Canada 2007b). Lake St. Martin is regularly mixed by winds during the open water season, and thermal stratification is not evident (Stone 1965). Freeze-up typically occurs in early November and the lake remains ice-covered until early April (Stone 1965). Mean annual temperature in the area is approximately 1.1^{o}C.

Mean monthly water levels for Lake St. Martin have ranged from 242.4 m in October, 1964, to 244.7 m in July, 1955 (Traverse 1999). Typical fluctuations within a given year are from 0.5 m to 1.0 m.

2.5 DAUPHIN RIVER

Dauphin River enters the west side of Lake Winnipeg at Sturgeon Bay, just north of the narrows (Figure 5). It has a total drainage area of 82,300 km^2 and flows for approximately 50 km from Lake St. Martin to Sturgeon Bay on Lake Winnipeg.

From 1977-2009, the mean monthly discharge of the river has from varied from a low of 1.13 cms in January 2004 to a high of 313 cms in June 1978 (Environment Canada Water Survey 2011). The annual mean discharge of the Dauphin River over this period was 78 cms. In contrast, the Dauphin River was flowing at 586 cms on July 13, 2011.

2.6 STURGEON BAY - LAKE WINNIPEG

Lake Winnipeg is the largest lake in Manitoba with a surface area of approximately 24,000 km^2. The lakebed is flat and shallow, consisting of two basins: a wide north basin (100 km width) and a narrow south basin (40 km width) separated by narrows (2.5 km width). The two basins differ in terms of depth as well as chemical and biological characteristics. The north basin covers approximately 74% of the total lake area and holds 81% of the lake's volume (Brunskill et al. 1980). The lake is relatively shallow with a mean depth of 12 m (13.3 m in the north basin and 9 m in the south basin) and a maximum depth of 36 m. Water temperatures are typically lower in the north basin than those in the south. For example, mean summer surface water temperatures from 1999 to 2007 were 19.7°C in the north basin and 21.5°C in the south basin and narrows (MWS 2011c). Lake Winnipeg waters are wind-mixed and generally homogenous in temperature with depth, though thermal stratification has been observed over brief periods of time during the open water and ice-cover seasons (MWS 2011c).

Major tributaries entering Lake Winnipeg include the Winnipeg River, Saskatchewan River, Red River, Dauphin River, Pigeon River, and Berens River. Lake Winnipeg drains into the Hudson Bay via the Nelson River. The lake has been regulated since 1976 as part of Manitoba Hydro's Lake Winnipeg Regulation. Under this program, the natural annual water outflow pattern of Lake Winnipeg is reversed; outflow into the Nelson River is decreased in the spring and early summer and stored for use during the fall and winter. Sturgeon Bay is located in the south-western portion of the north basin and receives inflow from the Dauphin River.

3.0 EXISTING AQUATIC ENVIRONMENT

The following sections provide a summary of available aquatic environment information pertinent to each of the water bodies within the study area. Aquatic ecosystem components considered here include water quality, aquatic habitat, and fish resources, including commercial fisheries. No previously published data were available for Big Buffalo Lake or Buffalo Creek.

3.1 WATER QUALITY

Lake Manitoba contributes the majority of water flow into the Fairford River and subsequently to Pineimuta Lake and Lake St. Martin, although the latter two likely receive significant overland inputs from their local watersheds. The earliest records of water quality in the study area date to a survey conducted in Lake Manitoba in 1928 (LMRRAC 2003).

Manitoba Water Stewardship (MWS) has monitored water quality in Lake Manitoba at 28 locations, in the Fairford River at PTH #6 west of Fairford, the Dauphin River near Anama Bay, and Sturgeon Bay over various time periods since 1973 (MWS 2011a; Figure 3, Table 1). The frequency of sampling has varied over the monitoring period and some sites in Lake Manitoba have not been sampled in recent years. Monitoring in Sturgeon Bay has only been recently initiated (since 2008). Additionally, the list of water quality parameters measured at these sites varies and in some instances only a limited number of parameters have been measured. MWS data presented in this document were provided by the Water Quality Management Section (2011a). No water quality data were located for the Buffalo Creek Drainage System.

3.1.1 Lake Manitoba

The Lake Manitoba Regulation Review Advisory Committee (LMRRAC 2003) requested that a statistical analysis of water quality data in Lake Manitoba be conducted and they then summarized the conclusions of this assessment. The following refers to the information presented by the LMRRAC (2003).

Phosphorus concentrations are higher in the south basin than in the north basin; a trend towards increasing phosphorus levels is apparent from the 1960s to the 1970s. The south basin was classified as “likely mesotrophic” on the basis of phosphorus and chlorophyll *a* concentrations, implying that the lake can support a healthy aquatic community, although nuisance algal blooms may also occur. Salinity is relatively high in Lake Manitoba and is believed to arise from the intrusion of saline groundwater at the west side of the lake. The south basin is also relatively alkaline; pH was 8.5 or greater 30% of the time over the period examined. Relatively high fecal coliform densities have been detected on occasion near beach areas in the south basin; these events are typically acute and short in duration. Concentrations of trace elements and toxic metals such as arsenic, copper, and nickel do not exceed Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOG) that were current at the time of the study.

Pesticides were rarely detected and typically, where detected, were below the MWQSOGs for the protection of aquatic life that were current at the time of the study. Dicamba, a component of the herbicide formation 2,4-D, was historically detected on occasion and exceeded guidelines for water used for irrigation on two of those occasions. The herbicide MCPA was detected on two occasions in this analysis, and in both instances exceeded guidelines for irrigation.

Raw water quality data for Lake Manitoba provided by MWS (2011a) were also reviewed to assist with characterization of the lake. A total of 28 sites have been sampled since routine monitoring was initiated in 1973. The most extensive sampling (i.e., the greatest number of parameters measured) occurs at the Narrows (site MB05LKS009), although monitoring was only initiated relatively recently (2004).

3.1.2 Fairford River

Water quality is monitored by MWS in the Fairford River at PTH #6 for a wide range of parameters, including routine variables, such as nutrients, DO, TSS, pH, metals, and pesticides. Monitoring was initiated at this site in 1978 but was not conducted from 1985-1993 and 1995-2004.

The Fairford River is generally well-oxygenated (Figure 4), slightly alkaline (Figure 5), very hard (Figure 6), and relatively nutrient-rich (Figures 7 and 8). The concentration of dissolved oxygen (DO) has met the MWQSOGs for the protection of cool- and cold-water aquatic life on all but three occasions over the period of monitoring. In March 1978 and February 1980, DO was slightly below the most stringent MWQSOG of 9.5 mg/L and in May 1981 DO was slightly below the most stringent guideline of 6.5 mg/L (MWS 2011b). All measurements of pH, ammonia (Figure 9), and nitrate (Figure 10) were within the MWQSOGs for the protection of aquatic life. Approximately 8% of total phosphorus (TP) measurements exceeded the narrative guideline for streams and rivers (0.050 mg/L) and the Fairford River would be classified as mesotrophic on the basis of the mean TP concentration over the period of record and the CCME trophic classification scheme (CCME 1999; updated to 2011). The majority of TP is composed of particulate phosphorus although the fraction of TP in dissolved form varies considerably over time (Figure 11). There are relatively few measurements of chlorophyll *a* for the Fairford River; available data indicate a fairly wide range of concentrations (< 0.5 µg/L to 19.5 µg/L; Figure 12). TSS ranged from 1 to 64 mg/L in the Fairford River (Figure 13).

Several routine water quality parameters vary seasonally in the Fairford River. DO is generally higher in the ice-cover season, at least in part due to lower water temperatures. The pH is lower in the ice-cover season, which typically occurs in north temperate aquatic ecosystems due to limited photosynthesis (a process that consumes carbon dioxide thus increasing pH) and the presence of ice cover, which may prevent release of carbon dioxide to the atmosphere. Ammonia is also generally higher in winter which commonly occurs due to low primary production. Other parameters that varied seasonally include total suspended solids (TSS) and turbidity (Figure 14), which are higher in the open-water season, and conductivity (Figure 15), which is lower in the open-water season. A number of variables are also significantly correlated to TSS and turbidity; TP and pH are positively correlated to these variables while ammonia, nitrate/nitrite, TDS, and conductivity are negatively correlated to TSS and turbidity. The positive correlation between TP and TSS reflects the significant portion of phosphorus that is bound in particulate form.

3.1.3 Lake St. Martin

Water quality studies conducted in Lake St. Martin by the Manitoba Department of Mines and Natural Resources during low water periods in the early 1960s determined that the lake had a high level of TSS (Stone 1965). The pH generally ranged from 7.8 to 8.4. Dissolved oxygen (DO) levels dropped to approximately 50% saturation between freeze-up and late February. DO values dropped below 3 ppm in shallow bays and in the deepest areas of the lake; in the northeast basin, DO dropped to 0 by mid-February (Stone 1965). The low oxygen values were concurrent with discharges of 1.42-1.98 cms (50-70 cfs) from the Fairford River dam. During higher discharge rates (i.e., 88.9 cms; 3,140 cfs) in the winter of 1967/68, oxygen levels were significantly higher and did not inhibit fish activity (Crowe 1969). Mean monthly discharge rates at the Fairford River dam have remained well above early 1960s levels through to present (Environment Canada 2007a). More recent data are not available.

During a study of the southern marsh area in Pineimuta Lake, Ould (1980) measured pH ranges between 7.3 and 8.3; specific conductance ranged between 550-1000 µmhos/cm. Although neither turbidity nor TSS were measured, Ould (1980) reported that, based on observations, water in the sheltered areas of the marsh and in most of Pineimuta Lake appeared to be relatively clear, while water in the Fairford River and Pineimuta Delta appeared to be relatively turbid (Ould 1980).

3.1.4 Big Buffalo Lake

No water quality information specific to Big Buffalo Lake was available. However, a brief field program was conducted at Big Buffalo Lake during August, 2011 as part of the studies identified in Section 5.0 of this report. The following is based on information collected during that field program.

In situ measurements collected from four sites in Big Buffalo Lake indicated that the lake was not thermally stratified, was relatively well-oxygenated, and near-neutral. Turbidity was less than 7 NTU and Secchi disk depth ranged from 1.2-2.2 m. For comparison, Secchi disk depths measured in Sturgeon Bay from 2008 to 2010 (open-water season) ranged from 0.3-1.7 m (MWS unpublished data).

3.1.5 Dauphin River

Water quality is frequently monitored in the Dauphin River near Anama Bay by MWS for a wide range of parameters, including routine variables, such as nutrients, DO, TSS, pH, metals, and pesticides (MWS

2011a). Monitoring of this river was initiated in 1978 but the site was relocated to its current location in 1985 (Figure 3, Table 1). Monitoring was not conducted from 1989-2003.

Water quality of the Dauphin River is generally similar to the Fairford River and is typically well-oxygenated (Figures 16 and 17), slightly alkaline (Figure 18), very hard (Figure 19), and relatively nutrient-rich (Figures 20 and 21). Qualitatively, the Dauphin River appears to experience somewhat lower concentrations of DO than the Fairford River during some periods and consequently, conditions were more frequently below the MWQSOGs for the protection of aquatic life (Figure 22). The available data indicate that DO typically decreases over winter in the Dauphin River and commonly drops below the most stringent objective for cold-water species and on occasion below the most stringent objective for cool-water species. Hypoxic or anoxic conditions have been observed at this site in winter (Figure 16). This may relate to a combination of long periods of ice-cover coupled with reduced river discharge over winter; a correlation analysis did not, however, indicate that DO is significantly correlated to river flow.

All measurements of ammonia (Figure 23) and nitrate (Figure 24) were within the MWQSOGs for the protection of aquatic life. Two pH measurements slightly exceeded the upper range of the water quality guideline for the protection of aquatic life (6.5-9). Approximately 2% of TP measurements exceeded the narrative guideline for streams and rivers (0.050 mg/L), but 4% of samples exceeded the guideline for streams and rivers near the point of entry to lakes, ponds, or reservoirs.

The Dauphin River would be classified as eutrophic on the basis of the mean TP concentration over the period of record and the CCME trophic classification scheme (CCME 1999; updated to 2011); the mean TP concentration is approximately twice that of the Fairford River but this may reflect, in part, differences in the frequency and timing of sampling. The more recent data indicate relatively similar concentrations of TP (Figure 25). On average, TP is composed equally of particulate and dissolved fractions, although the fraction of TP in dissolved form varies considerably over time. There are relatively few measurements of chlorophyll *a* for the Dauphin River but the mean concentration over the period of record (5.5 µg/L) is similar to the mean for the Fairford River (Figure 26). TSS ranged from 1 to 34 mg/L in the Dauphin River (Figure 27).

Like the Fairford River, several routine water quality parameters vary seasonally in the Dauphin River. DO is generally higher in the late fall/early winter, but decreases in most winters until breakup. Like the Fairford River, pH, conductivity (Figure 28), and ammonia tend to be higher in the ice-cover season, while TSS is generally higher under open-water conditions. Also consistent with the Fairford River, TP and pH are positively correlated to TSS, while ammonia, nitrate/nitrite, TDS, and conductivity are negatively correlated to TSS.

3.1.6 Sturgeon Bay - Lake Winnipeg

MWS has monitored water quality in Sturgeon Bay on six occasions from 2008 to 2010. Parameters measured are limited to nitrogenous parameters, chlorophyll *a*, conductivity, carbon, phosphorus, Secchi disk depth, biochemical oxygen demand (BOD), TSS, pH and one sample for *Escherichia coli*. All sampling was conducted in the open-water season.

Of the variables measured, pH, ammonia, and nitrate were within MWQSOGs for the protection of aquatic life in Sturgeon Bay over the periods monitored. Total phosphorus, which ranged from 0.027 mg/L to 0.07 mg/L, exceeded the MWQSOG narrative guideline (0.025 mg/L) for lakes during each sampling period and on the basis of this information, the area would be classified as meso-eutrophic to eutrophic according to the CCME trophic categorization scheme (CCME 1999; updated to 2011). Secchi disk depths were typically less than one meter and chlorophyll *a* ranged from approximately 1 µg/L to slightly greater than 10 µg/L. The data are inadequate to delineate seasonal trends. As no information is available regarding variability across depth, it is not known if the area stratifies. However, Environment Canada and MWS (2011) report that thermal stratification in the north basin of Lake Winnipeg occurs infrequently.

3.1.7 Spatial Comparison of Water Quality Conditions

Water quality data for the Fairford and Dauphin rivers and Sturgeon Bay provided by MWS (2011) were compared through scatter plots to qualitatively identify differences in water quality conditions. As previously noted, on average, TP is higher in the Dauphin River relative to the Fairford River (Figure 25), and data are inadequate to compare to conditions in Sturgeon Bay. The Dauphin River also appears to experience more frequent and severe oxygen depletion during at least some ice-cover seasons, possibly related in some degree to reduced river flows. Other qualitative differences include possible lower concentrations of TSS in the Dauphin River than the Fairford River (Figure 29), indicating some settling may occur between the sites, and a lower specific conductance in Sturgeon Bay than the two river sites (Figure 30).

3.1.8 Seasonality of Water Quality Conditions

As previously noted, the Fairford and Dauphin rivers appear to experience seasonal variability in some water quality parameters that are common in north temperate systems that experience long periods of ice cover. Specifically, pH, ammonia, and specific conductance tend to be higher in winter while TSS is higher under open-water conditions. There is insufficient information to delineate potential seasonal trends for some variables, such as chlorophyll *a*, or for Sturgeon Bay due to the lack of winter water quality data.

3.2 AQUATIC HABITAT

3.2.1 Lake Manitoba

Few studies have been conducted with regard to aquatic habitat within Lake Manitoba, particularly with respect to fish habitat. As a consequence, the impacts on fish habitat as a result of stream crossings and the straightening of streams due to agriculture, road construction and other activities are not well known around the lake (LMSB 2008). Though there is a general lack of published information, suitable aquatic habitat for several fish species occurs in the lake, including deeper waters that support species such as walleye and sauger, slow moving waters with areas of vegetation and cover (Carp, Yellow Perch, and Northern Pike) and turbid areas (Goldeye).

There is an estimated 2,367 km^2 of wetlands in the area surrounding Lake Manitoba, Pineimuta Lake and Lake St. Martin (Figure 31). These wetlands provide important habitat for a variety of species, including fish, waterfowl, and aquatic mammals such as muskrats. The LMSB (2008) have noted that invasive species are also present, which can negatively affect native species in Lake Manitoba and the surrounding wetlands. Of particular concern to the LMSB (2008) is the invasive Common Carp, which has altered many of the wetlands surrounding Lake Manitoba, affecting many native aquatic species.

Wardrop Engineering Inc. (2001) noted that the maintenance of relatively stable water levels in Lake Manitoba despite rapid fluctuations between drought and flooding conditions through operation of the Fairford Dam has resulted in significant deterioration of wetlands and wildlife habitat (Wardrop Engineering Inc. 2001). The LMSB (2008) has identified winter stagnation problems in Lake Manitoba and that a further lowering of minimum lake water levels would further aggravate this particular problem. It has been suggested by the LMSB (2008) that winter fish kills caused by stagnation would negatively affect valued commercial species.

3.2.2 Fairford River

Aquatic habitat data for the Fairford River are limited. Habitat is somewhat similar to that observed in Lake Manitoba and it is, therefore, suitable for several fish species. Wetland habitat occurs along sections of the river (Figures 31 and 32), but its use by wildlife and fish has not been studied. Wardrop Engineering Inc. (2001) reported that operations of the Fairford Dam and Portage diversion increased the frequency and severity of both high and low water levels along the Fairford River, Pineimuta Lake and Lake St. Martin with a direct impact on local wildlife, fish, and First Nations communities associated with flooding. The Fairford Dam and Portage Diversion have also doubled the outflow rate from Lake Manitoba to 351 cms (12,395 cfs) compared to the natural 174.3 cms (6,155 cfs) and increased the variability of Fairford River flows (Wardrop Engineering Inc. 2001). During critically dry years, Fairford River flows may be reduced to the minimum allowable 1.4 cms (50 cfs) when Lake Manitoba is below 812.17 m asl (Ould 1980).

3.2.3 Pineimuta Lake

The north end of the Pineimuta Lake complex consists of meadows and potholes; the south end is dominated by a large alluvial delta that comprises approximately one third of the basin area (Ould 1980). This southern portion is heavily vegetated with large tracts of emergent aquatic macrophytes, including common reed grass (*Phragmites australis* [originally *P. communis*]), hardstem bulrush (*Schoenoplectus acutus var. acutus* [originally *Scirpus acutus*]), and common cattail (*Typha latifolia*) (Ould 1980). The east shoreline is relatively steep, gravelly, and fringed with willow. Numerous pressure ridges and embayments characterize the west shoreline. The wetland habitat surrounding Pineimuta Lake is illustrated in Figures 31 and 32. Associated marsh habitat (Pineimuta Marsh) occupies approximately 44.5 km^2 of open-water, marshland and upland habitat (Ould 1980). Emergent vegetation is widely distributed in shallow regions of the delta and peripheral bays but tends to be sparse. Pineimuta Marsh receives water from three sources, the largest of which is the Fairford River.

The general area of Pineimuta Lake lies in the zone of transition between sedge peat and deep moss-covered peat bogs in the Interlake Till Plain. The lake is considered to be fertile, particularly in the delta and north marsh (Ducks Unlimited 1978). This is a result of the fluvial products of the inflowing Fairford River, Partridge Creek and the drainage ditch at the northwest end of the lake. According to a study by Ducks Unlimited (1978), the high productivity of the area has created excellent conditions for the growth of upland and emergent vegetation. The emergent zone is dominated by hard and softstem bulrush, flagreed, spanletop and cattail. Despite the capability for high production of waterfowl and muskrats, actual production numbers are extremely low (e.g. waterfowl production is only about 4% of its capability). Biological investigations by Ducks Unlimited (1978) indicated that this was a result of frequent and severe water level fluctuations during waterfowl nesting and muskrat production and wintering seasons.

Wardrop Engineering Inc. (2001) reported that after construction of the Fairford Dam and Portage Diversion, regulated maximum and minimum water levels on Pineimuta Lake were 0.68 m higher and 0.24 m lower, respectively, compared to natural levels. Pre-construction, the natural fluctuation of water levels would be within 1.0 m 85% of the time; however, under regulated conditions the fluctuation is within 1.0 m only 60% of the time. The increased magnitude and frequency of high levels is affecting the marsh habitat in the vicinity of the lake.

3.2.4 Lake St. Martin

The substrate in Lake St. Martin is primarily composed of soft mud; however, there is an extensive area of gravel, sand, and compacted mud along the lake's western shore near the mouth of the Fairford River. The northeast basin and connecting narrows contain large areas of bare bedrock; extensive gravel bars and boulders are also abundant, which can provide suitable spawning habitat for several fish species. Much of the area immediately surrounding Lake St. Martin is wetland-herb/shrub habitat (Figure 32).

Traverse (1999) reported that Lake St. Martin has been repeatedly exposed to flooding since the construction of the Fairford Dam in 1961 and the Portage Diversion in 1970, which has altered the water regime and vegetation in the lake. Wardrop Engineering Inc. (2001) found that regulated maximum and minimum water levels on Lake St. Martin are 0.79 m higher and 0.66 m lower, compared to natural, pre-dam/diversion levels. In 39 surveyed years since completion of the Fairford Dam and Portage Diversion, 18 annual peak water levels exceeded the flooding threshold of 244 m (800 ft) compared to 2 years prior.

3.2.5 Big Buffalo Lake

No aquatic habitat information specific to Big Buffalo Lake was available. However, a brief field program was conducted at Big Buffalo Lake during August, 2011 as part of the studies identified in Section 5.0 of this report. The following is based on information collected during that field program. Additional information and details of the field program will be provided in a subsequent technical report.

Big Buffalo Lake is a small (surface area of 0.55 km^2) lake located about 7 km north east of Lake St. Martin. The lake is shallow (maximum measured depth of 2.2 m) and substrate is comprised of a deep layer of loosely compacted organic sediments. Aquatic vegetation (primarily *Potamogeton* sp.) occurs throughout most of the lake, although is considerably less dense in the central portion of the lake compared to peripheral areas. Lake shore lines are composed largely of herb and shrub wetlands (Figure 32), as well floating bog in some areas. Few areas surrounding the lake support trees (Figure 33). Lake inflow is comprised of local run off from surrounding wetlands. Outflow is through Buffalo Creek (Figure 2).

3.2.6 Buffalo Creek

No aquatic habitat information specific to Buffalo Creek was available. However, a brief field program was conducted at Buffalo Creek during August, 2011 as part of the studies identified in Section 5.0 of this report. The following is based on information collected during that field program. Additional information and details of the field program will be provided in a subsequent technical report.

Buffalo Creek originates at Buffalo Lake and flows for approximately 16 straight line km to its confluence with the Dauphin River. For approximately the first 4 km downstream of Big Buffalo Lake, Buffalo Creek flows through a treeless wetland and is characterized by a narrow channel (< 5 m wide) that becomes indeterminate in some locations (Figure 34). Topography in this area is very flat. Water depths up to 1 m were measured near the creek origin at the outlet of Big Buffalo Lake. Substrate through this portion of the creek is composed primarily of loosely compacted organic sediments.

Upon leaving the wetland, the creek enters an area of better-drained soils, and develops a meandering pattern where riffle/run/pool sequences flow over local deposits of cobble, gravel, and sand (Figure 35). Gradient increases along this portion of the creek and beaver dams are common. Substrate varies along the reach, depending upon water flow and, to a lesser extent, proximity to beaver dams. In most areas where some flow is maintained through the year, substrate is comprised of sand, gravel, and periodic clusters of boulders. In peripheral areas or in places where gradient is flatter and water flow is decreased, a film of loosely compacted organic sediment may be deposited over the harder granular materials. Upstream of the beaver dams, deposition of organic materials is greater. Water depth along this portion of the creek peaks at greater than 1 m upstream of beaver dams. Large, dense beds of lily pads occur upstream of beaver dams in the lower portion of the creek. The stream banks through this reach are vegetated with willows and spruce trees, and become higher and wider in downstream areas.

The lower-most 1.5 km of the creek are characterized by a well-defined channel that, at the time of the field survey, was greater than 1.0 m deep due to back water effects caused by high flows in the Dauphin River. Substrate was largely compacted granular material.

3.2.7 Dauphin River

Limited information exists on aquatic habitat within the Dauphin River. During a study of pelicans along the Dauphin River, McMahon and Evans (1992) found that the river ranges from 50 to 210 m wide. A series of rapids occurs approximately 6 km upstream from the river mouth where water depth varies between 4 and 5 m (0.5 m along the rapids). Sand bars are present throughout the river, and provide important loafing habitat for pelicans (McMahon and Evans 1992).

According to a report by LMRRAC (2003), gravel deposits in the Dauphin River are thought to provide spawning grounds for Lake Whitefish. First Nations representatives have described negative effects of widely varying flows to spawning beds along the Dauphin River and Lake St. Martin (LMRRAC 2003).

Regulation of Lake Manitoba and maintenance of water levels within a narrow range has required continually adjusting the outflow from Lake Manitoba through the Fairford River. According to LMRRAC (2003), this has had negative impacts downstream on Dauphin River and other downstream waterbodies where the variability in water levels and flows has increased significantly since the construction of the Fairford River Dam.

3.2.8 Sturgeon Bay - Lake Winnipeg

Very little information describing aquatic habitat within Lake Winnipeg is available and information specific to Sturgeon Bay is even less common. A limited amount of depth information provided by the Canadian Hydrographic Service along a narrow transportation corridor from the north basin of Lake Winnipeg into Dauphin River suggests a maximum depth of about 10.4 m (34 ft) at the northern end of the bay. Examination of satellite imagery and aerial photographs indicate Sturgeon Bay shorelines to the north and south of the Dauphin River are largely sand and cobble beaches with gently sloping nearshore areas (Figure 36). No additional information specific to aquatic habitat within Sturgeon Bay is available, so the following paragraphs describe the characteristics of habitat in general to Lake Winnipeg.

The Partners for the Saskatchewan River Basin (2009) reported that a large proportion of the bottom terrain of Lake Winnipeg is underlain with hummocky, undulating Precambrian Shield bedrock. Lake Agassiz clays extend to approximately 50 m deep in the south basin and over 100 m deep in the north basin, while more recent sediment deposits rarely exceed 10 m in depth (Thorleifson et al. 1998; The Partners for the Saskatchewan River Basin 2009). Fine-grained sediments (sand) deposited in glacial Lake Agassiz rest directly on bedrock over most of the nearshore habitat, while clay/silt mud dominates the offshore sediments (Thorleifson et al. 1998; MWS 2011c).

Seven shoreline types have been associated with Lake Winnipeg: 1) marsh and deltaic shores; 2) low-energy Precambrian bedrock outcrop with discontinuous marsh; 3) sand-dominated beaches, spits and barriers; 4) heterogeneous sequences of sand or gravel beaches low scarps, and rock or boulder-lag headlands; 5) gravel beaches and barriers associated with sedimentary rock cliffs; 6) unlithified bluffs or unstable slopes with associated mixed beaches; and, 7) artificially modified shores (Thorleifson et al. 1998). Shore type is a function of substrate geology, basin morphology, lake level, wave climate, sediment supply, and the action of various shore-zone processes over time (Thorleifson et al. 1998).

The Lake Winnipeg watershed contains extensive bog habitat and areas of aquatic rooted vegetation (MWS 2011c). Strong currents in the narrows between the north and south basins near Black Island have removed bottom sediments, creating the lake's maximum depth of over 60 m (The Partners for the Saskatchewan River Basin 2009).

Lake Winnipeg is considered to be highly eutrophic, a result of extensive human activity over time (MWS 2011c). The frequency and intensity of algal blooms in the lake have increased due to increased phosphorous and nitrogen loading throughout the watershed (MWS 2011c). These algal blooms have covered large portions of water surface within Lake Winnipeg, which can significantly affect aquatic habitat and its suitability for local wildlife and aquatic organisms. Benthic macroinvertebrates within Lake Winnipeg have increased in recent decades, likely in response to the increased availability of food resources as a consequence of nutrient enrichment (MWS 2011c). Wetland habitat around Lake Winnipeg is extensive, particularly along the eastern and northern shores, representing approximately 25% of the landscape surrounding the lake (Figure 37).

3.3 FISH RESOURCES

3.3.1 Lake Manitoba

Thirty-seven species of fish, including small-bodied forage species, are known to inhabit the Lake Manitoba watershed (Table 2). Species of commercial and/or domestic importance include White Sucker, Walleye, Common Carp, Northern Pike, Yellow Perch, Lake Whitefish, Sauger, Goldeye, and Freshwater Drum.

While the majority of fish species are found throughout the lake, species such as Bigmouth Buffalo, Brown Bullhead, Channel Catfish, Mooneye, Sand Shiner, and Tadpole Madtom occur only in the south basin of Lake Manitoba, while Blacknose Shiner has been found only in the north basin (Stewart and Watkinson 2008; Table 2). Few biological studies have been conducted for fish species in Lake Manitoba. However, information on age, growth and mortality rates of some commercially important species is available (Bajkov 1930; Hinks 1938; Kennedy 1948, 1949a, 1949b; and Doan and Andrews 1964).

The Fairford Fishway provides passage for fish between Lake Manitoba and the Fairford River and areas further downstream (LMSB 2008). Historical tagging studies conducted by Derksen (1988) revealed that, after passing upstream through the Fairford Fishway, some Walleye travel extensively throughout Lake Manitoba.

3.3.2 Fairford River

With the exception of studies documenting fish movements through the Fairford Fishway (Derksen 1988; Gillespie and Remnant 2008), little published information pertaining to fish or fish communities specific to the Fairford River is available. A total of 14 species of fish, including several minnow and sucker species, Burbot, Black Bullhead, Common Carp, Freshwater Drum, Northern Pike, Walleye, Yellow Perch, Lake Whitefish, and Cisco were captured during a 2007 survey of the Fairford River (Gillespie and Remnant 2008). Stewart and Watkinson (2008) listed thirty-three fish species whose distributional ranges include the Fairford River (Table 2). Many of the fish species known to inhabit Lake Manitoba and Lake St. Martin are likely also using available habitat in the Fairford River. Although Pollard (1973) reported that the river contains suitable Walleye spawning habitat, no evidence of spawning in the river was documented.

Following construction of the Fairford Dam in 1961, commercial fishermen on Lake Manitoba and adjoining Lake Winnipegosis expressed concerns that Walleye were leaving the lakes via the Fairford River and could not return as a result of the dam (Katopodis et al. 1991). Consequently, a Denil fishway was constructed in March 1984. An attraction water flume with a discharge capacity of 3.0 cms was positioned alongside the fishway, which consisted of three flumes equipped with planar baffles, two resting pools, and two vertical lift control gates (Derksen 1988; Katopodis et al. 1991). The net passage width is 300 mm and the fishway slope for the upper flume is 12.9%. Depths near the fishway exit varied between 1.01 m and 0.49 m. Water velocities are low at the bottom of the flume and increase upwards toward the water surface (Katopodis et al. 1991). A layer of fast water exists near the water surface, and fish ascending the fishway face varying water velocities depending on their swimming depth (Katopodis et al. 1991).

Derksen (1988) and Katopodis et al. (1991) reported that 8,871 fish representing 13 species and multiple size classes (250-750 mm) were observed moving upstream in the Denil Fairford Fishway between May 6-28 and June 2-12, 1987. White Sucker (57%), Walleye (26%), and Sauger (10%) comprised 93.0% of the movements. Although some of these fish were captured moving back downstream (7.6% of the catch), Derksen (1988) suggested there was no evidence of significant movements of adults downstream from Lake Manitoba to the Fairford River. Katopodis et al. (1991) concluded that the fishway was effective in passing the majority of species and size classes of fish found in the Fairford River. However, the effect of the fishway on forage (e.g., cyprinids) and smaller juvenile fish movements is largely unknown as the large mesh size of the traps utilized by Katopodis et al. (1991) was ineffective at catching smaller fish. In a more recent study conducted during the fall, only four fish (two immature Cisco, one Walleye and one Burbot) were captured moving upstream into the fishway (Gillespie and Remnant 2008).

3.3.3 Pineimuta Lake

Detailed information on fish within Pineimuta Lake is not available. However, the fish community is likely similar to that of Lake St. Martin and Lake Manitoba. Stewart and Watkinson (2008) reported thirty-three species of fish whose distributional ranges include Pineimuta Lake (Table 2).

Lake Pineimuta is surrounded by a significant amount of wetland habitat that is reported by LMRRAC (2003) to contain nursery areas for fish. However, no detailed studies of these wetlands have been conducted to determine which species utilize the area and to what extent. According to LMRRAC (2003), large increases in annual variation in the extent of wetlands surrounding Pineimuta Lake have resulted in significant deterioration in the health of the marshlands and are believed to negatively impact fish nursery habitat.

3.3.4 Lake St. Martin

Thirty-seven species of fish, including small-bodied forage species, are known to inhabit the Lake St. Martin watershed. Species of commercial and domestic importance known to occur in Lake St. Martin include: Northern Pike, Walleye, and Lake Whitefish. Common Carp, Goldeye, Burbot, Longnose Sucker, White Sucker, Yellow Perch, Sauger, and Cisco comprise a smaller portion of the commercial fishery.

Large numbers of Lake Whitefish from Lake Winnipeg are known to migrate up the Dauphin River each fall to spawn on extensive gravel bars in the northeast basin of Lake St. Martin and in the narrows between basins and then return downstream (Stone 1965; Cook and MacKenzie 1979; Kristofferson and Clayton 1990). Furthermore, mark-recapture studies of Lake Whitefish spawning in Lake St. Martin suggest that the range of this subpopulation may be fairly localized (Kristofferson and Clayton 1990). Cook and MacKenzie (1979) also suggest that Lake Whitefish may return to Lake St. Martin in successive years to spawn.

3.3.5 Big Buffalo Lake

No information specific to fish use of Big Buffalo Lake was available. However, a brief field program was conducted during August, 2011 as part of the studies identified in Section 5.0 of this report. The following is based on information collected during that field program. Additional information and details of the field program will be provided in a subsequent technical report.

Experimental gill nets of various sized meshes (ranging from 16 to 127 mm inch stretched mesh) were used to investigate fish presence/abundance and community composition in Big Buffalo Lake. At least four species of fish were captured, including Golden Shiner, Northern Pike, White Sucker and Yellow Perch. Young-of-the-the-year cyprinids (minnows) were observed in large numbers in areas of high aquatic vegetation abundance, but were not captured and, consequently, not identified to species.

Yellow Perch were the most frequently captured fish species. The Yellow Perch catch included very large numbers of young juvenile fish and fewer older juvenile and adult fish. Yellow Perch born in spring of 2011 may have been susceptible to capture in the gill nets used during the August field program, but the abundance of young juveniles suggests that Yellow Perch were successfully spawning in Big Buffalo Lake. Small numbers of juvenile White Suckers, adult Golden Shiners, and small Northern Pike (243-486 mm length) were also captured.

3.3.6 Buffalo Creek

No information specific to fish use of Buffalo Creek was available. However, a brief field program was conducted during August, 2011 as part of the studies identified in Section 5.0 of this report. The following is based on information collected during that field program. Additional information and details of the field program will be provided in a subsequent technical report.

Fish were collected using a backpack electrofisher in two reaches of Buffalo Creek. The first reach was located where the creek flowed out of the wetland surrounding Big Buffalo Lake, approximately 4 km downstream of the lake. Large numbers of young-of the-year cyprinids (minnows), either Northern Redbelly Dace or Finescale Dace, were observed and captured in this reach of the river. Other species captured included Central Mudminnows, juvenile White Suckers (70-120 mm length), Ninespine and/or Brook Stickleback, and Logperch. Large numbers of crayfish and other aquatic macroinvertebrates such as snails were observed.

The second reach included the lowermost 1.8 km of Buffalo Creek. For most of this reach, water was slow and deep due to back water effects from the Dauphin River. Small numbers of Yellow Perch, Logperch, and Northern Pike were captured. At the upstream end of the sampling reach and upstream of back water effects from the Dauphin River, the creek became shallower was characterized by riffle and glide sequences. Longnose Dace and sculpins (Slimy and/or Mottled), species typically associated with faster flowing water were captured. Small numbers of Logperch and juvenile Northern Pike were also captured.

A commercial fisherman from the community of Dauphin River indicated that White Sucker, Northern Pike, and Yellow Perch move into the creek during spring. Suitable spawning habitat occurs within the lower reach of the creek and it is possible these species may spawn there. Habitat appears to be suitable for Walleye spawning as well, but the commercial fisherman did not think that Walleye moved into the creek.

3.3.7 Dauphin River

A recent fish inventory of the Dauphin River is not available. However, the river likely contains many of the same species that inhabit Lake Winnipeg and Lake St. Martin.

Pollard (1973) indicated that the Dauphin River is an important Walleye spawning area. Large numbers of Lake Whitefish from Lake Winnipeg are known to migrate up the Dauphin River each fall to spawn within Lake St. Martin, but it has also been suggested that some of these fish may spawn within the river (Stone 1965; Cook and MacKenzie 1979; Kristofferson and Clayton 1990; Traverse 1999). Doan (1945) reported that a large spawning run of Walleye enters Dauphin River at the time of spring break-up. Adult Walleye gather in the lower part of the river during late winter, remaining there until the ice begins to break-up.

Doan (1977) attributed the closure of the Dauphin River hatchery to the construction of the Fairford Dam in 1961, which caused the loss of Lake Whitefish eggs due to poor water quality and low dissolved oxygen. According to LMRRAC (2003), low water levels in winter are known to cause low oxygen levels and freezing of pools, which contribute to the loss of fish.

3.3.8 Sturgeon Bay - Lake Winnipeg

Recent fisheries investigations specific to Sturgeon Bay have not been conducted. Doan (1961) indicated that Walleye, Lake Whitefish, Sauger, Northern Pike, Burbot, suckers, Yellow Perch, Cisco, and Freshwater Drum were all captured in the river. Kristofferson (1978) and Kristofferson and Clayton (1990) noted that a single Lake Whitefish population from Lake Winnipeg is known to use the Lake St. Martin-Dauphin area for spawning and that this population exhibits differences in morphological characteristics and allelic frequencies compared to other Lake Whitefish stocks.

Fifty-two species of fish commonly occur in Lake Winnipeg with several additional species occur occasionally (Franzin et al. 2003). Fish species whose distributional ranges include Lake Winnipeg and Sturgeon Bay are listed in Table 2. Three invasive species have become established in Lake Winnipeg; Rainbow Smelt, Common Carp, and White Bass. Five species in Lake Winnipeg have been designated "At Risk" by the Committee on the Status of Endangered Wildlife in Canada (accessed 2011): Silver Chub (special concern); Chestnut Lamprey (special concern); Bigmouth Buffalo (special concern); Shortjaw Cisco (threatened); and Lake Sturgeon (endangered) (COSEWIC 2010).

Franzin et al. (2003) described the habitat preferences and relative abundance of fish species within Lake Winnipeg. Most prefer nearshore habitat (e.g., redhorse, bullheads, Northern Pike, sculpin, and bass). Species that occur primarily in offshore areas include Lake Whitefish, Rainbow Smelt, Goldeye, Mooneye, Lake Sturgeon, Flathead Chub, Shortjaw Cisco, and Lake Trout (Franzin et al. 2003). Franzin et al. 2003 reported that the most abundant species in the lake are found in both nearshore and offshore waters as adults (e.g., Walleye, Sauger, Yellow Perch, White Sucker, Burbot). Small bodied fish species that dominate in offshore waters include Emerald Shiner, Rainbow Smelt and Cisco (MWS 2011c). Emerald Shiner and Cisco are more abundant in the south basin and the narrows, while Rainbow Smelt are more abundant in the north basin (MWS 2011c).

3.4 FISH HARVEST

All the water bodies in the area (Lake Manitoba, Fairford River, Lake St. Martin, the Dauphin River, and Sturgeon Bay) support domestic, sport, and/or commercial fisheries. Information specific to domestic and sport harvest is limited and most information that is available is not current. Lake Manitoba, Lake St. Martin, and Sturgeon Bay support commercial fisheries that provide substantial employment and economic support for communities that surround those water bodies. Considerable information exists regarding the commercial harvest of fish in those areas.

The following sections describe the historic and current fisheries occurring in Lake Manitoba, Lake St. Martin and Dauphin River/Sturgeon Bay.

3.4.1 Lake Manitoba

Lake Manitoba supports large domestic, sports and commercial fisheries. The commercial fishery is the third largest fishery and the largest winter fishery in the province of Manitoba. The majority of available information pertains to the commercial fishery, and consists largely of annual records of fish production and the number fishers involved.

Historic Fishery

Commercial fishing operations began on Lake Manitoba in 1855 and included summer and winter fisheries (LMWSB 2010). By the end of the 19th century, large commercial fishing companies were harvesting large numbers of fish from the lake. Local concern regarding the capacity of fish populations to sustain the heavy harvest prompted closure of the summer fishery in 1905 (LMWSB 2010). In 1964, a small summer commercial fishery was opened, but targeted only coarse fish (Carp, suckers) and was restricted to the south basin of the lake. Since 1905, the majority of commercial fishing production on Lake Manitoba has occurred during winter.

Initially, the Lake Manitoba fishery was focussed on Lake Whitefish, but has shifted to Walleye, Sauger and Yellow Perch in more recent years. Production from the late 1940s to the mid-1960s averaged about 2.3 million kilograms annually, but declined to an average of about 1.7 million kilograms annually in the late 1960s and early 1970s (Pollard 1973). Production remained around 1.0-2.0 million kilograms per year, until very recently, when production has further declined to less than 1.0 million kilograms per year (Table 3). To support the fishery, hatcheries in St. Laurent, Swan Creek and Lonely Lake are used to supply larval Walleye for stocking In Lake Manitoba.

Little information specific to sports or domestic fisheries on Lake Manitoba are available. A creel survey conducted in 1977 and 1978 focussed on sites around the north basin of the lake, and illustrated that most sports fishing occurred at the Lake Manitoba Narrows, on the Waterhen and Fairford rivers and a few other access points around the north basin (Valiant and Smith 1979).

Current Fishery

Lake Manitoba currently supports summer rough fish (Carp and suckers only) and winter commercial fisheries, and provides employment for approximately 800 licensed fishers and helpers annually (LMWSB 2010). Fish packing stations on or near the lake are located at Amaranth, Ashern, Eddystone, Lundar, St. Ambrose, St. Laurent and St. Martin Junction. Commercial catches are sold through the Freshwater Fish Marketing Corporation (FFMC).

Commercial fishing for Walleye and Sauger occurs between 02 November and 15 March with a quota of 907,200 kg (round weight). Commercial fishing for these species is not permitted from March 16 to when ice forms on or after November 1. The summer rough fish fishery is closed only between October 30 and November 1, and has an unlimited annual quota. The number of fishers delivering catches to the FFMC has decreased steadily from 413 in 2001/2002 to 185 in 2010/2011 (Table 3). Consequently, the landed catch has decreased from over 2 million kg to less than 400,000 kg over the same period. Cisco, Walleye, Yellow Perch, Carp, and Northern Pike have been the most important species in the Lake Manitoba commercial fishery in recent years (Table 3). However, catches of some species (Cisco, Yellow Perch, and Carp) have declined in the last five years (2006/2007 – 2010/2011) compared to the previous five (2001/2002 – 2005/2006).

3.4.2 Lake St. Martin

Lake St. Martin supports small but locally important domestic, sports, and commercial fisheries. Less information is available for Lake St. Martin relative Lake Manitoba or Sturgeon Bay.

Historic Fishery

Lake St. Martin has sustained a winter fishery since prior to 1905; commercial fishing began in 1922 (Stone 1965; MWC 1978). A summer season was initiated in 1963, but contributed only a small proportion of total commercial production on Lake St. Martin. A domestic summer fishery also exists in Lake St. Martin (MWC 1978), but historic or current catch totals and numbers of fishers are not known. Sports fishing pressure on Lake St. Martin has traditionally been less than on Lake Manitoba or Sturgeon Bay (Pollard 1973; Valliant and Smith 1979), but no information was found describing current sports fishing activity.

Historically, Walleye, suckers and, to a lesser extent, Yellow Perch were targeted in the commercial fishery. In the late 1970s, a shift in production of the various species was observed; Lake Whitefish became more predominant in the catch and Walleye and Sucker production declined. On average, about 100,000 kilograms of fish were harvested annually (Manitoba Conservation 2001; LMRRAC 2003).

Current Fishery

Lake St. Martin currently supports a winter commercial fishery (01 November to 01 April) that targets Walleye, Lake Whitefish, and Sauger. Quota on the lake is 340,200 kg for the three species combined. A year-round (closed 30 October to 01 November) rough fish (Carp and suckers only) fishery of unlimited quota also occurs on the lake.

Since the 2001/2002 season, the number of fishers delivering catches to the FFMC has varied from 28 in 2007/2008 to 60 in 2001/2002 and 2003/2004 (Table 4). The total landed weight of commercial catches over the last ten seasons has remained well below quota, ranging from a peak of 231,505 kg in 2002/2003 to a low of 72,598 in 2009/2010.

No current information describing domestic or sports fishing activities in Lake St. Martin was available.

3.4.3 Dauphin River and Sturgeon Bay

The Dauphin River and Sturgeon Bay support large sports and commercial fisheries. Domestic fishing also occurs. The commercial fishery is conducted in Sturgeon Bay largely by fishers from the community of Dauphin River, but people from other nearby communities also participate. Sport fishing occurs within the Dauphin and Mantagao rivers, Sturgeon Bay, and in Sturgeon Bay tributaries to the north of the Dauphin River (Pollard 1973). In addition to commercial and sports fishing, domestic fishing and bait fishing are also prominent on the lake (MWS 2011c).

Historic Fishery

The commercial fishery in Lake Winnipeg began in the 1870s and has long been the largest commercial fishery in western Canada. Originally, the fishery targeted Lake Whitefish but, as the whitefish population decreased in the 1930s, production of Walleye and Sauger increased (Franzin et al. 2003; MWS 2011c). Lake Whitefish stocks declined again in the 1960s in response to over-fishing (Davidoff et al. 1973). Other species harvested from the lake include Cisco, Northern Pike, Yellow Perch, Goldeye, Lake Sturgeon, and Channel Catfish.

Commercial fishing in Sturgeon Bay has been the most important source of income to the residents of Dauphin River, as well as providing employment to residents of other nearby communities (Pollard 1973). Total commercial production of quota species (Walleye, Sauger and Lake Whitefish) from the Sturgeon Bay fishery in 1972/73 was 85,500 kg (188,100 lb.), which was slightly higher than the ten year average of 78,273 kg (172,200 lb.) for the years 1960-1969. Captured fish are processed in Dauphin River and sold through the FFMC in Winnipeg.

The Dauphin River sport fishery became increasingly popular following construction of the road to Anama Bay the mid-1960s. By the early 1970s, the river maintained significant sport and commercial fisheries. Pollard (1973) reported that between June and August, 1972, approximately 10,200 anglers captured 16,091 kg of Walleye in the area.

Current Fishery

No recent information is available describing current domestic or sports fishing activities in in the Dauphin River area.

Since 1986, the Lake Winnipeg commercial fishery has been regulated using an Individual Transferable Quota system, referred to as Quota Entitlement. This differs from most other lakes in Manitoba (only Lake Winnipegosis is also managed using a Quota Entitlement system) where individual fishers are assigned set quotas that are non-transferable. The Quota Entitlement system allows for the transfer of quotas between fishers. The total overall quota for Walleye, Sauger, and Lake Whitefish from Lake Winnipeg was 6.27 million kilograms as of March 2007 and was divided between 12 Community Licensing Areas plus Norway House. The Dauphin River/Gypsumville Licensing Area was allocated 577,560 kilograms of Walleye and Sauger production and 31,760 kilograms of Lake Whitefish production. Production at the Dauphin River delivery Point has declined by about 100,000 kilograms over the last five years (Table 5). In 2009, the overall total quota for Lake Winnipeg was increased to 6.52 million kilograms of annual Walleye, Lake Whitefish, and Sauger production.

There are two open-water fisheries (summer and fall) and a winter fishery specified for Lake Winnipeg. The summer fishery remains the most productive (MWS 2010b). Lake Whitefish roe is sold as part of the fall fishery at Dauphin River.

3.5 SUMMARY OF EXISTING INFORMATION

A summary of the aquatic environment information presented in the previous sections is provided in Table 6.

4.0 POTENTIAL CHANGES DUE TO CONSTRUCTION OF THE EMERGENCY CHANNEL

Construction of Reach 1 and operation and closure of the diversion route will have some effect on local aquatic ecosystems. Through the process of scoping potential project-related effects, physical linkages from construction, and closure of the project were considered in relation to water quality, aquatic habitat, and fish resources. These are discussed in the following sections.

4.1 WATER QUALITY

The potential linkages between the Project and water quality impacts are complex but relate primarily to three main physical effects pathways:

- Alterations in the rate and seasonality of flow discharged to Sturgeon Bay and other waterbodies in the study area;
- Effects of flooding along the flow diversion route; and,
- Potential for erosion and/or mobilization of sediments due to the diversion.

4.1.1 Alterations in Flows

The Project will result in a greater rate of discharge from the Lake Manitoba/Lake St. Martin drainage to Sturgeon Bay over the fall, winter and spring than would occur without the Project. As the flows would eventually drain to Lake Winnipeg without the Project, the primary linkage of potential concern relates to how alterations in the timing/volume of this discharge may alter water quality in Sturgeon Bay and other watercourses along the emergency outflow route. Preliminary review of routine water quality variables indicates that water quality in the Fairford and Dauphin rivers exhibits seasonal differences which may in turn affect conditions in the ultimate receiving environment (i.e., Sturgeon Bay). Specifically, increased winter discharges may increase conductivity, ammonia, and pH in the bay as well as the area typically influenced by the Dauphin River inflow (i.e., the size of “the plume”).

Conversely, increasing discharge over winter may somewhat mitigate the potential effects related to flooding on eutrophication in Sturgeon Bay. Increasing discharge (and therefore loading of nutrients) over winter would result in a comparatively lower rate of nutrient loading to Sturgeon Bay during the open water season when effects on primary production would be greatest.

In addition, there is potential for effects on DO in Sturgeon Bay should the Project result in lower DO concentrations over winter in the inflow entering Lake Winnipeg and/or due to the increased volume of discharge over the ice-cover season (i.e., a larger area may be affected than without the Project), and/or should substantive quantities of organic matter be introduced to Sturgeon Bay. It is not known if Sturgeon Bay experiences thermal stratification or if it experiences DO concentrations that are below Manitoba water quality objectives for the protection of aquatic life; should stratification occur, there is a greater potential for oxygen depletion to occur at depth which would be exacerbated by introduction and subsequent settling of organic matter in this area.

Potential effects on other water quality variables in the Buffalo Creek Drainage System and Sturgeon Bay related to the diversion route cannot be readily characterized due to lack of baseline water quality data for these areas. Collection of additional baseline data this fall would assist with delineating potential effects on other parameters such as metals.

4.1.2 Effects Related To Flooding

Flooding of terrestrial habitat may affect water quality through leaching and decomposition of organic materials, which may in turn consume DO, decrease pH, and increase nutrients and metals in water. In addition, flooding of terrestrial habitat may mobilize mercury and increase mercury methylation, ultimately leading to increased bioaccumulation of mercury in aquatic biota.

As there is existing extensive flooding in the drainage basin, the diversion/increase of outflows to Lake Winnipeg would reduce effects related to existing flooding but also result in flooding/wetting of new areas. Therefore, the potential effects related to this pathway on water quality are complex and not easily discerned. Conceptually, the ultimate effects related to flooding would be the net effect of existing flooding versus flooding along Reach 1, which may in turn be affected by factors such as the total area flooded, differences in the quality of the flooded terrestrial habitat (e.g., mass of organic materials), and more complex interrelated variables such as changes in water residence times or thermal regimes. Overall, as the Project effects would be largely confined to winter, effects related to flooding in general would be somewhat limited by low water temperatures which would reduce the rate of biological activities, such as mercury methylation and decomposition.

4.1.3 Erosion and Sediment Mobilization

Project construction and operation have the potential to increase shoreline, lake bed, and creek bed erosion, as well as mobilize existing sediment, ultimately increasing TSS, turbidity, and related variables. This may in turn have direct effects on aquatic biota within these areas as TSS may have lethal and sub-lethal adverse effects on fish and other aquatic life. Indirect effects may also include reductions in water clarity which may reduce primary production; however, primary production is typically limited in winter by low water temperatures and low light due to ice and snow cover. Other indirect effects may include increased loading of variables associated with soils/sediments to Sturgeon Bay, which may in turn affect water quality while in suspension, and/or sediment quality, once the particulates settle out of the water column. The magnitude of potential effects related to this pathway cannot be readily identified as the magnitude of potential increases in TSS has not been defined.

4.1.4 Other Potential Effects

Other potential effects of the Project on water quality include potential introduction of contaminants such as petroleum hydrocarbons or metals due to accidental spills or releases, and potential changes in water quality in the Buffalo Creek Drainage System due to diversion of flows. Buffalo Creek water quality may be directly affected through the diversion of flows should existing water quality differ, or indirectly through flooding and/or erosion within the drainage.

4.1.5 Summary of Anticipated Effects to Water Quality

A substantial change in water quality is expected to occur in the Buffalo Creek Drainage System due to diversion of flows, and/or flooding, and/or increases in TSS related to erosion and sediment re-suspension. Due to the lack of existing information on this system, the nature and magnitude of these effects cannot be identified at this time. Effects to water quality in the Buffalo Creek Drainage System and the mouth of the Dauphin River are expected to be short term and will not persist long after the life span of the project.

Impacts to water quality in Sturgeon Bay are related to alterations in the rate and seasonality of inflows and to potential erosion and/or mobilization of sediments from the diversion route. The effects may include increased TSS and related variables, reductions in DO concentrations, and an increase in the spatial extent of the Dauphin River plume in Sturgeon Bay over the period of the Project. The effects will generally be short term with the exception of effects on DO in Sturgeon Bay related to introduction and deposition of organic materials.

Effects of the Project on water quality in the north basin of Lake Winnipeg as a whole are expected to be negligible:

- due to an expected low magnitude of change in the basin volume related to the increased inputs over winter; and
- because the flows would eventually drain to Lake Winnipeg without the Project and the residence time of the north basin has been estimated to range from approximately 2 to 6 years (based on the period of 1999-2007, MWS and EC 2011).

Collection of additional baseline data for the Project study area would assist with characterizing potential impacts related to the Project.

4.2 AQUATIC HABITAT

Potential linkages between aquatic habitat and the proposed Reach 1 and operation of the FRWCS relate primarily to the following effects pathways:

- Direct loss of habitat due to the footprint of structures;

- Alteration of habitat due to increased flow and flooding along the diversion route; and,
- Alteration of habitat due to erosion and sedimentation.

4.2.1 Habitat Loss/Gain Due to Structure Footprints

Construction and operation of Reach 1 will result in the direct loss or alteration of a small amount of fish habitat in Lake St. Martin at the entrance to the channel. Conversely, construction of tReach 1 will create new, albeit temporary, fish habitat within the channel.

4.2.2 Alteration of Habitat from Increased Flows along the Diversion Route

Increased flows along the diversion route are expected to affect habitat in the Buffalo Creek Drainage System and Dauphin River downstream of its confluence with Buffalo Creek. At Big Buffalo Lake, it is expected that water level will increase and flooding will occur around the lake, the spatial extent of which has not yet been determined. The surrounding area is largely wetlands, including some floating bog. Flooding of those types of habitat likely will provide an increase in usable habitat for fish. Increased flow into and out the lake may also decrease water residency time in the lake, and result in more riverine habitat in areas where flow is concentrated. It is likely that habitat changes caused by scour and erosion will occur, including removal of loosely compacted organic sediments that occur on the lake bottom and surrounding wetlands. Depending upon water velocity conditions and consolidation of substrates in surrounding areas, the spatial extent of Big Buffalo Lake could be increased following closure of Reach 1.

In Buffalo Creek, increased flow and associated scour and erosion may cause changes in channel geometry (meander breaches), cross-sectional morphometry of the channel, removal of riparian and instream vegetation, and changes in bed composition due to removal of loosely compacted organic and fine-grained sediments. Changes to channel geometry and cross-sectional morphometry would be expected to be greatest in the upper reaches of the creek, where the channel flows through wetlands with abundant organic soils. Changes in channel geometry would be expected to occur in the lower reaches of the creek where the existing channel is more defined and more meanders occur. Additionally, increased flow will result in increased water velocity within the creek, reducing its suitability for fish that favour slow-moving water.

Habitat changes to the Dauphin River downstream of Buffalo Creek will occur through increased water level and increased water velocity. Increased flow will also result in increased erosion and removal of sediments, particularly along banks of the Dauphin River across from the mouth of Buffalo Creek.

Closure of Reach 1 is expected to dewater channels and wetlands surrounding Big Buffalo Lake that were inundated during operation. Increased rates of dewatering, depending on the timing of closure, may result in exposure of spawning habitat and reduced littoral zone habitat. If water releases through the diversion route cease prior to the spring movement period when fish ascend watercourses to spawn, any effects will be limited to overwintering habitat use by resident fishes. However, if water releases through Reach 1 cease during or after spring movements of fish, the decrease in flows in Buffalo Creek may expose egg incubation and early larval rearing habitat in the Dauphin River.

4.2.3 Alteration of Habitat due to Erosion and Sedimentation

Diverting flow from Lake St. Martin into Reach 1 is expected to erode and transport sediments and surficial soils and sediments from along the length of the route. Transported materials will range from organic materials to mineral soils. In addition, there is expected to be some shoreline erosion on the Dauphin River at and downstream of the mouth of Buffalo Creek. Transported materials will eventually be deposited in Sturgeon Bay. The potential for catastrophic effects to habitat is low but, without additional information on the mobilization and deposition of sediments, the magnitude of effect is difficult to estimate at this time. Changes to the composition of Dauphin River substrate below the confluence with Buffalo Creek will be related to the change in flow pattern and is not expected during operation of the diversion route. However, as flows diminish from the diversion route during closure, small amounts of transported materials may be temporarily deposited at or near the water surface as the Dauphin River levels fall. If inflows to the Dauphin River remain high, changes to the substrate are expected to be small and likely fall within natural variation.

4.2.4 Summary of Anticipated Effects to Aquatic Habitat

Increased flows along the diversion route are expected to affect habitat in the Buffalo Creek Drainage System and the Dauphin River downstream of its confluence with Buffalo Creek. Habitat effects related to increased flows will be short term, lasting only for the duration of the diversion flows. Lake and channel geometry and cross-sectional morphometry will change significantly post-project and a decrease in riparian vegetation is expected to occur. Aquatic habitat within the Big Buffalo Lake and Buffalo Creek watershed is considered resilient and is not expected to suffer a significant decrease in productive capacity post-project.

Shorelines and substrates at the mouth of the Dauphin River downstream of the confluence of Buffalo Creek are expected to suffer site-specific increases in erosion due to changes in flow patterns. The most significant effects will occur in the vicinity of the confluence with Buffalo Creek.

Deposition of sediments in Sturgeon Bay has the potential to affect substrate composition and the suitability of foraging, overwintering, spawning and incubation habitat. It is not possible to determine the extent of the effect without an estimate of the amount of material that will be mobilized from Reach 1 and the Buffalo Creek Drainage System.

4.3 FISH RESOURCES

The potential linkages between the Project and fish resource impacts relate primarily to three main physical effects pathways:

- Habitat change due to altered flow, resulting in potential impacts to spawning behaviour and timing, egg deposition and incubation, rearing success, overwintering, general movements, and metal concentrations in muscle tissue;
- Altered access to habitat due to increased flow, creating possible attraction flows and/or velocity barriers during operation; and,
- Re-distribution of fish species in all affected waterbodies resulting directly from changes to flow patterns.

4.3.1 Habitat Changes from Alterations in Flows

Increased flows from Lake Manitoba to Sturgeon Bay as a result of the operation of the diversion route will affect fish movements and habitat utilization within the system. Flow increases into and out of Lake St. Martin during late fall and winter could result in an increase of upstream or downstream movement of fish from the lake. In addition, an increase in the use of Buffalo Creek by fish species adapted to higher water velocity may occur due to increased flows out of Big Buffalo Lake. Flooding and erosion of aquatic and terrestrial vegetation in the Buffalo Creek Drainage System and the Dauphin River may affect the availability and distribution of spawning habitat for fall and spring spawning species, potentially affecting spawning behaviour and timing. Increased depths, sedimentation, and turbidity from increased flows could impact the littoral zone habitat used by many species of fish for rearing and feeding, resulting in at least temporary redistribution of fish to other areas within the watershed or to adjacent, unaffected watersheds. Yellow perch, the most common fish species in Big Buffalo Lake, prefers abundant littoral vegetation. Transportation of invertebrate prey items downstream may indirectly affect fish distribution within the watershed. Increased flows at potential egg incubation sites may alter substrate composition, affecting both egg distribution and incubation success rates. Changes to key habitat may result in increased mortality rates for fish eggs, larvae, and juveniles. Flooding and increased flows may also increase the amount of available overwintering habitat or affect the timing and extent of ice formation, particularly in Buffalo Creek and the Dauphin River.

Mobilization of sediments along the diversion route and subsequent deposition downstream following closure of Reach 1 has the potential to cause sedimentation in spawning, egg incubation, and/or rearing habitat. This, in turn, has the potential to affect fish distribution, community composition, and mortality rates in the short term, as fish preferring clear waters will avoid areas of high turbidity and deposited eggs may become buried. In addition, increased water discharge in winter may affect pH, decrease DO, and increase nutrients and metals (e.g., mercury) in Sturgeon Bay which may affect fish health.

Shifts in habitat use and abundance of fish in the Buffalo Creek Drainage System will occur, first as a result of increased flooding along the diversion route and temporary creation of aquatic habitat, then again after closure of the diversion route. In addition, the flooding and scouring of Buffalo Creek will alter fish use of the upper channel and wetland habitat as well as the lower portion of the creek.

The increased water levels and velocities during winter and potential substrate shifts at the mouth of the Dauphin River could affect suitability of spawning habitat and movements of fish in the area. In addition, spawning and overwintering fish in Sturgeon Bay and Lake Winnipeg could be impacted by the deposition of mineral and organic materials on substrates in those areas. The increased drift of invertebrates associated with increased flows may temporarily decrease invertebrate densities in the Buffalo Creek Drainage System and the Dauphin River, while increasing them in Sturgeon Bay. Increased densities of fish may be observed in Sturgeon Bay during this time.

Numerous empirical and experimental studies have clearly demonstrated that human land-use changes can make mercury more available to biota, resulting in mercury bioaccumulation up the food chain (Jernelöv and Lann 1971; Cox et al. 1979; Hall et al. 1997) and elevated concentrations in fish (Schetagne et al. 2003; Bodaly et al. 2007) that impact the health of wildlife and human fish consumers (Mergler et al. 2007; Scheuhammer et al. 2007; Sandheinrich and Wiener 2011). Among the various anthropogenic land-uses, flooding of terrestrial soils and wetlands, and the disturbance/removal of the soil litter/organic layer of terrestrial vegetation will likely have the greatest potential to affect fish mercury levels. Flooding increases mercury availability because the inundation of soils and vegetation introduces inorganic mercury and organic nutrients to the flood water, which, in turn, stimulates microbial production of methylmercury (Ramlal et al. 1987; Kelly et al. 1997), the form of mercury that biomagnifies (Watras et al. 1998). The disturbance or removal of the upper soil horizons can dramatically increase methylmercury concentrations in the runoff, has been identified as a major mercury source to aquatic ecosystems (Munthe and Hultberg 2004), and has been linked to elevated mercury concentrations in fish (Bishop et al. 2009; Porvari et al. 2009).

For the above reasons it can be expected that the construction of Reach 1 through an area mainly consisting of wetlands and carbon-rich forest soils has the potential to increase mercury methylation rates in the Buffalo Creek Drainage System compared to present conditions, release currently bound methylmercury into surface waters, and to result in exports of methylmercury into downstream water bodies, such as Little Buffalo Lake and Lake Winnipeg. It should also be noted that reducing the flooding on Lake St. Martin through diversion flows should reduce mercury methylation rates in Lake St. Martin.

Mercury concentrations in most of the commercially important species of Lake Winnipeg seem to have declined from the elevated levels observed in the early 1970s that resulted in the temporary, partial closure of the fishery (Blight 1971; Derksen 1979). Some uncertainty exists regarding current mercury levels in fish from Lake Winnipeg because:

- only very limited (in terms of sample size and number of species) data have been collected in recent (post 2001) years (Kevin Jacobs, MB Water Stewardship, pers. comm., January 2010);
- the available data cannot always be connected to a precise geographical location;
- the number of species with sufficient individuals to make statistically meaningful comparisons is relatively small for many years; and,
- a comprehensive analysis of the existing data for the years 1980-2001 has, to our knowledge, never been undertaken.

For a large waterbody such as Lake Winnipeg, regional differences in fish mercury concentrations can be expected and have been demonstrated (Bill Franzin, formerly DFO Freshwater Institute, Winnipeg, pers. comm.). However, to our knowledge, mercury data for fish from Sturgeon Bay have never been collected. Furthermore, contemporary data from Lake St. Martin appears to be lacking.

4.3.2 Changes to Habitat Accessibility from Alterations in Flows

Increased flows may act as attractants to certain species during fall and spring spawning runs affecting the timing and distribution of spawning activity. In particular, increased flows at the confluence of Buffalo Creek and the Dauphin River may cause some spawning fish that would normally migrate upstream in the Dauphin River to Lake St. Martin to be diverted into Buffalo Creek and, ultimately, Big Buffalo Lake. If Reach 1 is closed during or shortly after fall or spring migrations, spawning fish may become trapped or unable to find suitable spawning habitat.

Increased flows may present velocity barriers to certain species of fish. Many of the fish species present in the Buffalo Creek Drainage System are adapted to slower flow conditions (e.g., Yellow Perch, Northern Pike, certain species of dace, Central Mudminnows). Increased flows during operation of the channel may limit the amount of available habitat for these species. Fish tolerant of or adapted to higher water velocity conditions (e.g., Longnose Dace, sculpins) are likely to become more prevalent during the operation of Reach 1. Closure of Reach 1 and subsequent dewatering may result in the stranding of fish that were using flooded habitat. The timing of the closure may also affect fish spawning movements.

4.3.3 Redistribution of Fish Species from Alterations in Flows

In addition to indirectly affecting fish distributions due to habitat alterations, increased flows have the potential to directly affect fish distributions throughout the watershed. With the opening of Reach 1 and maximized use of Fairford River Water Control Structure, large volumes of water are expected to flow from Lake Manitoba to Lake Winnipeg. Several species of fish present in the watershed, particularly in the Buffalo Creek Drainage System, may be less tolerant of increased water velocity (e.g., Yellow Perch) and move downstream to the Dauphin River or Lake Winnipeg as a result. Other species currently found only in faster areas in the downstream reaches of Buffalo Creek and the Dauphin River (e.g., Longnose Dace) may expand their distribution into areas vacated by species intolerant of the higher flows.

Depending on the timing, higher flows may have a particularly significant impact on egg and larval fish distribution. Eggs may be flushed downstream into habitat unsuitable for incubation. Larval fish tend to occupy low velocity, shallow areas for rearing. High flows during operation of Reach 1 could transport drifting larval fish further downstream to areas of unsuitable habitat or with increased numbers of potential predators, increasing mortality rates.

4.3.4 Summary of Anticipated Effects to Fish Resources

The introduction of flows through the Buffalo Creek Drainage System is expected to have short term effects on the resident fish communities. Species composition is expected to change as water velocities increase and fish are introduced to the system from Lake St. Martin and fish migrate out of the system to Lake Winnipeg. There is also the possibility that mercury concentrations will increase in the system post-project due to transfer of methylmercury from Lake St. Martin. The fish populations in the Buffalo Creek Drainage System are considered resilient and are expected to re-establish rapidly post-project. There may be a small reduction in post-project productivity in Buffalo Creek for a number of years until sediments are redistributed and riparian cover is re-established.

Increased flows from Buffalo Creek have the potential to attract fall and spring spawning fish from the Dauphin River. Depending on timing, termination of flow has the potential to strand fish and dewater eggs. Increased flows from Buffalo Creek also have the potential to modify habitats at the mouth of the Dauphin River. The majority of Lake Whitefish and Walleye spawning habitat in the Dauphin River system is expected to occur upstream of the confluence with Buffalo Creek and in Lake St. Martin. Consequently, habitat effects at the mouth of the Dauphin River would not be expected to have measureable effects on regional fish stocks.

Deposition of mineral and organic material discharged from the diversion route has the potential to affect spawning, rearing and overwintering habitats for fish in Sturgeon Bay. Increases in sediment transport may also contribute to oxygen depletion and increases in mercury methylation rates. Methylmercury may also be transported downstream from the Buffalo Creek Drainage System. Potential effects are difficult to quantify without an estimate of the magnitude and distribution of sediment deposition and a better understanding of fish habitat within the Bay. However, it is expected that impacts would be local and would not be measurable in a regional context (i.e., Lake Winnipeg).

5.0 WORK PLAN

5.1 ASSESSMENT APPROACH

Two approaches were taken to develop a work plan for assessing the environmental effects of the project. The first was to identify studies that would provide information to fill data gaps to better understand aquatic impacts and to plan appropriate mitigation strategies. The second approach was to collect information to fill identified information deficiencies and provide a background against which post-project changes can be measured. Where possible, studies were designed to provide information to help assess aquatic impacts, as well as provide a baseline against which post-project changes could be measured.

5.2 PROPOSED STUDIES

5.2.1 Studies to Assist in Predicting Impacts and Planning Mitigation

To fill existing data gaps and assist in predicting and potentially mitigating project effects, the following tasks have been identified:

- Document existing habitat in the Buffalo Creek Drainage System;
- Document existing fish use of the Buffalo Creek Drainage System;
- Document existing habitat along the Dauphin River from its confluence with Buffalo Creek to the mouth of the Dauphin River; and,
- Determine fall use of Dauphin River by fish, with particular emphasis on assessing whether fall spawning species (i.e., lake whitefish) spawn in the lower reaches of Buffalo Creek, or in the reach of Dauphin River from Buffalo Creek to Sturgeon Bay;

Studies designed to address the above information needs are discussed in the following sections. Study design and requirements may change as additional information regarding the project or the existing environment (through consultation with First Nations, commercial fishermen, etc.) becomes available.

5.2.1.1 Fish Utilization and Habitat Assessment of Big Buffalo Lake and Buffalo Creek

Fish use information and a description of habitat within the Buffalo Creek Drainage System is required to assess potential impacts resulting from construction of Reach 1 and operation of the diversion route. A brief field program was conducted in August, 2011 to address these information needs. Results are summarized and included in Section 3 of this report. Detailed methods and results will be presented in a subsequent technical report.

Briefly, the program included:

- Collection of *in situ* water quality data. Parameters included water temperature, dissolved oxygen, specific conductance, turbidity, pH, and water clarity (determined using a Secchi disc);
- A gillnetting survey of Big Buffalo Lake to document fish presence and community composition within the lake. Sampling was conducted using nets of mesh sizes ranging from 16 to 127 mm stretched mesh;
- Collection of habitat information for Big Buffalo Lake. Water depth and substrate composition were documented, and qualitative descriptions of aquatic vegetation and shorelines were recorded;
- Backpack electrofishing along two reaches of Buffalo Creek to document fish presence and distribution; and,
- Collection of habitat information along two reaches of Buffalo Creek. Habitat variables included stream wetted width, substrate composition and compaction, and water depth. Notes on the distribution of other habitat features such as instream vegetation, riparian vegetation and beaver dams were noted.

5.2.1.2 Dauphin River Habitat Mapping

The proposed collection of habitat information presented here is intended to provide a baseline to help assess and evaluate potential impacts of the project on habitat at the mouth of the Dauphin River. It is proposed that the program be completed prior to the initiation of flow along the diversion route.

Objectives and Rationale

- To provide habitat information (i.e., substrate type) where information does not exist; and,
- To provide baseline depth and substrate information for the area in and surrounding the Dauphin River mouth, understood by local knowledge to be potential Walleye and Lake Whitefish spawning grounds.

Study Area and Methodology

The proposed study area is shown in Figure 38. A Quester Tangent Series 5.5 bottom typing sonar will be coupled with a differential GPS to characterize substrates. Ponar grabs will be conducted to obtain bottom samples for validation of the sonar soundings. Data collection will be in sufficient detail to capture the pattern of substratum types extending downstream from the mouth of Buffalo Creek to outside of the Dauphin River mouth.

5.2.1.3 Fall Fisheries Survey in the Dauphin River and Sturgeon Bay

The fisheries investigations presented here are intended to provide information to supplement existing aquatic environment information, as well as provide contemporary pre-project information that will assist in determining project-related effects. It is anticipated that this program would be conducted during late fall, 2011.

Objectives and Rationale

- To provide information on fish use of habitat within the lower-most reaches of Buffalo Creek and within the Dauphin River between its confluence with Buffalo Creek and Sturgeon Bay during late fall;
- To provide information on fish utilization of nearshore habitat in Sturgeon Bay during late fall;
- To provide additional information on fall fish movements (focus on Lake Whitefish) into the Dauphin River prior to operation of the emergency channel; and,
- To determine whether Lake Whitefish spawn along the reach of the Dauphin River between Buffalo Creek and Sturgeon Bay.

Study Area and Sites

Sampling will be focused along the lower 1.5 km or so of Buffalo Creek and the Dauphin River between its confluence with Buffalo Creek and nearshore areas of Sturgeon Bay. Additional sampling immediately upstream of Buffalo Creek will be conducted to identify potential upstream spawning movements directed towards Lake St. Martin.

Methods

Habitat use investigations will be conducted using a suite of sampling methods, the use of which will largely be determined by flow conditions occurring at the time of the project. It is anticipated that gill nets and hoop nets will be used to capture large-bodied fish such as Lake Whitefish. Gill nets will be used to sample nearshore Sturgeon Bay. Fish movements (upstream and downstream) will be monitored with hoop nets set upstream and downstream of the confluence with Buffalo Creek, as well as within Buffalo Creek upstream of its confluence with the Dauphin River. Whether spawning occurs and the extent to which it occurs will be determined by monitoring egg deposition by Lake Whitefish. Egg mats are frequently used to collect fish eggs in suspected spawning areas, and have previously been successfully used in high flow areas. It is anticipated that egg mats would be deployed in the Dauphin River upstream and downstream of Buffalo Creek, as well as within the lower reaches of Buffalo Creek. These locations may change somewhat, depending upon where adult Lake Whitefish are captured. The egg mats would be deployed prior to the Lake Whitefish spawn, and would be retrieved later in the fall.

5.2.1.4 Collection of Local Knowledge

Knowledge collected from local people (commercial fishermen and First Nations) can contribute considerable information about the existing aquatic environment, and can be of value in assessing and possibly mitigating project-related impacts. This process has been initiated and a small amount of information has been collected and included in this report. The process will continue and the information collected will be incorporated into future assessment reports.

5.2.2 Studies Required to Measure Post-Project Effects

To assist in determining or measuring post-project effects to the aquatic environment as a result of the project, the following tasks have been identified:

- Determine water quality conditions across all waterbodies within the study area;
- Acquire high resolution satellite imagery along the diversion route prior to the initiation of flow down the diversion route in late fall, 2012;
- Determine existing substrate conditions in nearshore areas of Sturgeon Bay, Lake Winnipeg;
- Determine bed load and suspended sediment inputs to Sturgeon Bay during operation of the diversion route;
- Determine fish use of the diversion route (Reach 1, Big Buffalo Lake, Buffalo Creek)following cessation of flows in spring, 2012; and,
- Determine fish methyl mercury concentrations in Walleye, Lake Whitefish, and Northern Pike from Lake St. Martin and Sturgeon Bay.

Studies designed to address the above information needs are discussed in the following sections. It should be noted that there may be some overlap with studies conducted for engineering purposes (e.g., bathymetric data collections in the mouth of the Dauphin River). Study design and requirements can be adjusted accordingly.

5.2.2.1 Water Quality

The proposed collection of water quality information presented here is intended to provide a baseline that is sufficient for evaluating spatial differences across the study area and for monitoring project impacts. It is proposed that the program be completed once prior to the initiation of flow along the diversion route.

It is anticipated that there will be a requirement for monitoring during operation and post-operation of the diversion route. A monitoring program would be designed as required following collection of baseline water quality data.

Objectives and Rationale

- To provide water quality information for waterbodies and areas of waterbodies where there is a lack of information;
- To provide baseline water quality information to assist with operational and post-project monitoring; and,
- To supplement existing monitoring information to expand the list of parameters measured at some locations and to evaluate spatial differences in water quality.

Study Area and Sites

The proposed study area would range from Lake Manitoba, the Fairford and Dauphin rivers, the Buffalo Creek Drainage System, lakes along these river systems, and Sturgeon Bay in Lake Winnipeg. Proposed sampling sites are as follows (also see Table 7):

- Lake Manitoba: three sites in the lake – one site in the south basin (MWS Site MB05LNS002), one site at the narrows (MWS site MB05LKS009), and a new site in Portage Bay (offshore but near the lake outflow);
- Fairford River: one site at or near the existing MWS site (Site MB05LMS001);
- Lake Pineimuta: one offshore site;
- Lake St. Martin: two sites in the lake. One site in the south and one in the north basins (both offshore and near the deepest points where possible);
- Dauphin River: three sites, including a site at or near the existing MWS site (MWS Site MB05LMS003), one site near the mouth of the river (new site) and the third site located near the upstream end of the river (near the outflow of Lake St. Martin)). This will assist in defining spatial changes in water quality along the length of the river;
- Buffalo Creek Drainage System: one site in Big Buffalo Lake and two sites along the creek – one site near the upstream end and one near the mouth (access considered). It should be noted that AECOM is currently conducting water quality sampling as part of their construction environmental monitoring program. These data will be incorporated into baseline data collections as appropriate; and,
- Sturgeon Bay: six sites in Sturgeon Bay, including the site currently monitored by MWS (MWS Site MB05SES012).

To minimize analytical costs, it is proposed to collect a single sample from river sites and to collect a surface grab from lake sites; bottom samples are proposed to be collected at lake sites if the site is thermally stratified at the time of sampling. For quality assurance/quality control purposes, it is proposed to collect one trip and one field blank and one triplicate sample (random site) as part of the sampling program.

Sampling Parameters

It is proposed to measure a suite of water quality variables including:

- Conventional or "routine" variables such as nutrients, total suspended solids, pH, and dissolved oxygen;
- Total metals;
- Dissolved metals;
- Chlorophyll *a*; and,
- Total mercury and methylmercury (total and dissolved).

The list of proposed water quality variables is provided in Table 8. These parameters were identified based on the potential linkages between the Project and water quality, including potential effects on TSS (and related variables), effects related to diversion, and potential effects of flooding and/or diversion on water quality (i.e., nutrients, dissolved oxygen, pH, metals, and mercury), and/or variables that provide supporting information for interpretation of other data. Ultratrace mercury and methylmercury have been included to facilitate comparison to the newly revised Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs; MWS 2011) and because both may be affected by flooding.

Consultation with Manitoba Water Stewardship (Water Quality Management Branch) identified consideration of inclusion of pesticides and *E. coli* in the list of water quality variables, as stakeholders commonly raise concerns regarding effects of runoff/flooding of agricultural areas on these components. It is suggested that should these parameters be included, that analyses would be limited to selected sites; suggested sites are indicated in Table 7 for consideration. A full list of pesticide variables is provided in Table 9. The list of variables is consistent with those measured by MWS in their current water quality monitoring programs in southern/central Manitoba.

5.2.2.2 Satellite Imagery of Diversion Route

It is proposed that high resolution satellite imagery be obtained to assist in documenting the current state of the existing environment before the diversion works are complete. Coverage would include aquatic and terrestrial habitat along the diversion route, as well as the distribution of water masses in Sturgeon Bay. The imagery would supplement the existing environmental description along the diversion route, and would be the basis from which the spatial extent over which project-related effects to aquatic habitat could be determined if comparable imagery was collected post-project.

5.2.2.3 Sturgeon Bay Habitat Mapping

The proposed collection of habitat information presented here is intended to provide a baseline against which post-project changes may be measured. It is proposed that the program be completed prior to the initiation of flow along the diversion route.

Objectives and Rationale

- To provide habitat information (i.e., water depth and substrate type) where information does not exist;
- To provide baseline depth and substrate information for the shallow water areas of Sturgeon Bay, understood by local knowledge to be potential walleye and whitefish spawning grounds; and,
- To conduct offshore depth and substrate sampling in the offshore area of Sturgeon Bay to characterize deep water substrate types.

Study Area and Methods

The proposed study area is shown in Figure 38. Sampling will be stratified into intensive and extensive datasets collected using a Quester Tangent Series 5.5 bottom typing sonar coupled with differential GPS. Ponar grabs will be conducted to collect bottom samples for validating sonar soundings. Data will be collected along transects extending about 4 km perpendicular from shore. In the offshore zone, sampling will be undertaken at spot locations east of Dauphin River and South of Dahls island to characterize the depth and substrate of the deeper areas of the bay that are more distant from riverine influences.

5.2.2.4 Bed Load and Suspended Sediment Inputs to Sturgeon Bay

High flow along the Dauphin River and through the diversion route once it becomes operational will result in an increase in the introduction of bed load and suspended organic materials and sediments to Sturgeon Bay. This has the potential to affect spawning, rearing and overwintering habitats for fish in Sturgeon Bay.

The studies proposed here are intended to provide information required to help assess the extent to which increased sedimentation may affect habitat within Sturgeon Bay.

Objectives and Rationale

There are several sub-components identified in the proposed program, including the following:

- Retention of a subset of sediment grab samples collected during habitat mapping studies in the Dauphin River and Sturgeon Bay (see Sections 5.2.1.2 and 5.2.2.3) for particle grain size analysis and analysis of organic content. This will provide validation for interpretation of sonar data from the mapping studies and will provide a baseline to help assess changes to substrates in areas of increased sedimentation;

- Collection of information regarding the amount of sedimentation occurring and possibly sediment type (organic vs. mineral) occurring in Sturgeon Bay during operation of the diversion channel;
- Collection of bed load sediment transport occurring in the Dauphin River prior to operation of the diversion route and, once the diversion route becomes operational, collection of additional information from the Dauphin River upstream of Buffalo Creek, from Buffalo Creek upstream of the Dauphin River (i.e., the diversion route), from the Dauphin River immediately downstream of the confluence of the Dauphin River and Buffalo Creek, and from the mouth of the Dauphin River at Sturgeon Bay. This will provide information to help determine the incremental contributions of bed load sediment to Sturgeon Bay; and,
- Retention of a subset of sediment grab samples collected during habitat mapping studies in the Dauphin River and Sturgeon Bay for possible future sediment quality analysis (organic content, metals concentrations, including mercury). While the requirement for this analysis is not evident at this point, there is an opportunity to collect the samples at no extra cost now. The samples will be available if the need for sediment quality data becomes necessary as the project becomes more defined.

Methods

Substrate samples retained for particle size and organic content analysis, as well as those archived for future sediment quality analysis would be collected with a Ponar grab during the conduct of habitat mapping studies. Sampling effort will focus on nearshore areas where spawning may occur, but will also be conducted in areas farther offshore to provide a baseline against which post-project conditions may be measured. Samples would be submitted to an accredited analytical laboratory (ALS Laboratories) in Winnipeg for analysis.

Sediment traps will be deployed in late fall and prior to operation of the diversion route to collect information that will help describe the amount and type of sediment that may be deposited through the winter. The distribution of sampling sites will be based partially upon results of the substrate mapping (sediment traps will be deployed in areas where a Ponar grab will not work, such as in areas of cobble substrate) and based on geographic distribution around the mouth of the Dauphin River.

Bed load samples will be collected using a bed load sampler from up to five sites along a single transect oriented perpendicular to water flow at each sampling location. Sampling effort will focus on the Dauphin River immediately upstream and downstream of the confluence with Buffalo Creek, within Buffalo Creek, and at the mouth of the Dauphin River. Samples would be submitted to an accredited analytical laboratory (ALS Laboratories) in Winnipeg for analysis.

5.2.2.5 Fish Utilization and Habitat Assessment of the Diversion Route

Once operational, it is probable that fish will move into habitat provided within the diversion route. The fisheries investigations presented here are intended to document fish use of available habitat during operation and following closure of the diversion route. The studies will serve to help assess post-project effects, and will assist in mitigation planning following closure (i.e., determine whether fish become stranded when water levels recede).

Objectives and Rationale

- To provide information on fish use during operation and following closure of the diversion route; and,
- To provide information that will assist in determining post-project effects, particularly with respect to the Buffalo Creek Drainage System.

Study Area and Methods

Fish use and habitat assessments would be focused along the diversion route, and would include sampling locations within the emergency channel, in the Buffalo Creek Drainage System, and the Dauphin River to Sturgeon Bay (see Figure 2).

A variety of sampling methods would be employed to capture fish, depending upon conditions at each sample location. It is anticipated that a combination of backpack electrofishing, gill nets, and hoop nets would be used. If water levels and flow conditions allow, boat electrofishing may also be used. Habitat assessments during the operational phase will be completed at each sampling location to describe habitat conditions where fish occur. If warranted, fish sampling would be conducted along the diversion route to determine whether fish were stranded following closure of Reach 1. A more detailed assessment of habitat in the Buffalo Creek Drainage System would be conducted following closure to determine the extent to which aquatic habitat has changed. Further, regulatory agencies may require that the re-development of fish communities in the lake and creek be monitored for an extended period (more than one year) following closure.

5.2.2.6 Fish Abundance in Lake St. Martin

There is a potential for some fish to move out of Lake St. Martin due to increased flows down the diversion route. The fisheries study proposed here is intended to provide post-project information regarding fish abundance in Lake St. Martin.

Objectives and Rationale

- To provide information on fish abundance in Lake St. Martin in year(s) following closure of the diversion route; and,

- To provide information that will assist in determining post-project effects, particularly with respect to the fish community in Lake St. Martin.

Study Area and Methods

Fish abundance in Lake St. Martin will be determined by gillnetting in the lake using experimental gill nets of standardized mesh sizes. Catch-per-unit-effort will be calculated and will be the metric by which change in fish abundance will be documented. The Province of Manitoba holds comparable data recently collected in Lake St. Martin which, although not published, can be accessed. If appropriate, these data will provide the baseline against which changes in fish abundance will be measured post-project. Sampling methods, including the same size and type of gill nets, used in the collection of the provincial data will be replicated in post-project studies to maximize comparability between years.

It should be noted that if the Provincial data set is inappropriate (i.e., insufficient fishing effort, inappropriate net types, etc.), experimental gillnetting should be conducted in fall 2011 to provide the appropriate baseline. If a change in fish abundance is detected immediately post-project, longer term monitoring (more than one year) may be required. Thus, it is important that the baseline data set be as strong as possible.

5.2.2.7 Mercury Concentration in Fish Tissue

The data collection presented here is intended to provide a baseline against which potential changes in tissue methylmercury concentration of fish residing in Sturgeon Bay and Lake St. Martin may be monitored following operation of the diversion route. It is proposed that up to 50 individuals of each of Walleye, Northern Pike, and Lake Whitefish be purchased from the fall or winter commercial fishery operating in Lake St. Martin and Sturgeon Bay. Fish would be bought whole and transported to the laboratory in Winnipeg for sampling and analysis.

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TABLES AND FIGURES

Table 1. Locations and descriptions of MWS water quality monitoring on Lake Manitoba, the Fairford and Dauphin rivers, and Sturgeon Bay.

Site ID	Location	Years Monitored	Comments
MB05LMS001	Fairford River at PTH #6, West of Fairford	1978-84; 1994-present	Routine, Metals, Pesticides
MB05LMS002	Dauphin River upstream of Anama Bay near discharge monitor site	1978-84	Routine and some metals
MB05LMS003	Dauphin River midway between Anama Bay and Gypsumville	1985-88; 2004-present	Routine, Metals, Pesticides
MB05SES012	Lake Winnipeg at Site 65 - mouth of Sturgeon Bay	2008-2010	Routine
MB05LKS006	Lake Manitoba at near Reed Island	1973-78; 1994; 2005	Routine and some metals
MB05LKS007	Lake Manitoba at north of Point Asham	1973-77; 1994; 2005-07	Routine and some metals
MB05LKS008	Lake Manitoba at east of Twin Island	1973-77	Routine and some metals
MB05LKS009	Lake Manitoba Narrows at PTH 68	2004-present	Routine, Metals, Pesticides
MB05LKS012	Lake Manitoba at Watchorn	2005-2007	Routine
MB05LKS013	Lake Manitoba at Margaret Bruce	2005-2007	Routine
MB05LKS014	Lake Manitoba at Manipogo	2005-2007	Routine
MB05LKS015	Lake Manitoba At Spence	2005-2007	Routine
MB05LKS016	Lake Manitoba At Davis Bay	2005-2006	Routine
MB05LLS013	Lake Manitoba near Delta Field Station	1991-present	Routine and some metals
MB05LLS018	Lake Manitoba ~4 Km north of mouth of Whitemud River	1994	Routine and some metals
MB05LLS045	Lake Manitoba St. Ambroise Beach	1997-2010	Bacteria
MB05LLS046	Lake Manitoba Delta Beach, Lake Manitoba	1997-present	Bacteria
MB05LLS047	Lake Manitoba Lynch's Point Beach, Lake Manitoba	1997-2010	Bacteria and routine (2005-07)
MB05LLS050	Lake Manitoba at south end of lake near Delta	1973-77; 2004	Routine and some metals (1973-77); bacteria (2004)
MB05LLS053	Lake Manitoba at near Sandy Bay	1973-77; 1994; 2005-07	Routine
MB05LLS065	Lake Manitoba at Langruth Beach	2001; 2003	Bacteria
MB05LNS001	Lake Manitoba at offshore from Twin Lakes Beach	1980-83; 1994; 2005	Chlorophyll a and Secchi disk depth
MB05LNS002	Lake Manitoba middle of south basin	2005	Routine
MB05LNS003	Lake Manitoba Laurentia Beach Boat Launch Area, Lake Manitoba	1998	Routine (1 sample)
MB05LNS008	Lake Manitoba at east of Ducharme Island	1973-77; 1994; 2005	Routine and some metals
MB05LNS009	Lake Manitoba at St. Laurent Beach	2002	Bacteria
MB05LNS010	Lake Manitoba at Steep Rock	2002; 2005-06	Bacteria and limited routine
MB05LNS011	Lake Manitoba close to Lundar	2005-07	Routine
MB05LNS012	Lake Manitoba at Elm Point	2005-06	Routine
MB05LNS014	Lake Manitoba at Oak Point	2006-07	Routine
MB05LNS015	Lake Manitoba at Twin Beaches public beach	2009-10	Bacteria

Table 2. List of fish species that occur in the study area. Y = present, I = introduced, S = present in south basin, N = present in north basin. Based on distributions presented in Stewart and Watkinson (2008).

Common Name	Latin Name	Lake Manitoba	Fairford River	Pineimuta Lake	Lake St. Martin	Dauphin River	Sturgeon Bay	Lake Winnipeg
Bigmouth buffalo	*Ictiobus cyprinellus*	S						S
Black bullhead	*Ameiurus melas*	Y	Y	Y	Y	Y	Y	Y
Black crappie	*Pomoxis nigromaculatus*							Y
Blacknose shiner	*Notropis heterolepis*	N	Y	Y	Y	Y	Y	Y
Blackside darter	*Percina maculata*							Y
Brook stickleback	*Culaea inconstans*	Y	Y	Y	Y	Y	Y	Y
Brown bullhead	*Ameiurus nebulosus*	S				Y	Y	Y
Burbot	*Lota lota*	Y	Y	Y	Y	Y	Y	Y
Common carp	*Cyprinus carpio*	I						I
Central mudminnow	*Umbra limi*	Y	Y	Y	Y	Y	Y	Y
Channel catfish	*Ictalurus punctatus*	S				Y	Y	Y
Chestnut lamprey	*Ichthyomyzon castaneus*							S
Cisco	*Coregonus artedi*	Y	Y	Y	Y	Y	Y	Y
Creek chub	*Semotilus atromaculatus*	Y						
Emerald shiner	*Notropis atherinoides*	Y	Y	Y	Y	Y	Y	Y
Fathead minnow	*Pimephales promelas*	Y	Y	Y	Y	Y	Y	Y
Finescale dace	*Phoxinus neogaeus*	Y	Y	Y	Y	Y	Y	Y
Flathead chub	*Platygobio gracilis*						Y	Y
Freshwater drum	*Aplodinotus grunniens*	Y	Y	Y	Y	Y	Y	Y
Golden redhorse	*Moxostoma erythrurum*							S
Golden shiner	*Notomigonus crysoleucas*	Y	Y	Y	Y	Y	Y	Y
Goldeye	*Hiodon alosoides*	Y	Y	Y	Y	Y	Y	Y
Iowa darter	*Etheostoma exile*	Y	Y	Y	Y	Y	Y	Y
Johnny darter	*Etheostoma nigrum*	Y	Y	Y	Y	Y	Y	Y
Lake chub	*Couesius plumbeus*						Y	Y
Lake sturgeon	*Acipenser fulvescens*				Y	Y	Y	Y

Table 2. (continued).

Common Name	Latin Name	Lake Manitoba	Fairford River	Pineimuta Lake	Lake St. Martin	Dauphin River	Sturgeon Bay	Lake Winnipeg
Lake trout	*Salvelinus namaycush*					Y	Y	N
Lake whitefish	*Coregonus clupeaformis*	Y	Y	Y	Y	Y	Y	Y
Logperch	*Percina caprodes*	Y	Y	Y	Y	Y	Y	Y
Longnose dace	*Rhinichthys cataractae*	Y	Y	Y	Y	Y	Y	Y
Longnose sucker	*Catostomus catostomus*						Y	Y
Mimic shiner	*Notropus volucellus*						Y	Y
Mooneye	*Hiodon tergisus*	S					Y	Y
Mottled sculpin	*Cottus bairdii*	Y	Y	Y	Y	Y	Y	Y
Muskellunge	*Esox masquinongy*	I						I
Ninespine stickleback	*Pungitius pungitius*	Y	Y	Y	Y	Y	Y	Y
Northern pike	*Esox lucius*	Y	Y	Y	Y	Y	Y	Y
Northern redbelly dace	*Phoxinus eos*	Y	Y	Y	Y			S
Pearl dace	*Margariscus margarita*	Y	Y	Y	Y	Y	Y	Y
Quillback	*Carpiodes cyprinus*	Y	Y	Y	Y	Y	Y	Y
Rainbow smelt	*Osmerus mordax*						I	I
Rainbow trout	*Oncorhynchus mykiss*				I		I	I
River darter	*Percina shumardi*	Y	Y	Y	Y	Y	Y	Y
River shiner	*Notropus blennius*					Y	Y	Y
Rock bass	*Ambloplites rupestris*	Y	Y	Y	Y	Y	Y	Y
Sand shiner	*Notropis stramineus*	S						
Sauger	*Sander canadensis*	Y	Y	Y	Y	Y	Y	Y
Shorthead redhorse	*Moxostoma macrolepidotum*	Y	Y	Y	Y	Y	Y	Y
Shortjaw cisco	*Coregonus zenithicus*						Y	Y
Slimy sculpin	*Cottus cognatus*						Y	Y
Silver chub	*Macrhybopsis storeriana*							S
Sliver lamprey	*Ichthyomyzon unicuspis*					Y	Y	Y
Sliver redhorse	*Moxostoma anisurum*	Y	Y	Y	Y	Y	Y	Y

Table 2. (continued).

Common Name	Latin Name	Lake Manitoba	Fairford River	Pineimuta Lake	Lake St. Martin	Dauphin River	Sturgeon Bay	Lake Winnipeg
Spoonhead sculpin	*Cottus ricei*						Y	Y
Spotfin shiner	*Cyprinella spiloptera*							S
Spottail shiner	*Notropis hudsonius*	Y	Y	Y	Y	Y	Y	Y
Stonecat	*Noturus flavus*							S
Tadpole madtom	*Noturus gyrinus*	S						Y
Trout-perch	*Percopsis omiscomaycus*	Y	Y	Y	Y	Y	Y	Y
Walleye	*Sander vitreus*	Y	Y	Y	Y	Y	Y	Y
Weed shiner	*Notropis texanus*							Y
Western blacknose dace	*Rhinichthys obtusus*						Y	Y
White bass	*Morone chrysops*							I
White sucker	*Catostomus commersonii*	Y	Y	Y	Y	Y	Y	Y
Yellow perch	*Perca flavescens*	Y	Y	Y	Y	Y	Y	Y

Table 3. Commercial fishery production in Lake Manitoba from 2001/2002 to 2010/2011 [1].

Year	Species-Specific Production (kg)								Total Production (kg)	Initial $	# of Fishers [2]
	Lake Whitefish	Walleye	Sauger	Northern Pike	Yellow Perch	Cisco	Carp	Other			
2010/2011	6,093	97,708	5,623	87,645	142,261	45,446	751	1,015	386,543	$747,100	185
2009/2010	7,307	244,041	4,484	83,529	106,743	314,666	10,418	1,512	772,701	$1,285,133	227
2008/2009	10,626	285,332	2,510	91,586	81,758	298,246	103,932	13,750	887,740	$1,473,616	228
2007/2008	3,729	101,232	1,256	90,798	241,052	394,029	66,294	8,018	906,408	$1,261,737	235
2006/2007	4,183	199,557	2,931	141,539	181,926	288,044	251,762	22,876	1,092,819	$1,514,939	263
2005/2006	3,972	145,935	7,904	66,604	133,055	428,848	165,098	18,333	969,751	$1,134,365	284
2004/2005	4,794	150,616	4,551	40,104	110,658	344,450	289,125	27,995	972,292	$1,052,858	306
2003/2004	6,576	359,191	21,920	125,439	136,088	911,470	163,101	30,756	1,754,542	$1,964,844	367
2002/2003	5,717	244,054	21,022	154,651	304,125	1,258,523	363,476	59,520	2,411,086	$2,639,051	384
2001/2002	10,728	261,533	14,685	66,951	444,277	1,097,378	97,021	11,212	2,003,785	$2,989,543	413

1 - data provided by the Freshwater Fish Marketing Corporation

2 - # of fishers represents the number of fishers who delivered fish to Freshwater Fish Marketing Corporation

Table 4. Commercial fishery production on Lake St. Martin from 2001/2002 to 2010/2011 [1].

Year	Species-Specific Production (kg)								Total Production (kg)	Initial $	# of Fishers [2]
	Lake Whitefish	Walleye	Sauger	Northern Pike	Yellow Perch	Cisco	Carp	Other			
2010/2011	53,242	2,973	7	27,122	20	4,967	1,784	1,264	91,379	$99,307	29
2009/2010	21,004	3,741	36	28,559	20	11,885	5,760	1,594	72,598	$71,514	42
2008/2009	21,665	4,167	5	49,004	13	32,770	19,619	4,099	131,342	$120,097	36
2007/2008	15,824	884	2	25,210	2	16,353	21,761	3,627	83,663	$60,209	28
2006/2007	73,649	1,413	8	30,429	11	37,777	27,427	3,548	174,260	$128,512	47
2005/2006	69,109	2,836	4	26,567	3	16,213	42,451	5,745	162,928	$110,139	37
2004/2005	77,334	1,985	10	24,225	24	12,737	8,524	2,754	127,594	$84,657	43
2003/2004	88,644	3,018	20	39,874	106	37,178	9,237	6,802	184,880	$135,897	60
2002/2003	92,935	3,114	94	46,478	161	50,835	30,487	7,401	231,505	$179,213	49
2001/2002	33,256	4,331	328	49,484	247	65,332	49,839	4,752	207,569	$137,276	60

1 - data provided by the Freshwater Fish Marketing Corporation

2 - # of fishers represents the number of fishers who delivered fish to Freshwater Fish Marketing Corporation

Table 5. Commercial fishery production in the Dauphin River area from 2001/2002 to 2010/2011 [1].

Year	Species-Specific Production (kg)								Total Production (kg)	Initial $ [2]	# of Fishers [3]
	Lake Whitefish	Walleye	Sauger	Northern Pike	Yellow Perch	Cisco	Carp	Other			
2010/2011	90,877	150,538	1,098	7,454	103	18,633	7	490	268,408	$540,213	48
2009/2010	100,720	126,630	1,124	19,228	421	37,132	270	909	286,432	$573,779	54
2008/2009	173,084	128,103	420	10,569	22	25,274	-	290	337,761	$749,815	47
2007/2008	114,667	154,696	330	3,707	17	8,492	-	-	281,910	$675,833	43
2006/2007	229,241	160,465	475	7,874	276	37,236	4	-	435,570	$868,568	62
2005/2006	194,555	105,113	985	6,651	294	24,291	-	-	331,889	$611,023	54
2004/2005	257,248	88,301	7,245	10,470	396	44,961	-	-	408,619	$690,918	56
2003/2004	291,532	101,980	888	9,005	148	55,545	18	372	459,488	$757,484	63
2002/2003	294,972	148,613	1,218	13,284	145	86,744	526	1,460	546,962	$983,775	81
2001/2002	150,642	118,535	47,580	15,512	2,344	74,433	230	1,555	410,832	$809,983	49

1 - data provided by the Freshwater Fish Marketing Corporation

2 - initial $ includes roe value

3 - # of fishers represents the number of fishers who delivered fish to Freshwater Fish Marketing Corporation

Table 6. Summary of existing information for each major waterbody and by aquatic ecosystem component.

Aquatic Ecosystem Component	**Lake Manitoba**	**Fairford River**	**Pineimuta Lake**	**Lake St. Martin**	**Big Buffalo Lake**	**Buffalo Creek**	**Dauphin River**	**Sturgeon Bay – Lake Winnipeg**
Water Quality	• Long-term monitoring data available (MWS); • Data have been collected by MWS at 28 sites; • List of variables and period of monitoring varies across sites; • Extensive list of variables currently monitored at the Narrows; • Other historical information is also available.	• Long-term monitoring data (MWS) at one site; • Parameters measured include routine variables, metals, bacteria, and pesticides.	• Limited historical information.	• Limited historical information.	• No information identified.	• No information identified.	• Long-term monitoring data (MWS) at one site; • Parameters measured include routine variables, metals, bacteria, and pesticides.	• One MWS water quality monitoring site in Sturgeon Bay sampled since 2008; • A limited number of parameters (e.g., nutrients, dissolved oxygen, TSS, pH) measured.
Aquatic Habitat	• Detailed water level and general depth data available.	• Some water level and habitat data are available.	• Some water level and shoreline and wetland habitat data are available.	• Limited substrate and wetland habitat data are available; • Some data on water level variation effects on aquatic vegetation are available; • Some data on lake whitefish spawning habitat are available.	• Limited depth, substrate and aquatic vegetation data are available.[1]	• Limited depth, substrate and wetland habitat data are available.[1]	• Limited depth, substrate, and aquatic vegetation data are available; • Limited data on fish spawning habitat are available.	• No information specific to Sturgeon Bay identified.
Fish Resources	• Fish community composition data available; • Some historical biological data are available for select species; • Fish movement data through the FWCS are available; • Commercial fisheries and angling statistics are available.	• Fish community composition data available; • Fish movement data through the FWCS are available.	• No information identified.	• Fish community composition data available; • Commercial fisheries and historic angling statistics are available.	• Fish community composition and biological data available.[1]	• Fish community composition and biological data available.[1]	• Fish community composition data available; • Historic fish movement data available; • Limited commercial fisheries and historic angling statistics are available • Limited data regarding winter stagnation and seasonal fish kills.	• Fish community composition data available; • Commercial and subsistence fisheries statistics are available.

Table 7. Proposed water quality sampling sites.

Waterbody	Site Description	Number of Sites			Parameters		
		Surface/ integrated	Bottom	Total	Routines and Metals	Chlorophyll *a*	Pesticides and *E. coli* (surface only)
Lake Manitoba	South Basin (MWS MB05LNS002)	1	1	2	All sites	surface only	1
	Narrows (MWS MB05LKS009)	1	1	2			-
	Portage Bay (near outlet)	1	1	2			-
Fairford River	MWS Site (MB05LMS001)	1	-	1			1
Lake St. Martin	South Basin	1	1	2			-
	North Basin	1	1	2			1
Pineimuta Lake	Offshore site	1	1	2			-
Dauphin River	Near Outflow	1	-	1			1
	MWS Site (MB05LMS003)	1	-	1			-
	Near Mouth	1	-	1			-
Buffalo Creek System	Big Buffalo Lake	1	1	2			-
	Downstream of Big Buffalo Lake	1	-	1			-
	Near the mouth	1	-	1			1
	Other site (as appropriate)	1	-	1			-
Sturgeon Bay	MWS site (MWS MB05SES012)	1	1	2			1
	5 other sites	5	5	10			1
QA/QC	Triplicate	2	-	2			-
	Field Blank	1	-	1			-
	Trip Blank	1	-	1			-
TOTAL		24	13	37			7

Table 8. Laboratory water quality variables (routine and metals) and *in situ* parameters.

Routine Variables	**Metals (total and dissolved)**
Alkalinity	Antimony (Sb)
Dissolved Organic Carbon	Arsenic (As)
Total Inorganic Carbon	Barium (Ba)
Total Organic Carbon	Beryllium (Be)
Chloride	Bismuth (Bi)
Colour, True	Boron (B)
Conductivity	Cadmium (Cd)
Hardness (Calculated from metals)	Calcium (Ca)
Fluoride	Cesium (Cs)
Total Kjeldahl Nitrogen	Chromium (Cr)
Ammonia by colour	Cobalt (Co)
Nitrate+Nitrite	Copper (Cu)
Nitrite as N	Iron (Fe)
Nitrate as N	Lead (Pb)
Phosphorus, Total	Lithium (Li)
Phosphorus, Total Dissolved	Magnesium (Mg)
Phosphorus Total Particulate (Calculated)	Manganese (Mn)
pH	Molybdenum (Mo)
Sulfate	Nickel (Ni)
Total Dissolved Solids	Potassium (K)
Total Suspended Solids	Rubidium (Rb)
Turbidity	Selenium (Se)
	Silicon (Si)
***In Situ* Variables**	Silver (Ag)
	Sodium (Na)
pH	Strontium (Sr)
Temperature	Tellurium (Te)
Dissolved oxygen	Thallium (Tl)
Turbidity	Thorium (Th)
Specific Conductance	Tin (Sn)
Secchi disk depth (lake sites)	Titanium (Ti)
	Tungsten (W)
	Uranium (U)
	Vanadium (V)
	Zinc (Zn)
	Zirconium (Zr)
	Mercury (Hg)
	Methylmercury

Table 9. List of pesticide parameters.

Parameter	
2,4,6-Tribromophenol	Eptam
2,4-D	Ethalfluralin
2,4-DB	Fenoxaprop
2,4-Dichlorophenylacetic Acid	g-chlordane
2,4-DP	Glyphosate
2-Fluorobiphenyl	Imazamethabenz-methyl
2-Fluorobiphenyl	Lindane
a-chlordane	Malathion
Alachlor	MCPA
alpha-BHC	Mecoprop
Atrazine	Methoxychlor
Atrazine Desethyl	Methyl Parathion
Azinphos-methyl	Metribuzin
Benomyl	Metsulfuron-methyl
beta-BHC	Parathion
Bromacil	Pentachlorophenol
Bromoxynil	Picloram
Carbofuran	Propachlor
Carboxin	Propanil
Chlorothalonil	Propoxur
Chlorpyrifos	Quizalofop
Cyanazine	Sethoxydim
d14-Terphenyl	Simazine
d14-Terphenyl	Terbufos
delta-BHC	Thifensulfuron-methyl
Deltamethrin	Tralkoxydim
Diazinon	Triallate
Dicamba	Tribenuron-methyl
Diclofop-methyl	Triclopyr
Dimethoate	Trifluralin
Dinoseb	Trifluralin
Diuron	

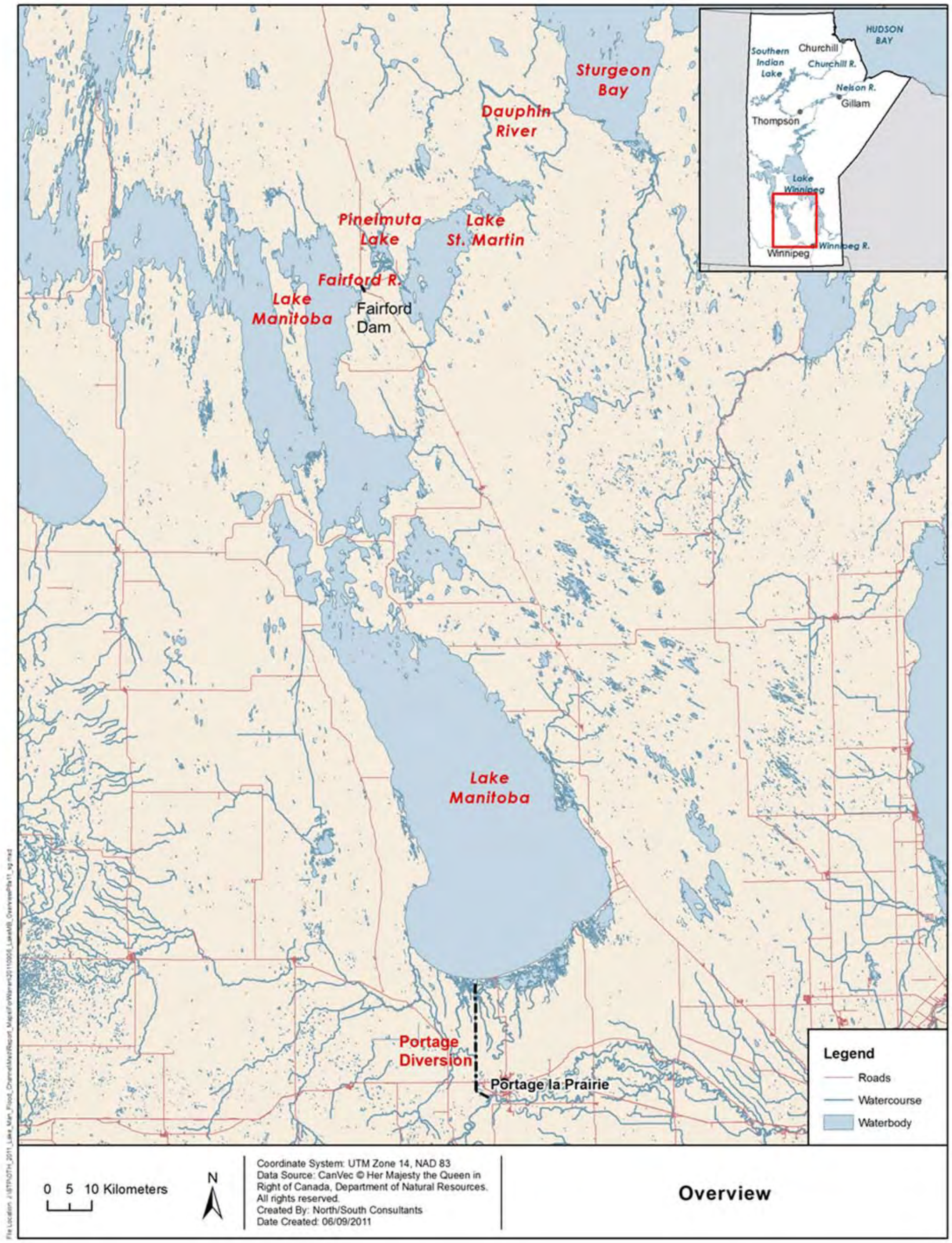

Figure 1. The study area.

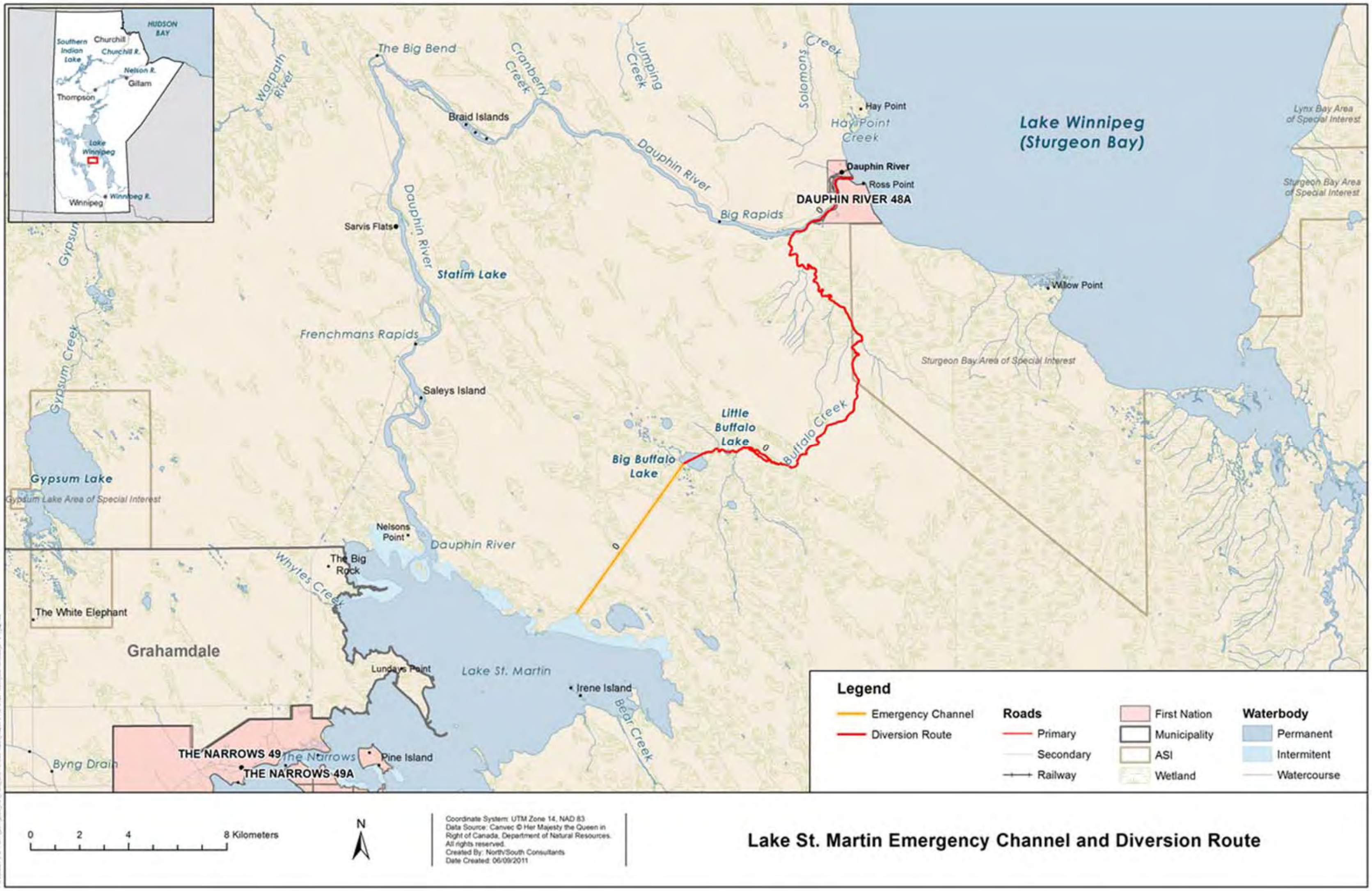

Figure 2. Location of the Lake St. Martin emergency channel and diversion route.

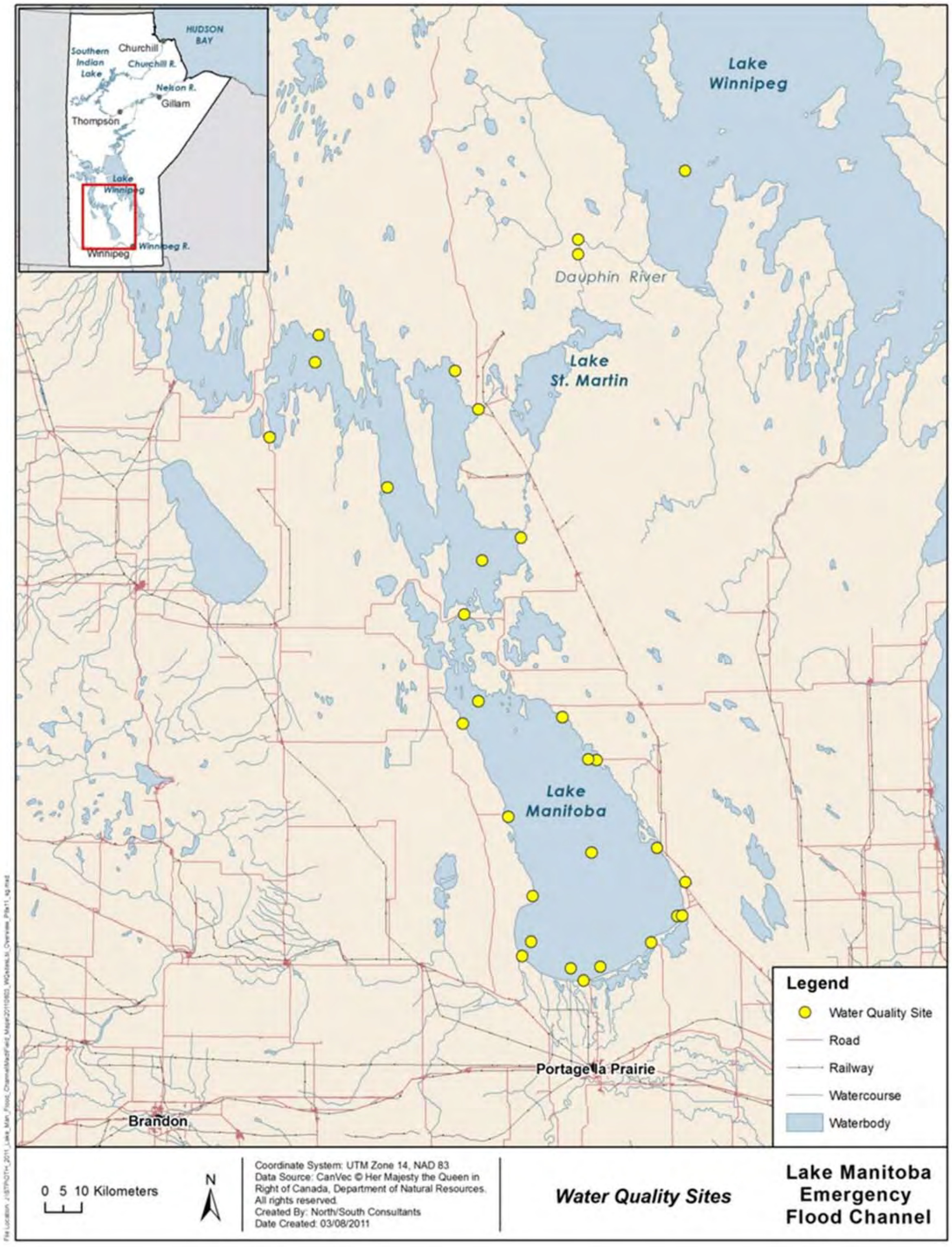

Figure 3. Locations of Manitoba Water Stewradship water quality monitoring sites in the study area.

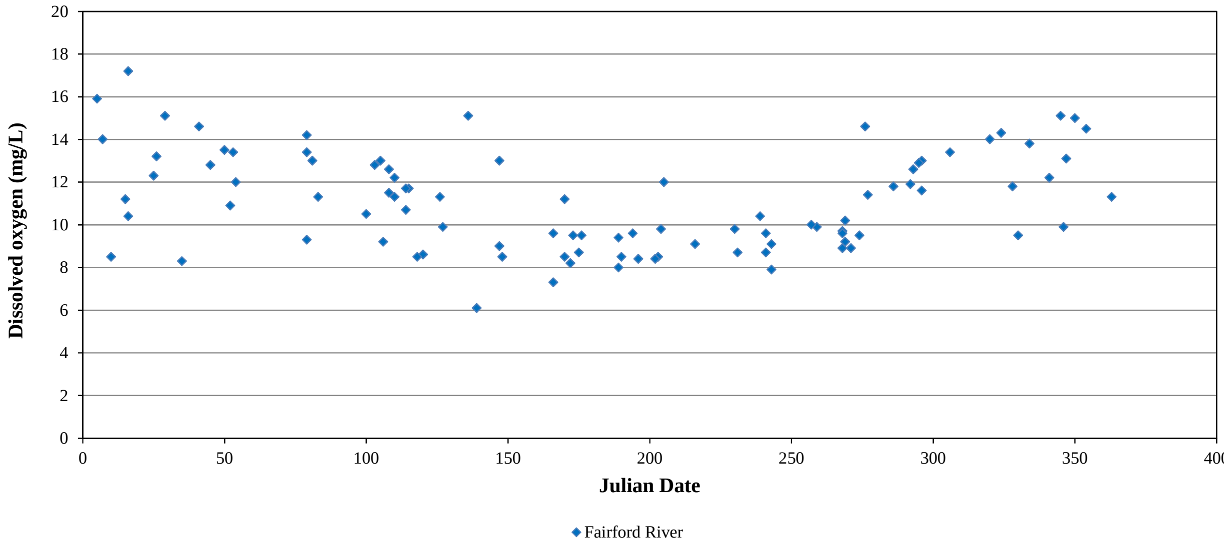

Figure 4. Dissolved oxygen in the Fairford River by Julian date.

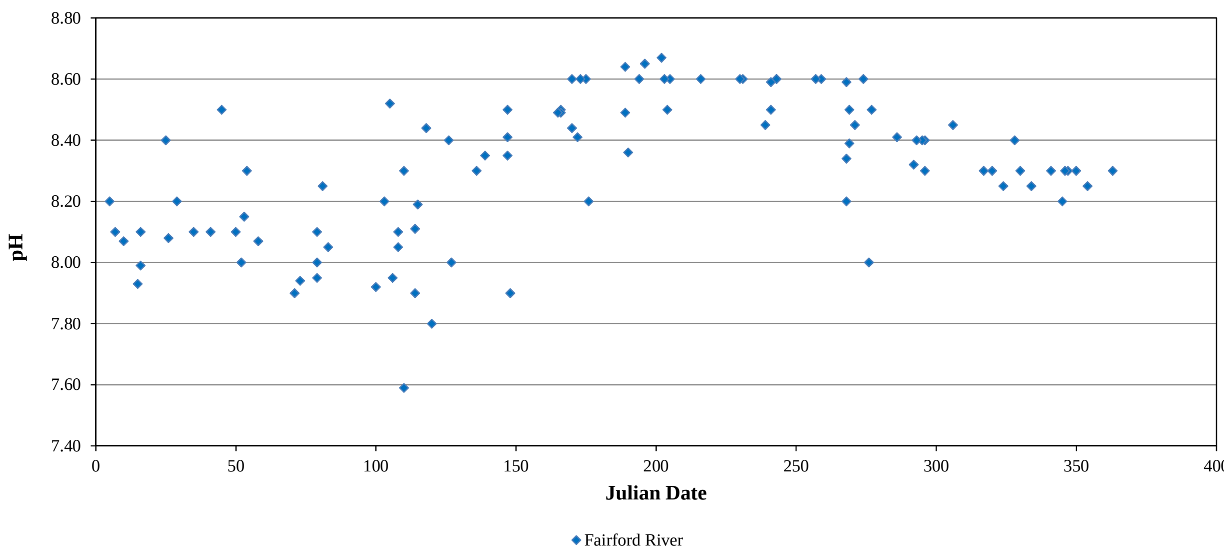

Figure 5. pH in the Fairford River by Julian date.

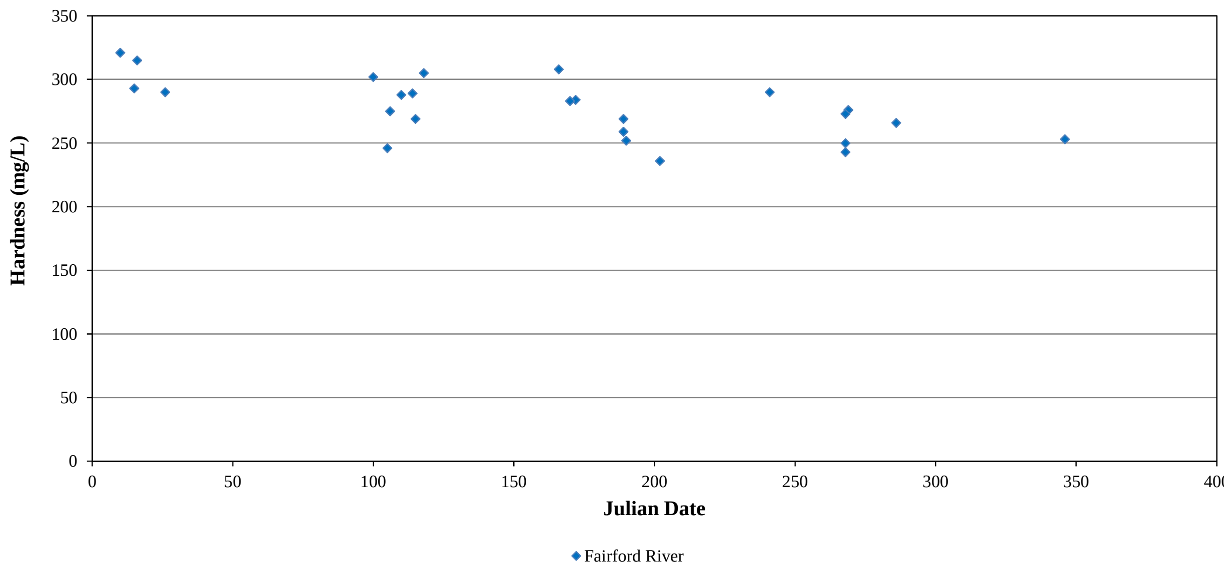

Figure 6. Hardness in the Fairford River by Julian date.

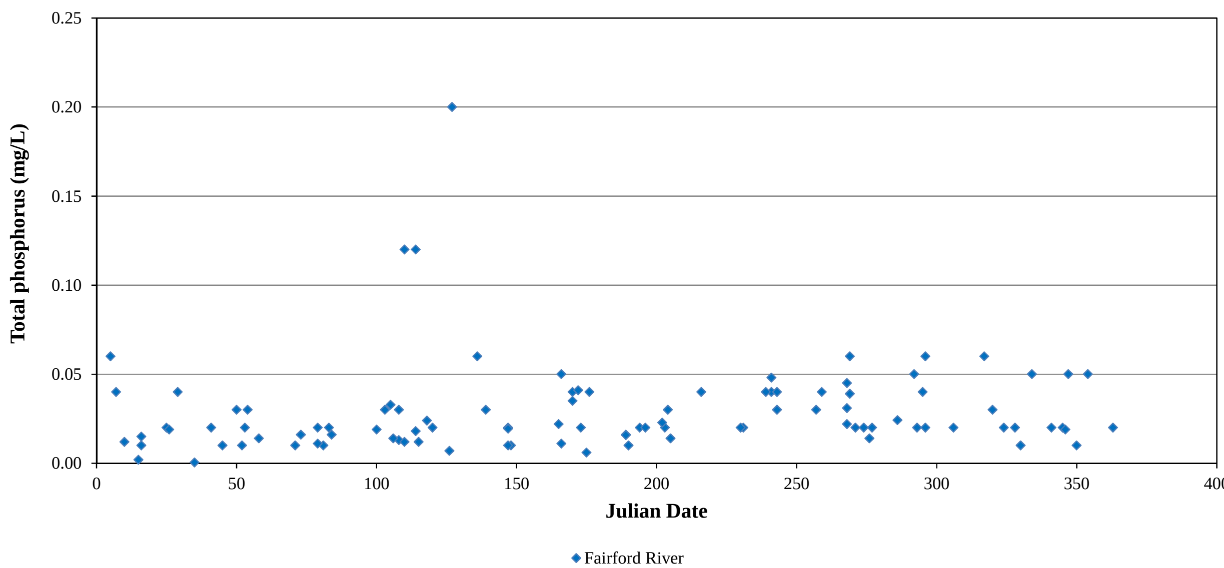

Figure 7. Total phosphorus in the Fairford River by Julian date.

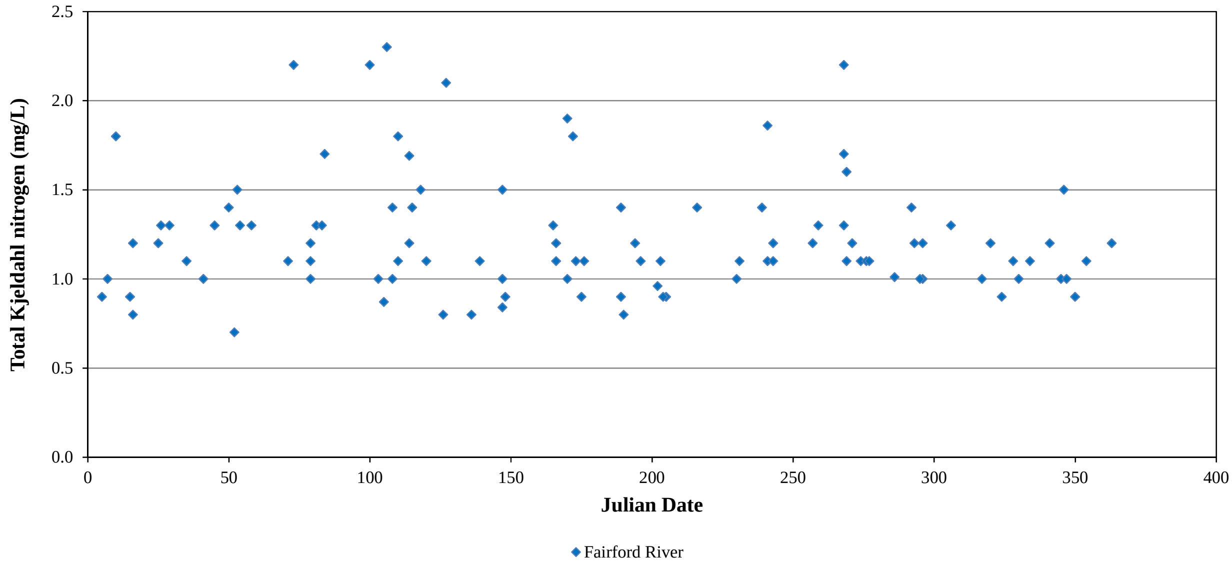

Figure 8. Total Kjeldahl nitrogen in the Fairford River by Julian date.

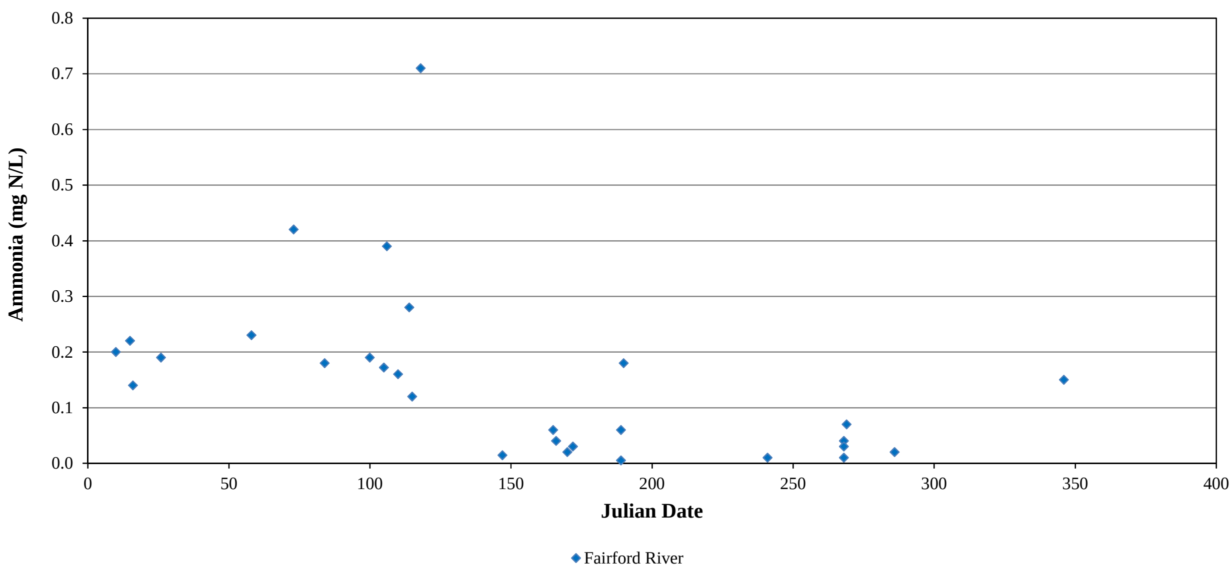

Figure 9. Ammonia in the Fairford River by Julian date.

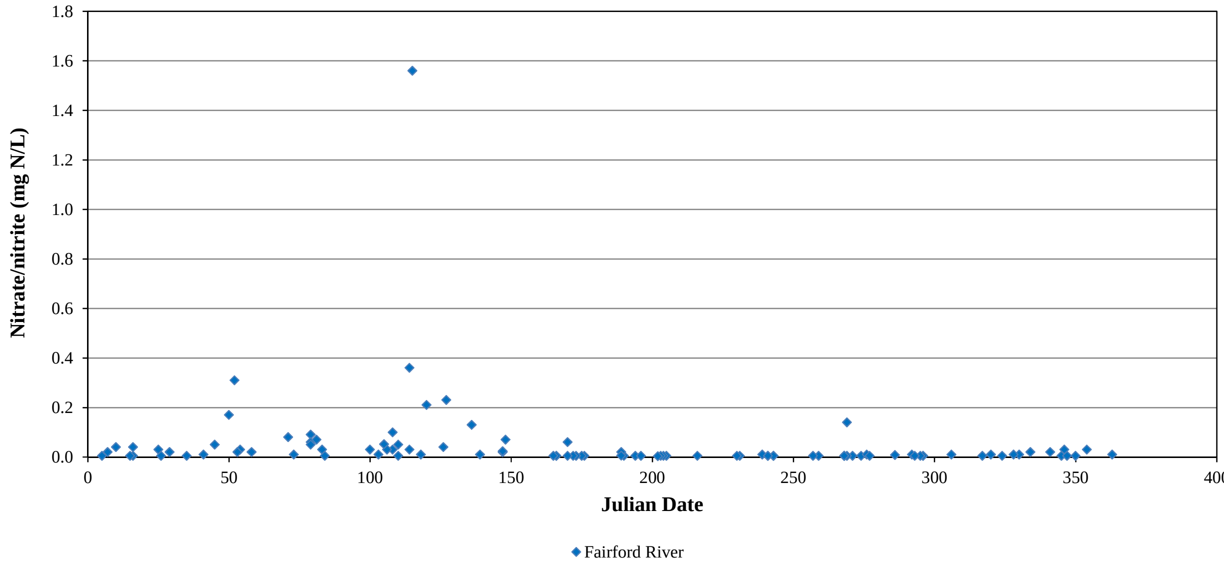

Figure 10. Nitrate/nitrite in the Fairford River by Julian date.

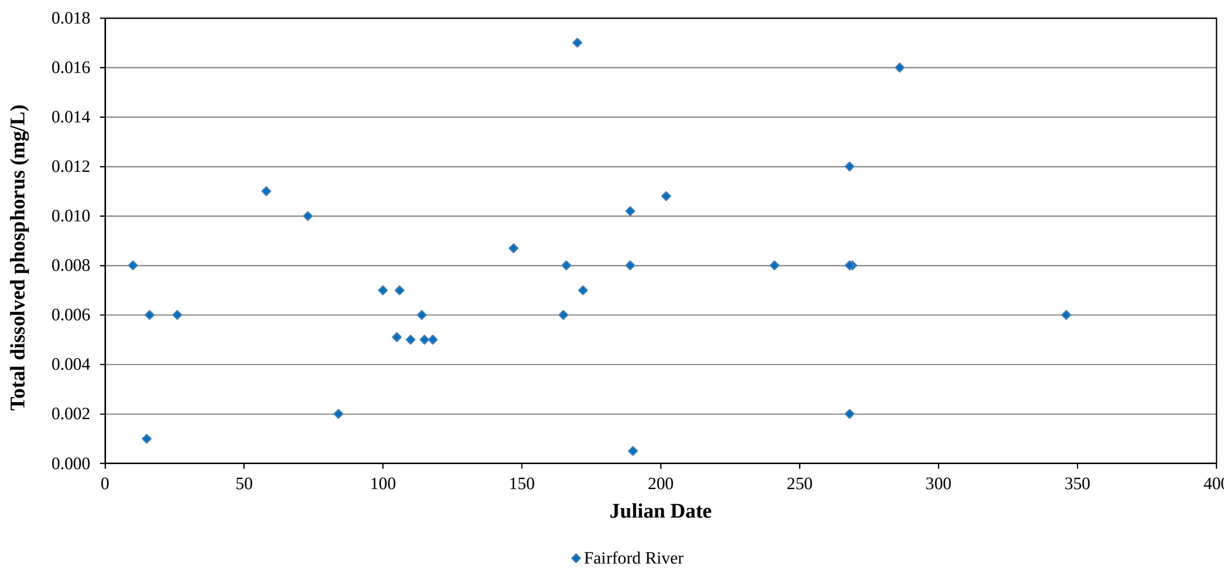

Figure 11. Total dissolved phosphorus in the Fairford River by Julian date.

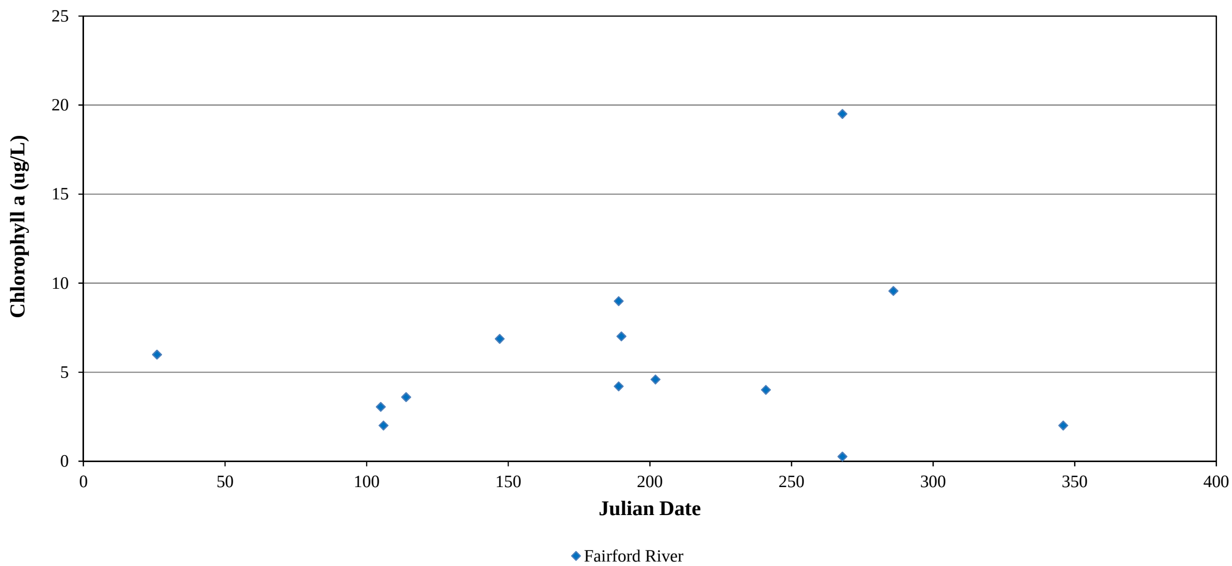

Figure 12. Chlorophyll *a* in the Fairford River by Julian date.

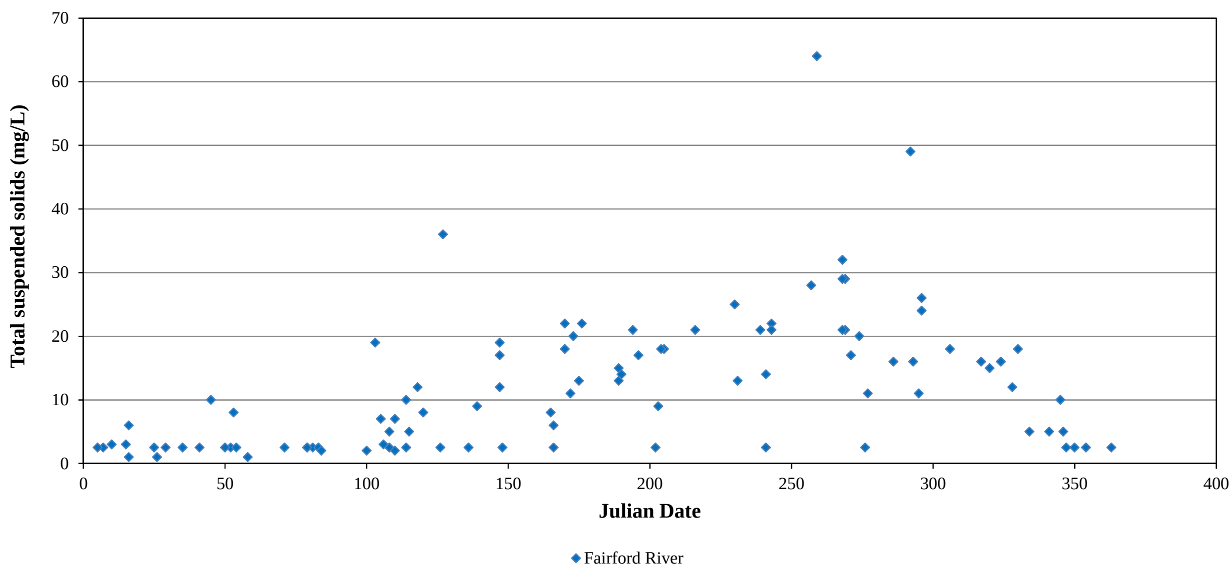

Figure 13. Total suspended solids in the Fairford River by Julian date.

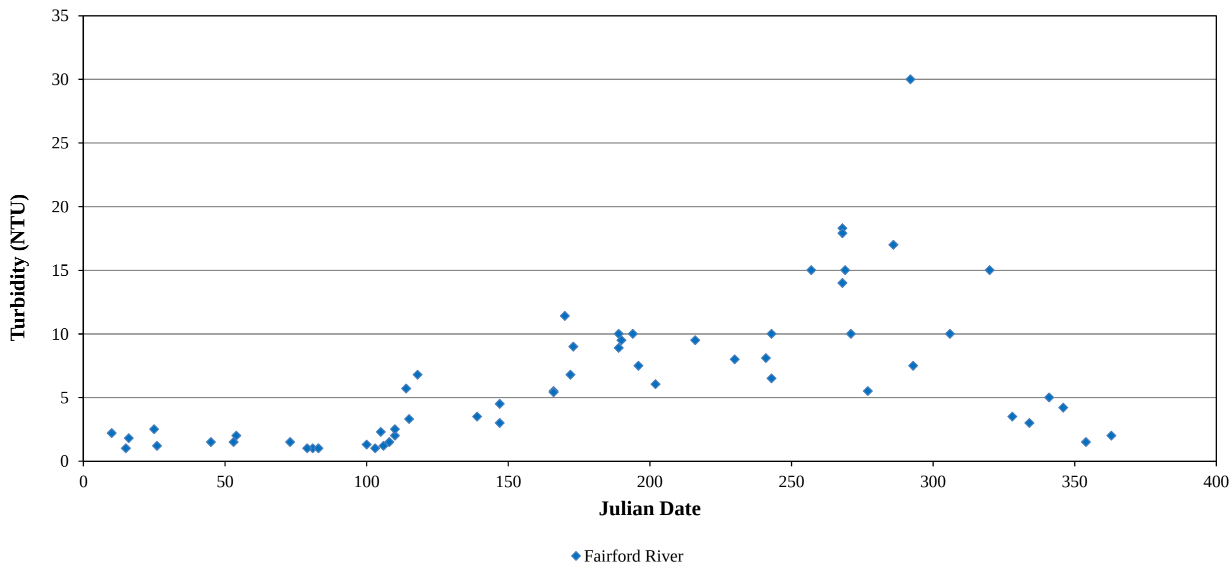

Figure 14. Turbidity in the Fairford River by Julian date.

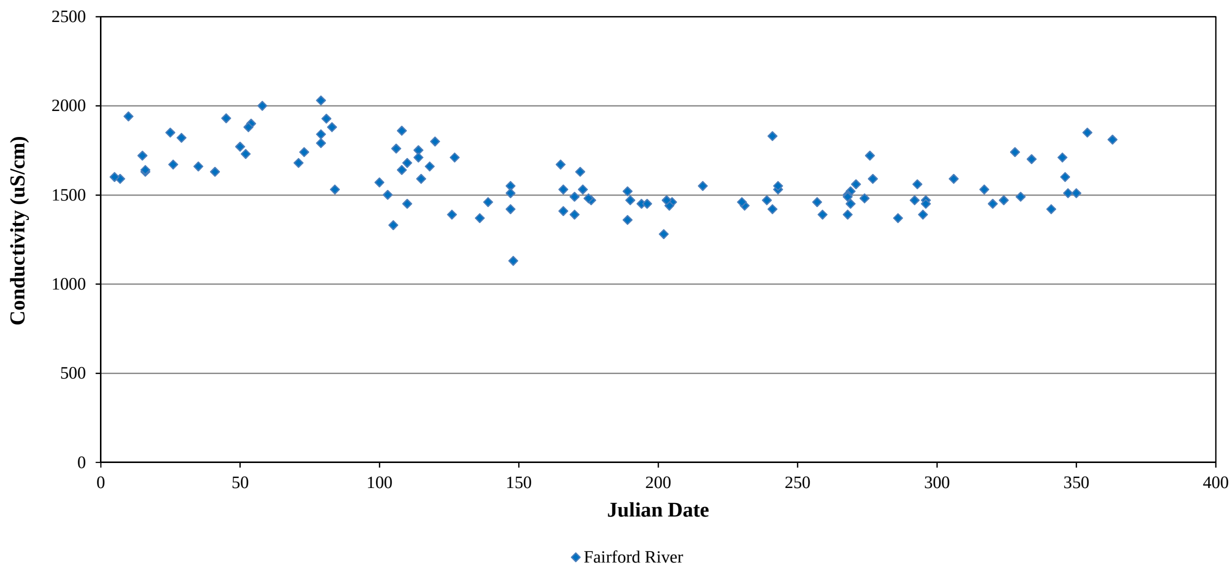

Figure 15. Conductivity in the Fairford River by Julian date.

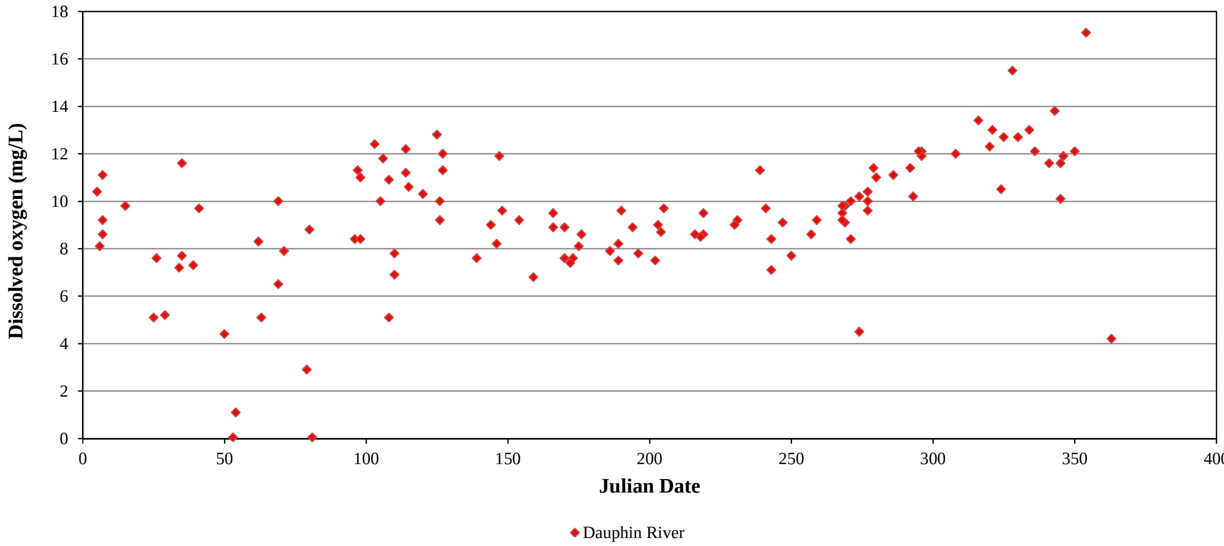

Figure 16. Dissolved oxygen in the Dauphin River by Julian date.

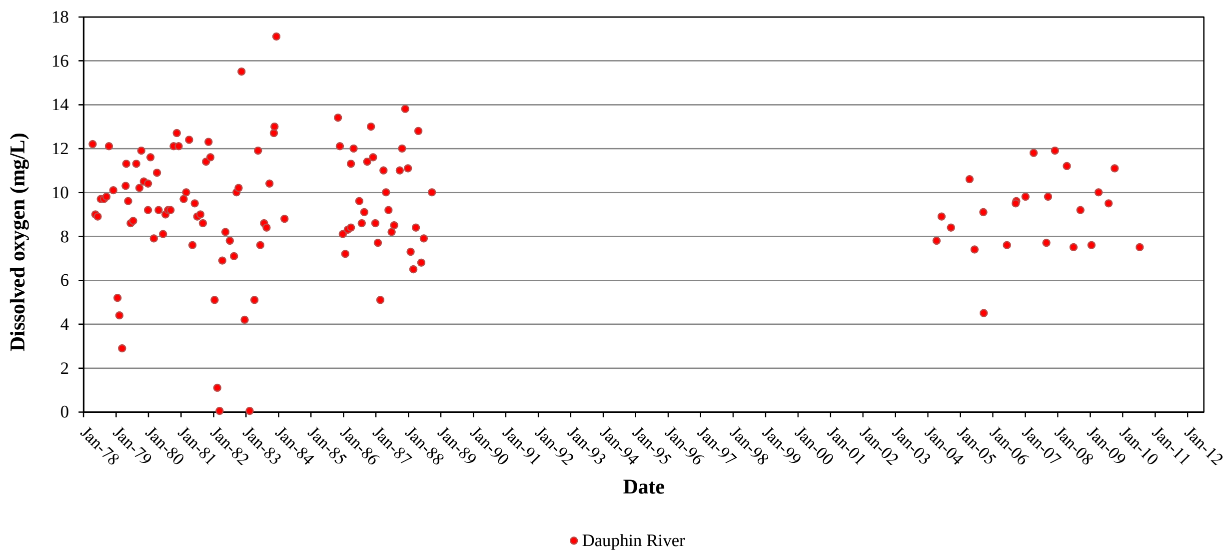

Figure 17. Dissolved oxygen in the Dauphin River by date.

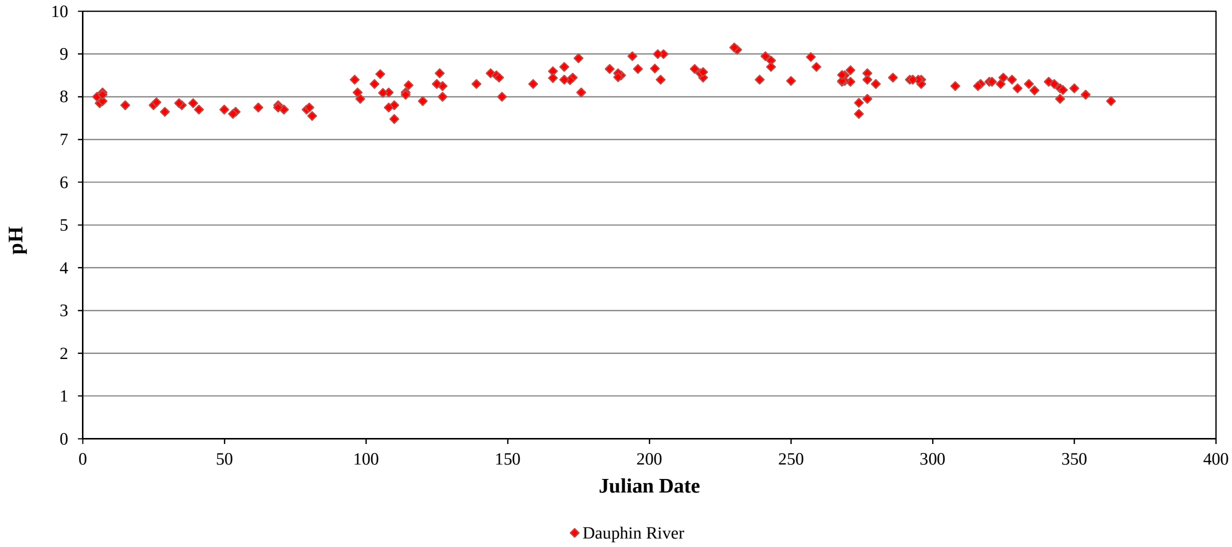

Figure 18. pH in the Dauphin River by Julian date.

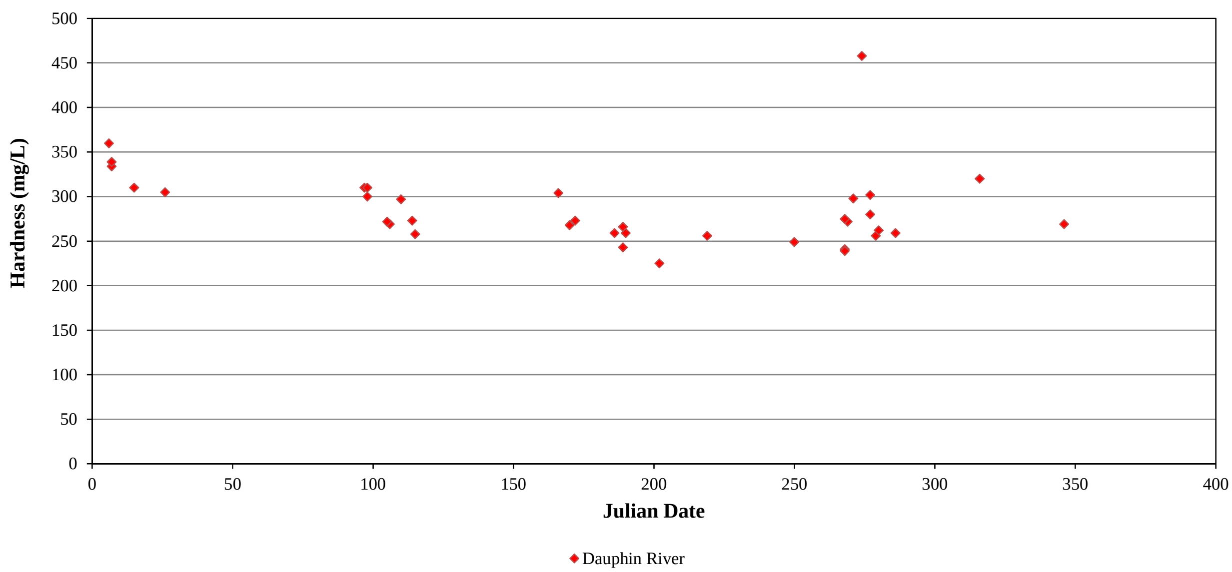

Figure 19. Hardness in the Dauphin River by Julian date.

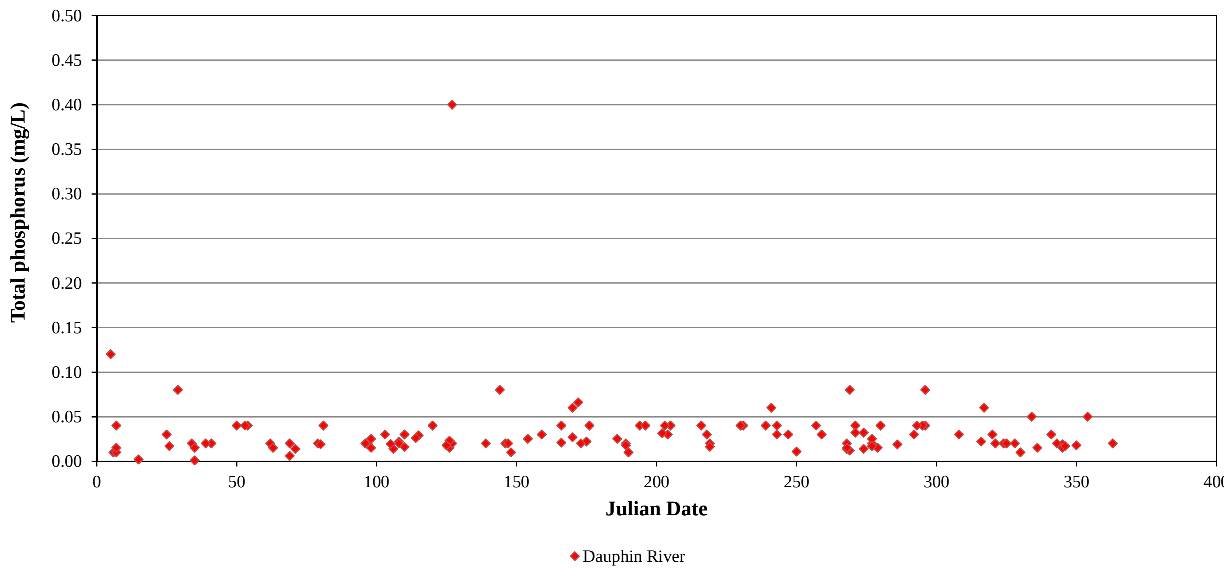

Figure 20. Total phosphorus in the Dauphin River by Julian date. One outlier removed.

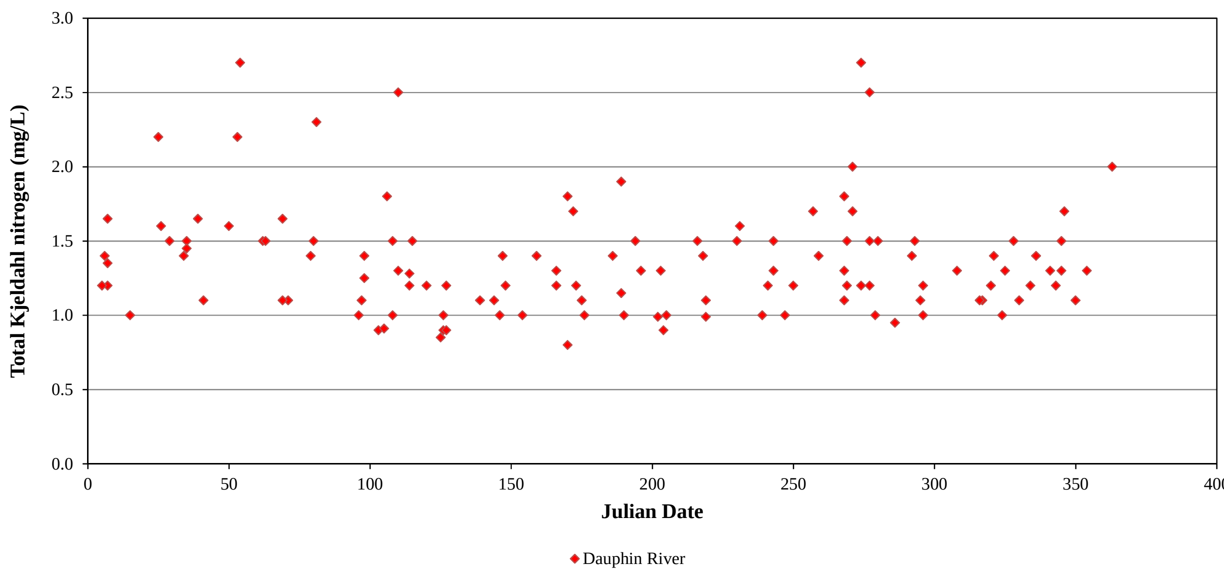

Figure 21. Total Kjeldahl nitrogen in the Dauphin River by Julian date.

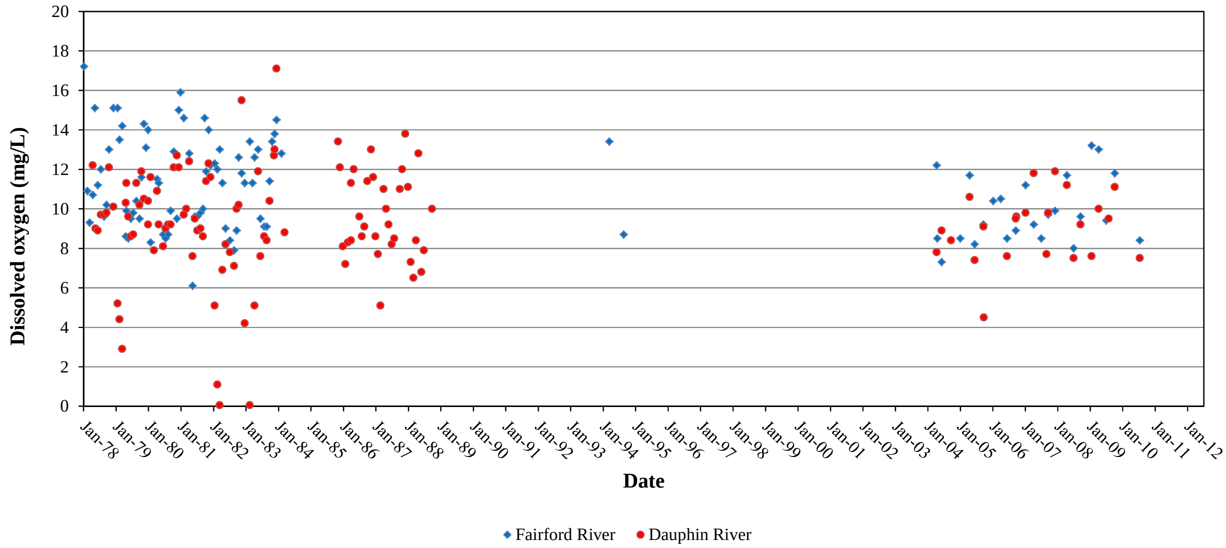

Figure 22. Comparison of dissolved oxygen (DO) in the Fairford and Dauphin rivers over the period of record. No DO data are available for Sturgeon Bay.

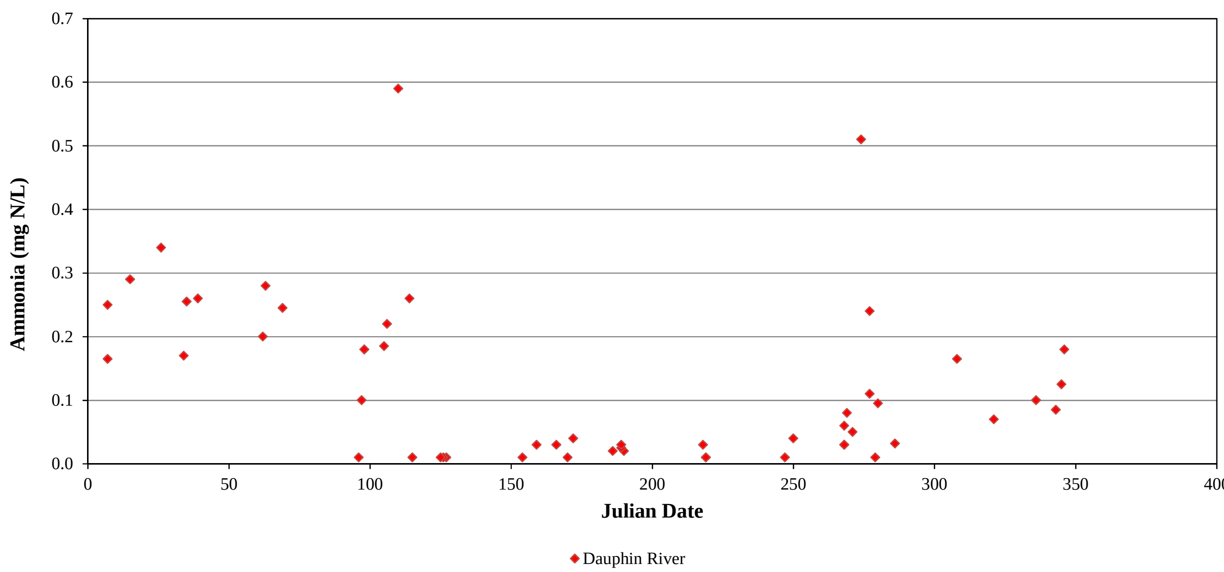

Figure 23. Ammonia in the Dauphin River by Julian date.

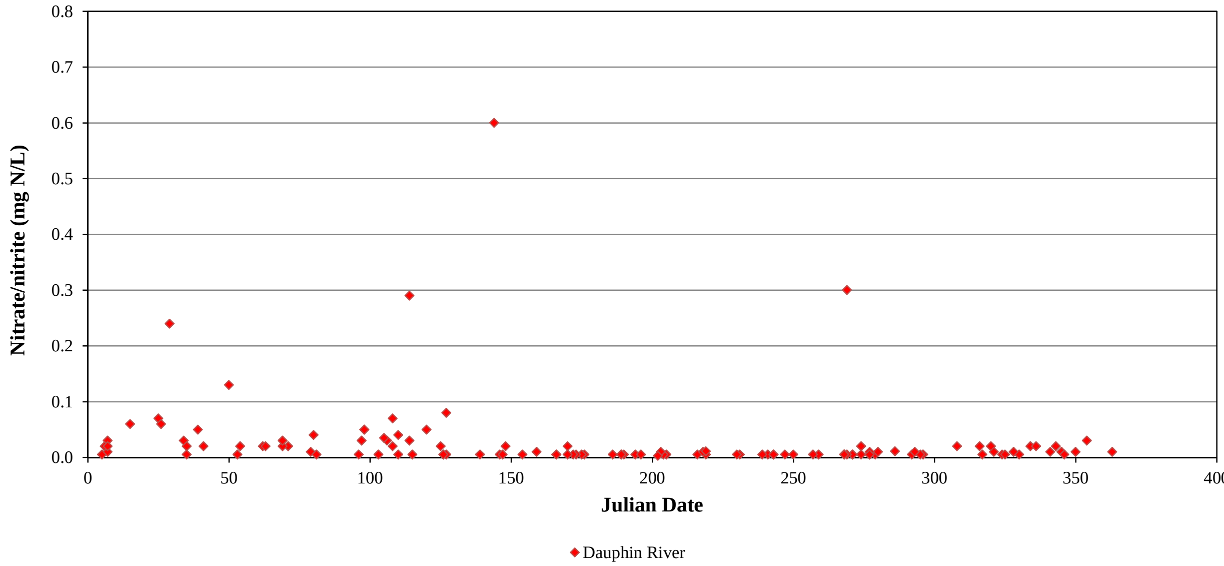

Figure 24. Nitrate/nitrite in the Dauphin River by Julian date.

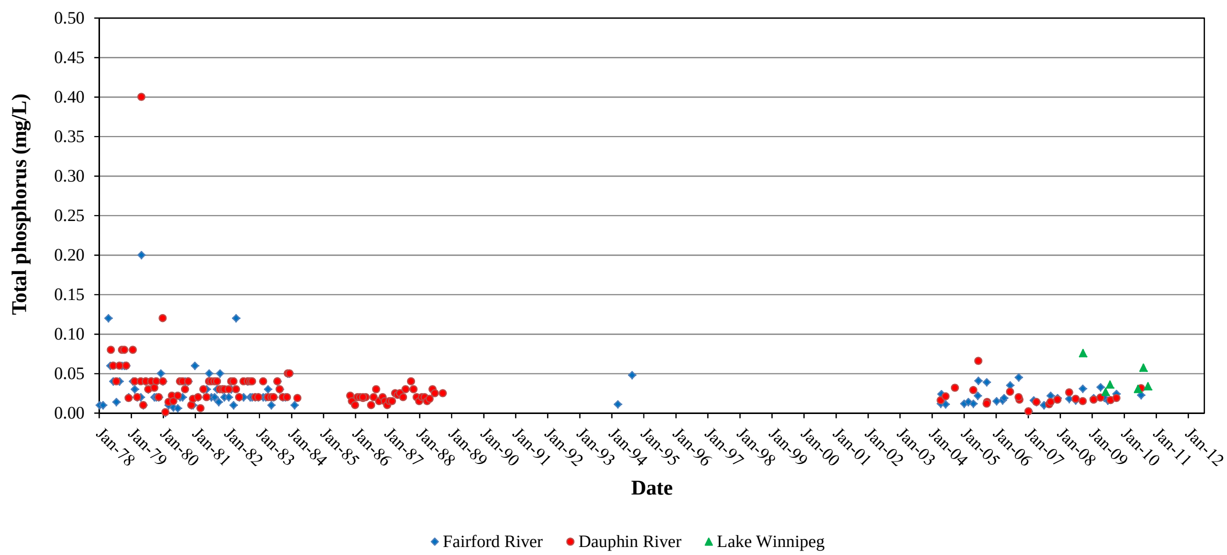

Figure 25. Comparison of total phosphorus in the Fairford and Dauphin rivers and Sturgeon Bay over the period of record.

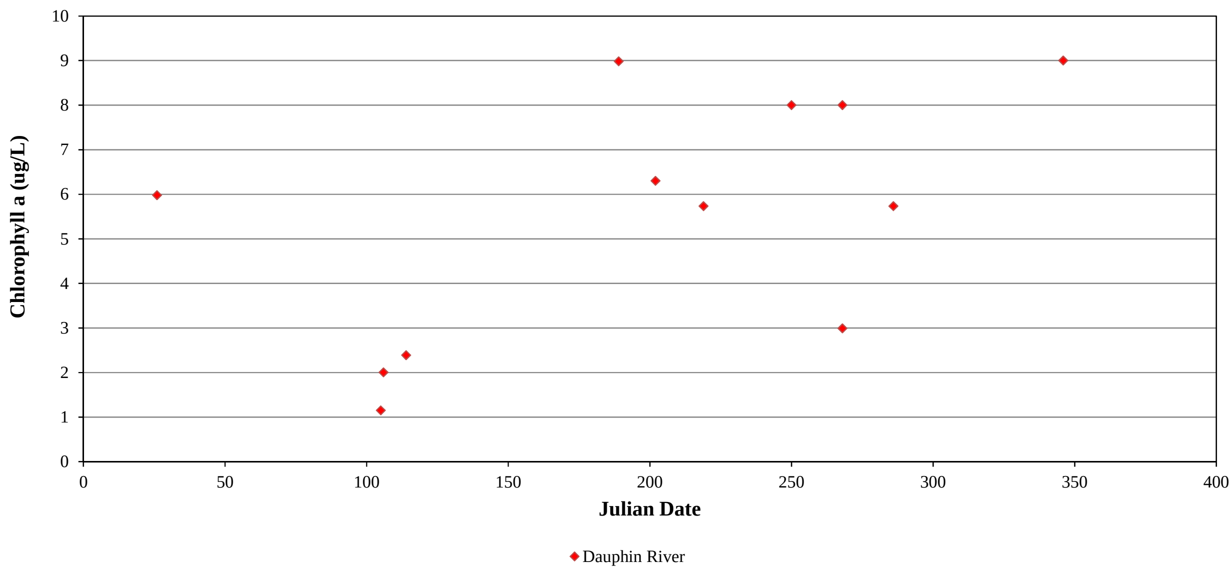

Figure 26. Chlorophyll *a* in the Dauphin River by Julian date.

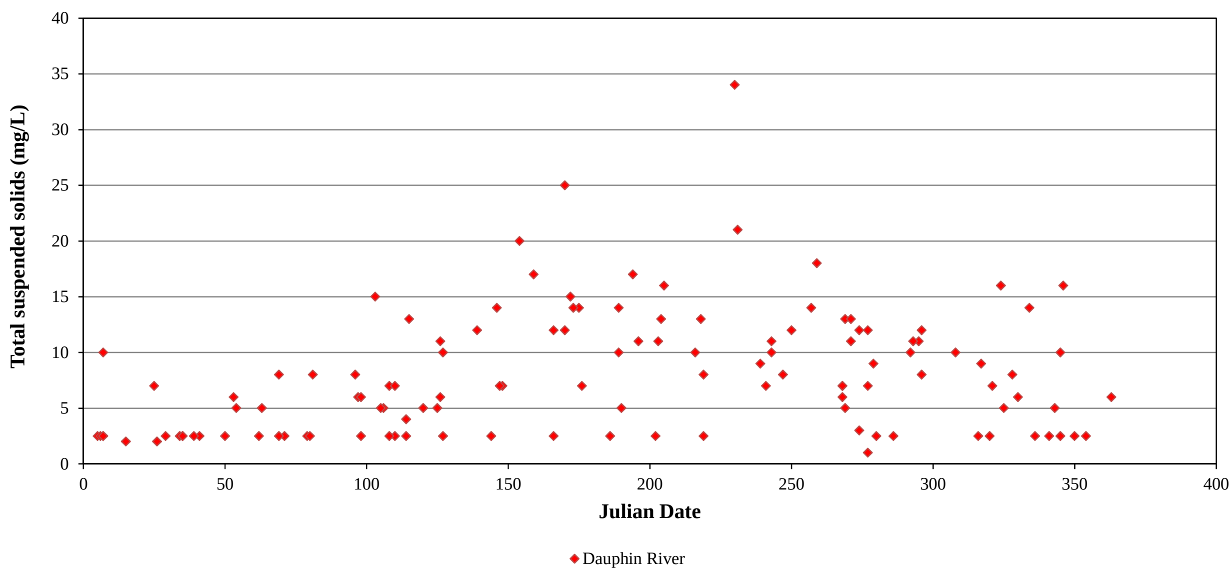

Figure 27. Total suspended solids in the Dauphin River by Julian date.

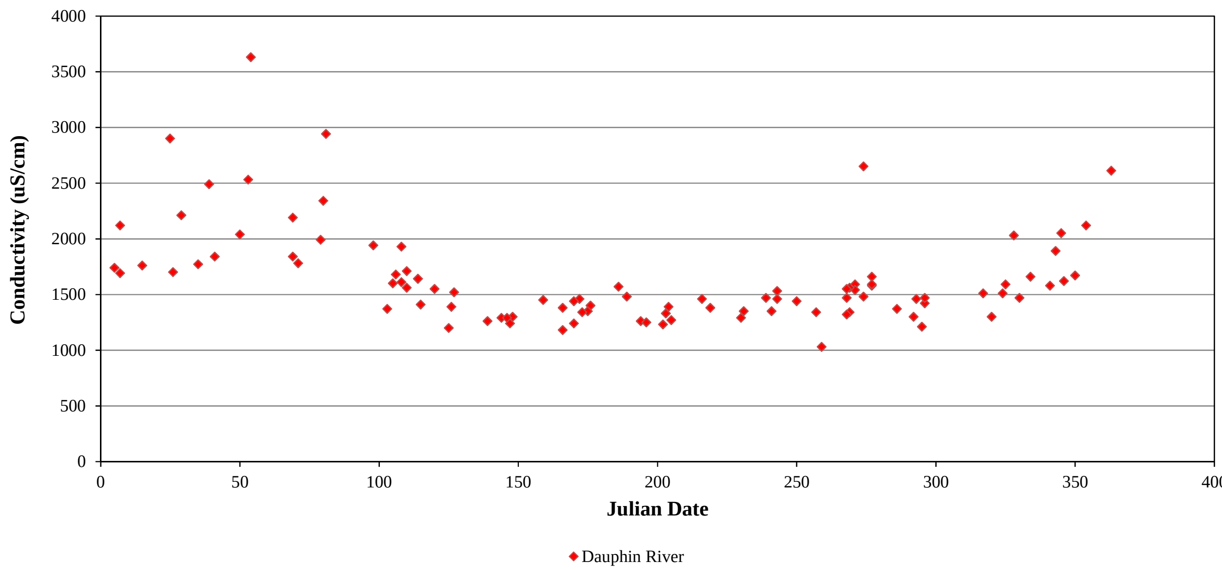

Figure 28. Conductivity in the Dauphin River by Julian date.

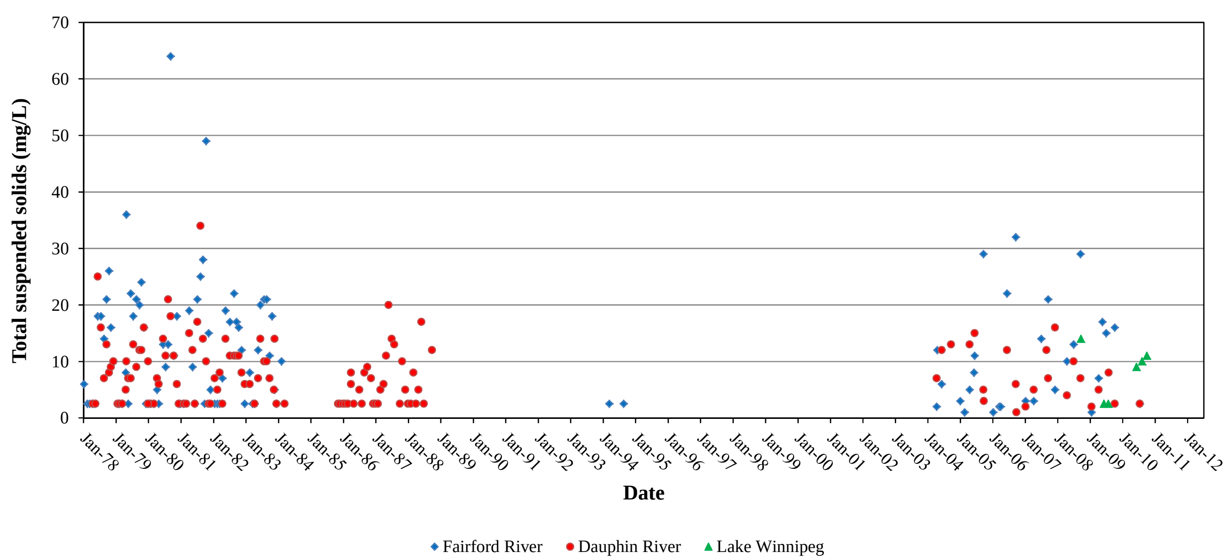

Figure 29. Comparison of total suspended solids in the Fairford and Dauphin rivers and Sturgeon Bay over the period of record.

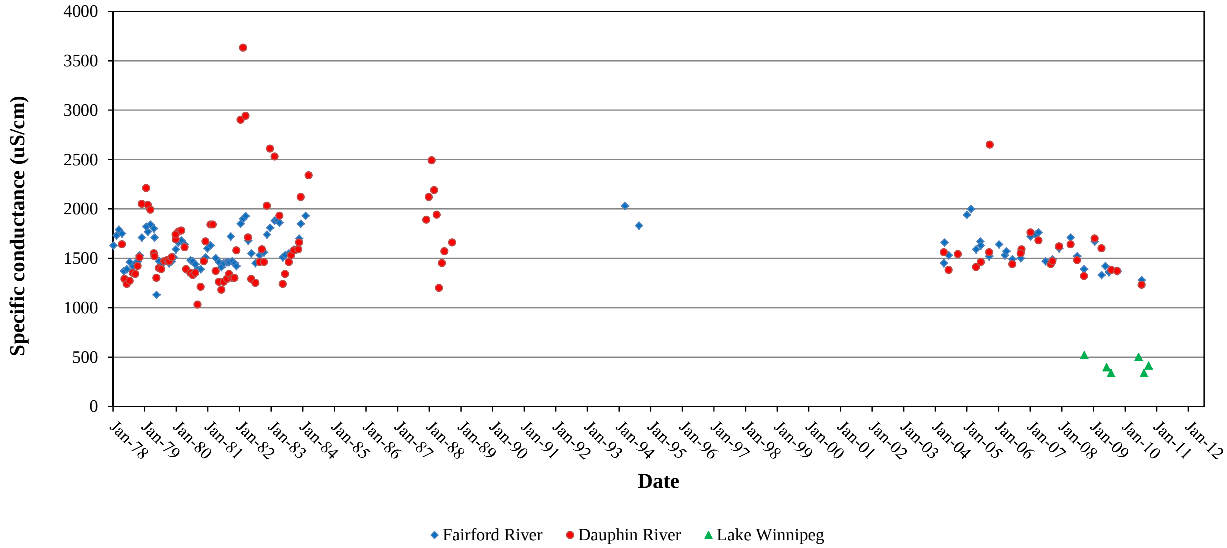

Figure 30. Comparison of specific conductance in the Fairford and Dauphin rivers and Sturgeon Bay over the period of record.

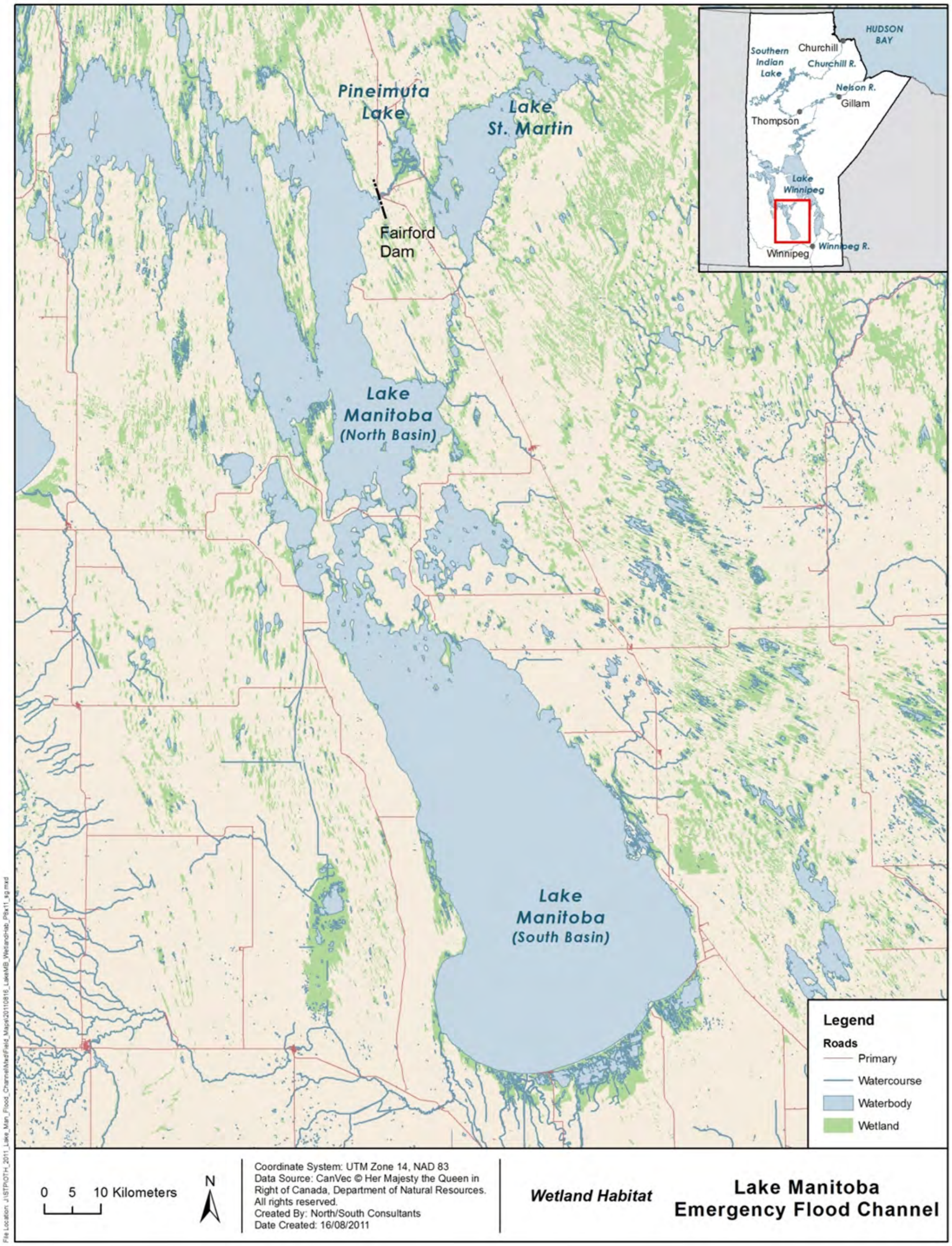

Figure 31. Wetland habitat around Lake Manitoba, Lake Pineimuta and Lake St. Martin. Data extracted from CanVec (Saturated Soils dataset, 8th edition; released 2011-04-18; ftp://ftp2.cits.rncan.gc.ca/pub/canvec/).

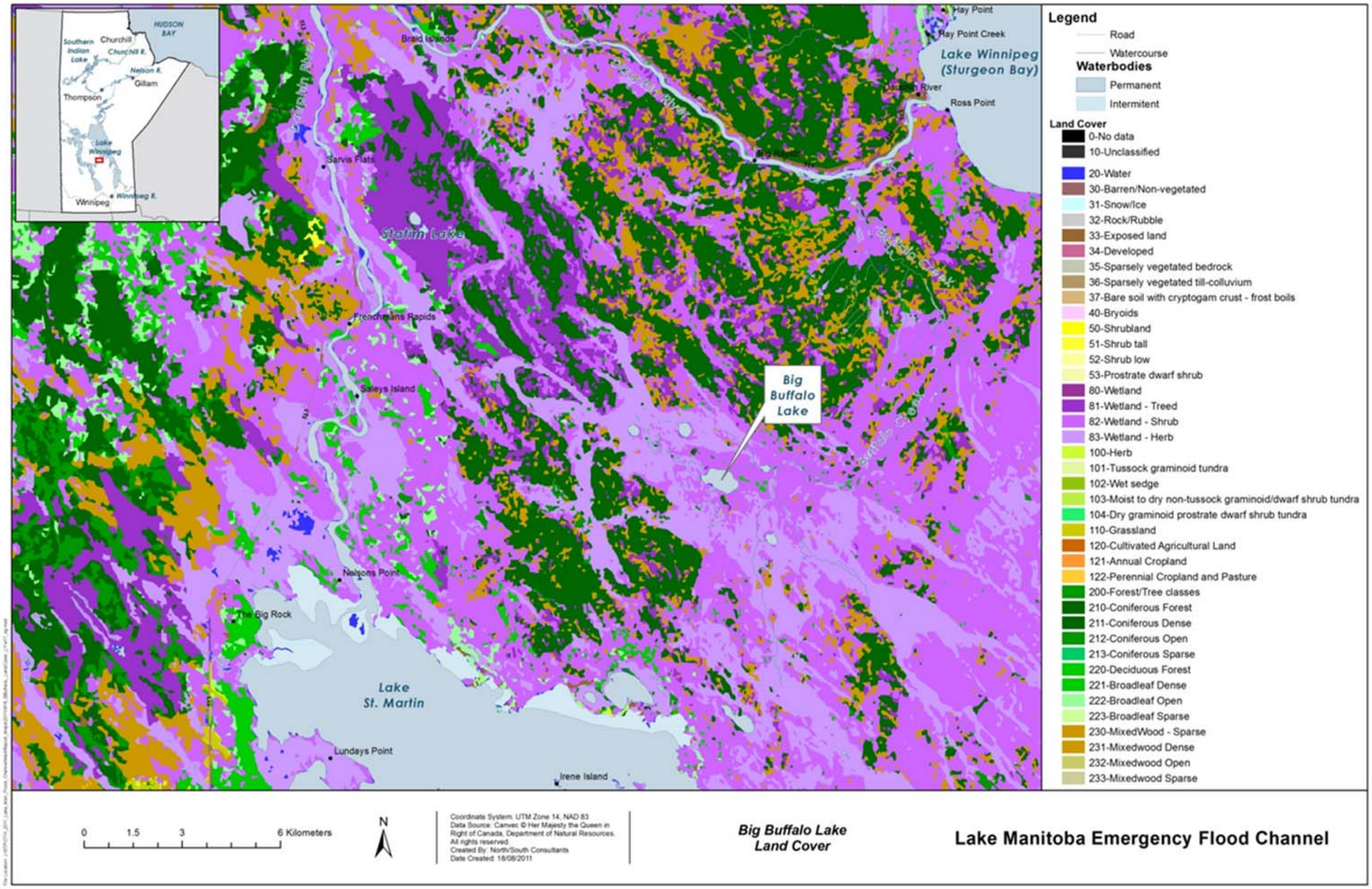

Figure 32. Land cover surrounding Big Buffalo Lake. Data from GeoBase (2000; www.geobase.ca)

Figure 33. Big Buffalo Lake and associated shoreline, August, 2011.

Figure 34. Buffalo Creek downstream of Big Buffalo Lake, illustrating wetlands through which the creek flows.

Figure 35. Buffalo Creek showing riffle/pool/run sequences and meandering pattern, August, 2011.

Figure 36. Shoreline of Sturgeon Bay in the vicinity of the Dauphin River, August, 2011.

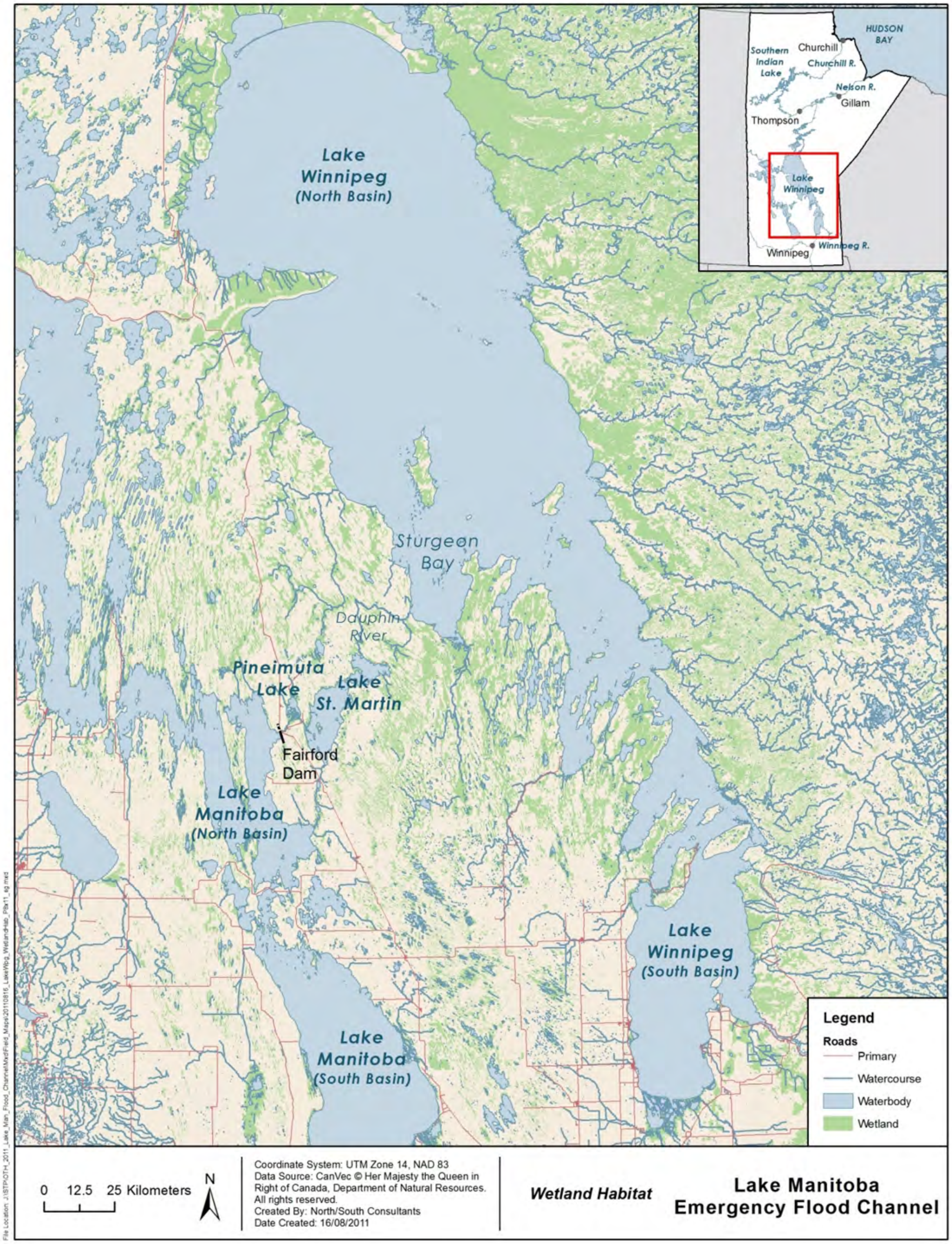

Figure 37. Wetland habitat surrounding Lake Winnipeg. Data extratcted from CanVec (Saturated Soils dataset, 8 edition; released 2011-04-18; ftp://ftp2.cits.rncan.gc.ca/pub/canvec/).

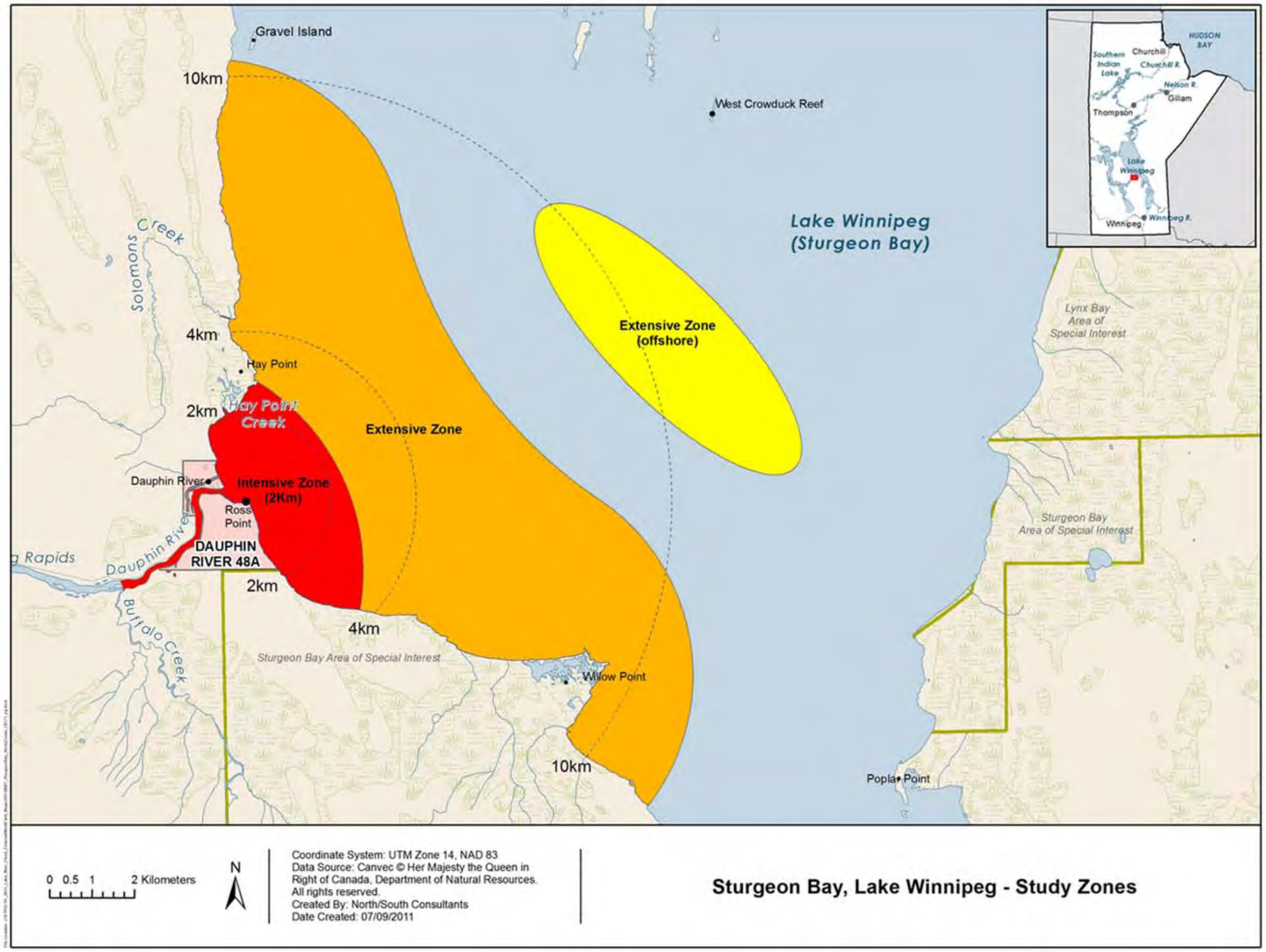

Figure 38. General distribution of habitat sampling zones in the Dauphin River and Sturgeon Bay where intensive and extensive datasets will be collected. The actual area of coverage may depend on results obtained during the survey.