Appendix C. Water Quality Summary Results

Lake St. Martin Emergency Relief Channel Monitoring and Development of Habitat Compensation

Volume 3 - Water Quality

REPORT

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Lake St. Martin Emergency Relief Channel Monitoring and Development of Habitat Compensation

2011-2015

Volume 3 – Water Quality

A Draft Report Prepared for

Manitoba Infrastructure and Transportation

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EXECUTIVE SUMMARY

Widespread record flooding throughout southern Manitoba during 2011 led to water levels in Lake Manitoba and Lake St. Martin that were 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 communities in the vicinity of Lake St. Martin. As part of emergency relief measures, the Province of Manitoba, through Manitoba Infrastructure and Transportation (MIT), constructed the Lake St. Martin Emergency Outlet Channel System, which is comprised of two emergency channels. The Reach 1 Emergency Outlet Channel (Reach 1) begins at the northeast shore of the north basin of Lake St. Martin and extends approximately 6 km to the bog area surrounding Big Buffalo Lake. Water from Reach 1 inundates the bog area and then follows the natural Buffalo Creek Drainage System until flowing into the lower Dauphin River and ultimately into Sturgeon Bay. Water began to flow through Reach 1 on November 1, 2011 and the channel was operated until November 21, 2012.

Computer models of potential water levels at the mouth of the Dauphin River indicated that there was a significant risk of major flooding of the Dauphin River communities in spring 2012. Consequently, a second channel (Reach 3 Emergency Channel; Reach 3) was constructed during winter 2012. Reach 3 was designed to divert excess flow from Reach 1 and Buffalo Creek and away from the lower Dauphin River. It was determined that operation of Reach 3 prior to the spring break up, in combination with the construction of dikes along the banks of the Dauphin River, should substantially reduce the risk of flooding for the Dauphin River communities.

Due to extremely mild winter conditions in 2011/2012, ice effects on both Reach 1 and the Dauphin River were much less severe than forecasted. With the continuous extreme mild conditions, updated flood forecasts indicated that the estimated discharge in the lower Dauphin River during ice break up would be well below the capacity of the Dauphin River community dikes. Consequently, the proposed operation of Reach 3 was no longer required.

Heavy precipitation during winter 2013/2014 and spring 2014 again elevated water levels in Lake Manitoba and Lake St. Martin, prompting MIT to re-open Reach 1 at the beginning of July 2014. The channel was re-opened in two stages. The first occurred during in July 2014 when approximately 35 m of the berm closing Reach 1 was removed. The second stage occurred in November 2014, when an additional 10 m of the closure berm were removed to allow additional flow into the channel. Flow into Reach 1 was halted in late August 2015.

Collectively, construction and operation of Reach 1, as well as construction of Reach 3, are referred to hereafter as “the Project”.

Concurrent with construction of Reach 1 in summer 2011, MIT initiated studies and monitoring to help describe and assess environmental effects arising from the Project. These included studies to document changes to the physical environment (*e.g.*, measurement of water flow through Reach 1 and the

Dauphin River; sedimentation and erosion studies) and possible subsequent effects to the biological environment (*e.g.*, possible change to fish community in Buffalo Creek). Environmental studies began in August 2011 and continued until September 2015.

This report provides an overview of the water quality monitoring programs including a summary of Project related effects to water quality in Lake St. Martin, the Buffalo Creek watershed, the lower Dauphin River, and Sturgeon Bay. This report also compiles all the raw data collected for the Project from September 2011 to September 2015.

Lake St. Martin

During dredging related to construction activities in October. 2011, total suspended solids (TSS) in the vicinity of the Reach 1 inlet exceeded the 30 day Manitoba Water Quality Standards Objectives and Guidelines (MWQSOGs)/ Canadian Council of Ministers for the Environment (CCME) long-term PAL (average of 5 mg/L above background), and periodically exceeded the 1-day MWQSOGs/CCME short-term PAL (25 mg/L above background).

There was no linkage to operation of Reach 1 and effects to water quality in Lake St. Martin.

Reach 1 and the Buffalo Creek Watershed

The water quality of the Buffalo Creek watershed changed as water from Lake St. Martin was introduced and then withheld from the system. During operation, conductivity, total dissolved solids (TDS), and hardness increased substantially, pH increased slightly, and colour decreased. The reverse took place during closure. During operation and closure, TDS exceeded the aesthetic objective for drinking water (≤ 500 mg/L) and was well below this objective during the Flood.

Dissolved oxygen (DO) concentrations below the PAL guidelines for cool and cold-water species were observed throughout the watershed during each phase of the Project and during baseline, particularly in winter. At the onset of 2014/2015 Operation, DO temporarily (for 1-10 days depending upon location) decreased below PAL guidelines throughout the watershed (this was not observed in 2011). This change in DO may be attributable to the Project, or it may be due to seasonal changes that are coincident with the timing of operation. Baseline data are too limited to determine if the changes to DO that were observed in the Buffalo Creek watershed can be attributed to the Project.

Baseline TSS concentrations in Buffalo Creek were low (< 2-6 mg/L). At the onset of operation in both 2011 and 2014, TSS increased in the Buffalo Creek watershed, ranging from 10-60 mg/L and from 3.2-180 mg/L, respectively. The magnitude of the increase at the downstream end of Buffalo Creek was three times greater in 2014 than in 2011. During 2011/2012 Closure, TSS was high in the spring and remained higher than baseline at the downstream end of Buffalo Creek. Similarly, TSS concentrations increased slightly following closure activities in 2015. After 02 November 2011, TSS was consistently higher at the downstream end of Buffalo Creek than at the upstream end of the creek, this was not observed during baseline. At the onset of operation in both 2011 and 2014, TSS exceeded the 1-day MWQSOGs/CCME short-term PAL throughout the watershed for more than a day. Exceedances of this guideline occurred at varying locations within the watershed on 04, 07, 17 and 25 November in 2011, and from 03 to 11 July in 2014. Additionally, during operation, TSS was frequently above the 30 day MWQSOGs/CCME long-term PAL throughout the watershed and, during 2011/2012 Closure, consistently exceeded the 30-day MWQSOGs/CCME long-term PAL at the downstream end of Buffalo Creek.

At the onset of operation in 2011 and 2014, total phosphorus (TP) increased in Buffalo Creek above the MWQSOGs narrative guideline for streams (0.050 mg/L), but returned to baseline within a week of onset in both years. In winter and spring following the closure of Reach 1 in 2012, TP increased from 2011/2012 Operation and was above baseline. Following the freshet, TP returned to baseline in most of the watershed, but remained high at the downstream end of Buffalo Creek throughout 2013. In the spring of 2014, there was another spike in TP. TP occasionally exceeded the narrative guideline for streams during 2011/2013 Closure.

Similar to phosphorus, nitrogen increased in the watershed in the winter and spring following the closure of Reach 1. During closure, ammonia occasionally exceeded the CCME PAL guideline in Big Buffalo Lake. Baseline data are too limited to determine if the ammonia exceedances observed in Big Buffalo Lake can be attributed to the Project.

Chlorophyll *a* concentrations in Buffalo Creek were consistently higher than baseline from spring 2012 to August 2015, though baseline data are limited. There are no MWQSOGs or CCME guidelines for chlorophyll *a*.

Several metals and major ions increased in Buffalo Creek during operation in 2011/2012 and 2014/2015, including: arsenic, barium, boron, calcium, chloride, fluoride, magnesium, molybdenum, potassium, sodium, sulphate, and uranium. Additionally, copper increased during 2011/2012 Operation, but decreased during 2014/2015 Operation. At the onset of 2014/2015 Operation there was a small increase in mercury and methyl mercury in Buffalo Creek, but both returned to baseline by October 2014. The analytical detection limit used for mercury in 2011 was too high to detect if mercury changed at the onset of 2011/2012 Operation and methyl mercury was not measured at that time.

Metals and major ions that had increased in Buffalo Creek during operation showed a decreasing trend during 2011/2012 Closure, though some remained higher than baseline prior to 2014/2015 Operation.

During operation in 2011/2012 and 2013/2014, chloride and fluoride exceeded the CCME PALs (120 and 0.12 mg/L, respectively) in the Buffalo Creek watershed. These guidelines were occasionally exceeded in Big Buffalo Lake during 2011/2012 Closure, but no longer in Buffalo Creek. During 2011/2012 Operation, selenium was frequently above the MWQSOGs/CCME PAL (0.001 mg/L) in the Buffalo Creek watershed. During 2011/2012 Closure, iron frequently exceeded the PAL/aesthetic objective for drinking water (0.3 mg/L), and chromium occasionally exceeded the CCME PAL (0.0089 mg/L) at the downstream end of Buffalo Creek. There were no other exceedances of MWQSOGs/CCME PAL and or drinking water for metals or major ions that could be attributed to the Project.

Lower Dauphin River

Conductivity, TDS, laboratory pH, true colour and hardness were similar upstream and downstream of Buffalo Creek during baseline, operation, and closure. No changes to routine water quality of the Dauphin River were observed that can be attributed to the Project.

The Dauphin River was generally well-oxygenated. A small decrease (<2 mg/L) in DO was observed downstream of Buffalo Creek during operation in 2015. However, DO concentrations below the MWQSOGs/CCME PAL have been observed throughout monitoring for the Project both upstream and downstream of Buffalo Creek during both the open-water and ice covered seasons.

At the onset of operation in 2011 and 2014, TSS increased in the lower Dauphin River such that a plume of sediment was visible along the shoreline. After approximately one month of operation in 2011 and two weeks of operation in 2014, TSS in the lower Dauphin River returned to background. However, during 2014/2015 Operation in March and spring 2015, TSS was again elevated downstream of Buffalo Creek. At the onset of operation in both 2011 and 2014, TSS concentrations in the lower Dauphin River exceeded the MWQSOGs 1 day/CCME long-term PAL as far downstream as Sturgeon Bay for more than a day. Additionally, TSS was consistently above the MWQSOGs 30 day/CCME short-term PAL from 04-25 November 2011, 05-16 July 2014, 27 March 2015; and, along the shoreline downstream of Buffalo Creek 01 May 2015 and 11 June 2015.

TSS also increased along the Dauphin River shoreline downstream of Buffalo Creek in spring 2013 during closure. During 2011/2012 Closure, TSS concentrations in the lower Dauphin River occasionally exceeded MWQSOGs 30 day/CCME short-term PAL.

At the onset of operation in 2011 and 2014, in the spring of 2013, and in March and spring of 2015, phosphorus concentrations increased in the lower Dauphin River as far downstream as Sturgeon Bay. At the onset of operation, TP exceeded the MWQSOGs narrative guidelines. No other changes to nutrient concentrations in the Dauphin River were observed that can be attributed to the Project.

Chlorophyll *a* was similar throughout the Dauphin River and was within the baseline range during operation and closure. There are no MWQSOGs or CCME guidelines for chlorophyll *a*. No changes to chlorophyll *a* concentrations in the Dauphin River were observed that can be attributed to the Project.

There were no observed changes to most metals or major ions in the Dauphin River that can be attributed to the Project. However, at the onset of 2014/2015 Operation, mercury and methyl mercury increased in the Dauphin River downstream of Buffalo Creek. At the onset of 2011/2012 Operation, the analytical detection limited used for mercury was too high to detect any changes in mercury concentrations that may have occurred and methyl mercury was not measured at this time. Mercury and methyl mercury remained well below the MWQSOGs/CCME PALs (26 and 4 ng/L, respectively) in the lower Dauphin River during 2014/2015 Operation.

Sturgeon Bay

The extent of the mixing zone between the Dauphin River and Lake Winnipeg increased during 2011/2012 Operation. During 2011/2012 Closure, the size of the mixing zone decreased, but it remained larger than baseline. As a result of the mixing zone changes, TDS was more frequently above the aesthetic objective for drinking water (≤ 500 mg/L) in areas of Sturgeon Bay away from the Dauphin River than baseline. No changes to routine water quality in Sturgeon Bay were observed during 2014/2015 Operation that can be attributed to the Project.

Sturgeon Bay was well-oxygenated during baseline, operation and closure. DO was consistently within PAL guidelines for cool and cold-water species. No changes to DO in the Sturgeon Bay were observed that can be attributed to the Project.

In the spring of 2011/2012 Operation, TSS increased in Sturgeon Bay near the Dauphin River and, at the onset of 2014/2015 Operation, TSS increased in Sturgeon Bay near the Dauphin River mouth and remained higher near the river for about a month. No data are available for Sturgeon Bay at the onset of 2011/2012 Operation, so an assessment of effects of operation in 2011 cannot be conducted. No changes to TSS in Sturgeon Bay were observed during 2011/2012 Closure that can be attributed to the Project.

There was a spike in nitrogen and phosphorus near the mouth of the Dauphin River in the spring of 2011/2012 Operation. This resulted in a guideline exceedance for TP; however, TP exceedances were frequently observed in Sturgeon Bay from 2011-2015. No other changes to nutrient concentrations in Sturgeon Bay were observed that can be attributed to the Project.

From 2012-2015, chlorophyll *a* was typically lower than baseline. Chlorophyll *a* concentrations near the Dauphin River were higher in spring 2012 and lower in October 2014, compared with the rest of Sturgeon Bay. At other times, chlorophyll *a* was generally similar throughout the bay. There are no MWQSOGs or CCME guidelines for chlorophyll *a*. Baseline data are too limited to determine if any changes to chlorophyll *a* concentrations that were observed can be attributed to the Project.

During 2011/2012 and 2014/2015 Operation, aluminum and iron increased in Sturgeon Bay near the Dauphin River; however, concentrations remained within the baseline range for Sturgeon Bay. During 2011/2012 Operation, methyl mercury was more frequently detected and at higher concentrations near the Dauphin River than in the rest of Sturgeon Bay. Similarly, In March 2015, during 2014/2015 Operation, methyl mercury was detected near the Dauphin River and Willow Point but not at other sites in Sturgeon Bay; concentrations were well below the MWQSOGs/CCME PAL (4 ng/L). From 2012-2014, chloride concentrations were more frequently above the CCME long-term PAL (120 mg/L) in areas of Sturgeon Bay away from the Dauphin River than during baseline (i.e., the area of high chloride concentrations in the bay increased). There were no other exceedances of MWQSOGs/CCME PAL and/or drinking water for metals or major ions that could be attributed to the Project.

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1.0 INTRODUCTION

Widespread record flooding throughout southern Manitoba during 2011 (Figure 1) led to water levels in Lake Manitoba and Lake St. Martin that were 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 communities in the vicinity of Lake St. Martin. As part of emergency relief measures, the Province of Manitoba, through Manitoba Infrastructure and Transportation (MIT), constructed the Lake St. Martin Emergency Outlet Channel System (LSMEOC System), which is comprised of two emergency channels (Figure 2).

The Reach 1 Emergency Outlet Channel (Reach 1) begins at the northeast shore of the north basin of Lake St. Martin and extends approximately 6 km to the bog area surrounding Big Buffalo Lake. Water from Reach 1 inundates the bog area and then follows the natural Buffalo Creek Drainage System until flowing into the lower Dauphin River and ultimately into Sturgeon Bay (Figure 2). Water began to flow through Reach 1 on 01 November 2011 and the channel was operated until 21 November 2012.

Computer models of potential water levels at the mouth of the Dauphin River indicated that there was a significant risk of major flooding of the Dauphin River communities in spring 2012. Consequently, a second channel (Reach 3 Emergency Channel; Reach 3) was constructed during winter 2011/2012. Reach 3 was designed to divert excess flow from Reach 1 and Buffalo Creek and away from the lower Dauphin River. Due to extremely mild winter conditions in 2011/2012, ice effects on both Reach 1 and the Dauphin River were much less severe than forecasted. Consequently, the proposed operation of Reach 3 was no longer required.

Heavy precipitation during winter 2013/2014 and spring 2014 again elevated water levels in Lake Manitoba and Lake St. Martin, prompting MIT to re-open Reach 1 at the beginning of July 2014. The channel was re-opened in two stages. The first occurred during in July 2014 when approximately 35 m of the berm closing Reach 1 was removed. The second stage occurred in November 2014, when an additional 10 m of the closure berm were removed to allow additional flow into the channel. Reach 1 remained in operation until at August 2015. Collectively, construction and operation of Reach 1, as well as construction of Reach 3, are referred to hereafter as “the Project”.

Concurrent with construction of Reach 1 in summer 2011, MIT initiated studies and monitoring to help describe and assess environmental effects arising from the Project. These included studies to document changes to the physical environment (e.g., measurement of water flow through Reach 1 and the Dauphin River; sedimentation and erosion studies) and possible subsequent effects to the biological environment (e.g., possible change to fish community in Buffalo Creek). Environmental studies began in August 2011 and concluded in September 2015.

Water quality monitoring studies have been conducted annually, focussing on routine parameters (e.g., conductivity, pH), dissolved oxygen (DO), total suspended solids (TSS), nutrients, chlorophyll *a*, metals and major ions, and petroleum hydrocarbons. Water quality data were collected from the Fairford River, Lake St. Martin, Reach 1 and the Buffalo Creek watershed, the Dauphin River, and Sturgeon Bay.

This report provides an overview of the water quality monitoring programs including a summary of Project related effects to water quality in Lake St. Martin, the Buffalo Creek watershed, the lower Dauphin River, and Sturgeon Bay. This report also compiles all the raw data collected for the Project from September 2011 to September 2015.

2.0 PROJECT DESCRIPTION AND STUDY AREA

2.1 PROJECT DESCRIPTION

Infrastructure constructed to support the emergency reduction of Lake Manitoba and Lake St. Martin water levels included two channels designed to increase flow from Lake St. Martin to Sturgeon Bay. The first channel, the Reach 1 Emergency Outlet Channel, was completed in fall 2011. The second channel, the Reach 3 Emergency Channel, was constructed during winter 2011/2012 but was not operated. Additional details pertinent to each of the channels are presented in the following sections.

2.1.1 Reach 1 Emergency Outlet Channel

As previously stated, Reach 1 was constructed to increase the flow of water from Lake St. Martin to Sturgeon Bay. The inlet to Reach 1 is located along the northeast shore of the Lake St. Martin north basin. The channel extends north east for approximately 6 km to a bog area surrounding Big Buffalo Lake. Drainage water from Reach 1 flowed through the bog area and Big Buffalo Lake into Buffalo Creek, and then flowed down Buffalo Creek to its confluence with the lower Dauphin River, approximately 4 km upstream of Sturgeon Bay.

The inlet of Reach 1 consisted of a fixed-level invert with a sill at an elevation of 243.1 m above sea level (mASL). The sill was designed to convey the desired flow of 142 m^3/s at 244.1 mASL and was 120 m in length, had a bottom width of 60 m, and 3:1 side slopes. At the onset of operation, flow through Reach 1 was estimated to be 255 m^3/s based on Lake St. Martin water level at that time.

2.1.2 Reach 3 Emergency Channel

Water level projections indicated that there was a substantial risk for major flooding in the Dauphin River communities in spring 2012 due to unprecedented flows along the Dauphin River downstream of Buffalo Creek and the increased potential for frazil ice jamming at the mouth of the Dauphin River. It was determined that the construction of an additional channel to divert Reach 1 flows away from the Dauphin River, and construction of dikes along the banks of the lower Dauphin River prior to spring break up was necessary to reduce the risk of flooding in the communities.

Following a review of configuration options, the Reach 3 Emergency Channel was constructed. Reach 3 originates at Buffalo Creek about 8 km downstream of Big Buffalo Lake (Figure 2), is approximately 6 km in length, and terminates in a lowland area 3 km inland of Sturgeon Bay. From the outlet of Reach 3, water would flow overland towards Sturgeon Bay, entering the bay through a proposed shoreline breach structure which was to be constructed through the beach ridge to the west of Willow Point.

It was expected that Reach 3 would only operate for a short period of time during the spring freshet in 2012 to limit the threat of flooding along the lower Dauphin River. However, an exceptionally mild winter in 2011/2012 allowed sufficient drainage from Lake Manitoba and Lake St. Martin to reduce water levels to a point where the risk of frazil ice jamming and flooding at Dauphin River communities became negligible. Consequently, Reach 3 was not operated.

2.1.3 Project Schedule

Construction of Reach 1 was initiated in mid-July 2011. The channel was completed and water began to flow through it by November 01, 2011. Closure of Reach 1 was initiated on November 15, 2012. Closure operations included constructing a dike across the Reach 1 inlet at Lake St. Martin to prevent water from flowing into the channel. By November 21, construction had progressed to where no flow was entering Reach 1 (Table 1).

Heavy precipitation during winter 2013/2014 and spring 2014 again elevated water levels in Lake Manitoba and Lake St. Martin, prompting MIT to re-open Reach 1 at the beginning of July 2014 (Table 1). The channel was re-opened in two stages. The first occurred during in July 2014 when approximately 35 m of the berm closing Reach 1 was removed. The second stage occurred in November 2014, when an additional 10 m of the closure berm were removed to allow additional flow into the channel. Flow into Reach 1 was halted in late August 2015.

2.2 STUDY AREA

The emphasis of aquatic monitoring is to determine what effects construction and operation of Reach 1 may have had on waterways downstream of the channel. These include the Buffalo Creek watershed, the lower Dauphin River, and Sturgeon Bay. However, these waterways are also affected by conditions occurring upstream of Reach 1 and, in some instances, fish move between areas upstream and downstream of Reach 1. Consequently, some components of the aquatic monitoring program (water quality monitoring and fisheries investigations) include waterways upstream of Reach 1.

Local hydrology is affected by water flow from across the province. 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 into Lake St. Martin, and then through the Dauphin River to Sturgeon Bay.

The Buffalo Creek watershed is situated between Lake St. Martin to the south and the Dauphin River and Sturgeon Bay to the north. Prior to operation of Reach 1, the watershed was isolated and did not receive water from other waterways; all flow was due to local run off. The headwaters of the watershed are comprised of a bog complex including Big Buffalo Lake and several other ponds. Buffalo Creek originates in Big Buffalo Lake and flows through the bog complex before entering into a more defined creek channel. The creek discharges into the Dauphin River approximately 4 km upstream of Sturgeon Bay.

3.0 WATER QUALITY MONITORING PROGRAMS

Aquatic environment monitoring for the emergency reduction of Lake Manitoba and Lake St. Martin water levels included two main water quality monitoring programs: (1) a Regional Water Quality Monitoring Program (RWQMP), which collected water quality information from all major waterbodies and waterways within the study area that were affected by flooding; and, (2) a localised water quality monitoring program within Reach 1 and the Buffalo Creek watershed (Lake St. Martin Emergency Outlet Channel Monitoring; LSMEOC Monitoring). Additionally, *in situ* water quality monitoring was conducted in Sturgeon Bay to gather spatial information on the water quality of Sturgeon Bay, and in particular to define the area of influence of the Dauphin River. Detailed results of these programs are presented in Appendices A to H. The data from 2011 to 2012 have been previously published in a series of reports (AECOM 2012, KGS 2013, NSC 2013a, NSC 2013b, NSC 2014).

3.1 REGIONAL WATER QUALITY MONITORING PROGRAM

The RWQMP was initiated in October 2011, prior to the operation of Reach 1, and continued until May 2015. The intent of this program was to provide a regional perspective on water quality conditions both upstream and downstream of Reach 1. Water quality in all major waterbodies and waterways within the study area were sampled. Water quality parameters included in the RWQMP were identified based on potential linkages between the Project and water quality, including potential effects on TSS and related variables (e.g., nutrients and metals), effects related to diversion, and potential effects of flooding and/or diversion on water quality (i.e., nutrients, DO, pH and metals), and/or variables that provide supporting information for interpretation of other data. Ultra-trace mercury and methyl-mercury were included to facilitate comparison to the Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs; MWS 2011) and because both may be affected by flooding. A complete list of water quality parameters selected for laboratory analysis and *in situ* measurements are provided in Table 2. In general, four sampling periods occurred during each year. Details on sampling site locations and sampling periods are provided in Table 3 and Figure 3.

3.1.1 Sample Sites

In general, sampling was conducted at 17 sites throughout the study area, as follows:

- Waterhen River – one site at the bridge on PR # 328 (at MWS site MB05LHS002);
- Lake Manitoba – one site at Lake Manitoba Narrows (at MWS site MB05LKS009);
- Fairford River – one site at the PTH # 6 bridge (at MWS site MB05LMS001);
- Lake St. Martin – one site in the north basin;
- Dauphin River – four sites, including one site near the outflow from Lake St. Martin, one site near the existing MWS site (MWS Site MB05LMS003), one site upstream of the confluence of Buffalo Creek, and one site in the mouth of the Dauphin River upstream of Sturgeon Bay;
- Buffalo Creek – one site at the creek mouth; and,
- Sturgeon Bay – eight sites.

However, not all sites were sampled during all sampling periods. The following exceptions occurred:

- Sampling at the Waterhen River and Lake Manitoba Narrows was discontinued after 2012 as it was felt that the site in the Fairford River captured the condition of the water quality entering the Lake St. Martin/Dauphin River system;
- The eighth site in Sturgeon Bay, LKW3B (near the Dauphin River mouth), was added in spring 2012; and,
- During winter sampling, some sites were not accessible due to ice/snow conditions and were therefore either relocated to a more accessible location or not sampled at all.

Additionally, occasional RWQMP sampling was conducted at sites within the LSMEOC system, including:

- Lake St. Martin - near the Reach 1 inlet (October 2011);
- Big Buffalo Lake –in the middle of the basin (March and May 2013; and, April and June 2014);
- Buffalo Creek - in the upper reaches of the creek (October 2011, January 2012, and May 2013); and,
- Dauphin River - immediately downstream of the confluence with Buffalo Creek (October 2011 and August 2014).

3.1.2 Sampling Methods

Sampling sites were accessed by truck, boat, helicopter, or snowmobile depending on site accessibility and season. Sample locations were recorded using a handheld Garmin GPS receiver. Sampling date and time were noted for each sampling site. Measurements of effective water depth (using a handheld depth sounder) and of ice thickness (if appropriate) were recorded at each site. In winter, where necessary, holes were drilled through the ice using a power auger.

In situ measurements of water quality parameters including pH, specific conductance, DO, turbidity, and water temperature were collected using a handheld water quality meter. At river sites and those accessed from shore, *in situ* parameters were measured at approximately 0.3 m below the water surface. At lake sites, *in situ* profiles were taken in one of two ways: measurements were recorded near the surface (i.e., at 0.3 m) and then at either 0.5 m (if total water depth was less than 5.0 m) or 1.0 m increments, or measurements were recorded both near the surface (about 0.3 m beneath the bottom surface of the ice) and at approximately 0.3 m above the lake bottom. Due to several water quality meter malfunctions, *in situ* measurements were not consistently measured with one brand of device throughout the sampling program (see Appendices A to E for details).

At each sampling site, grab samples were collected from approximately 0.3 m below the water surface into clean sample bottles supplied by ALS Laboratories. Under ice-cover, samples were collected from 0.5 m below the ice using a Kemmerer sampler. If thermal stratification was evident at lake sampling sites, water samples were also collected from approximately 1.0 m above the sediments using a Kemmerer sampler. Where necessary, samples were preserved according to instructions provided by the analytical laboratory. After collection, samples were placed in a cooler and kept cool using ice packs until submission (within 48 hours) to ALS Laboratories in Winnipeg for analysis. Additionally, Quality

Assurance/Quality Control (QA/QC) samples were submitted to the laboratory during each sampling event, including field blanks, trip blanks, and replicate samples. A detailed description of QA/QC procedures followed is provided in Section 3.4.1.

3.2 LSMEOC MONITORING PROGRAM

LSMEOC monitoring was initiated during the early construction of Reach 1 and provided additional and targeted temporal and spatial water quality monitoring in Reach 1 and the Buffalo Creek watershed. This program continued until September 2015. Waterbodies sampled included Lake St. Martin, Reach 1, the Buffalo Creek watershed and the lower Dauphin River; details on sampling site locations are provided in Figure 4. This program included special consideration of TSS and DO to determine potential changes due to project activities. Other parameters analyzed included nutrients, mercury, and petroleum hydrocarbons. A complete list of laboratory analysed parameters is provided in Table 4. *In situ* measurements of water quality parameters including turbidity, DO, temperature, pH, and specific conductance were also collected. Sampling was typically more frequent than the RWQMP but varied with Project phase; a list of sampling dates and parameters measured is provided in Table 5.

3.2.1 Sampling Sites

Sampling sites were added or removed as appropriate for each Project phase; however, in general, sampling was conducted at 12 sites within the LSMEOC system as follows:

- Lake St. Martin – one of two sites, including one site near the centre of the north basin (LSM1), and one site near the Reach 1 inlet (LSM2);
- Reach 1 – three sites, including one site at the upstream end of the channel (EC1), one at the downstream end of the channel (EC2), and one downstream of the channel where the water entered the wetland area surrounding Big Buffalo Lake (EC3);
- Buffalo Creek – five sites, including one site at the upstream most end of the creek (BC1), one site near the upstream end of the creek (BC2), one site downstream of the proposed entrance to Reach 3 (BC4), one site downstream of Creek 3 (BC5), and one site at the mouth of the creek (BC3); and,
- Dauphin River – three sites, one site upstream of the confluence of Buffalo Creek, one site immediately downstream of the confluence of Buffalo Creek, and one site in the mouth of the Dauphin River upstream of Sturgeon Bay.

Additionally, two sites in Lake St. Martin near the Reach 1 inlet (LSM03 and LSM04) were monitored for TSS and turbidity during the construction phase of the Project; one site was sampled in Big Buffalo Lake (BBL) in 2013 and 2014; and, water samples for analysis of TSS and turbidity were also collected at the turbidity monitoring station in Buffalo Creek (BC-TM),

3.2.2 Sampling Frequency

In general, sampling frequency changed in response to Project phase as follows:

- Baseline monitoring was approximately every two weeks;
- Construction monitoring was almost daily from 05 October to 07 November 2011;
- During operation, sampling was approximately monthly;
- During closure, sampling was conducted seasonally; and,
- When it was expected that there would be an increase in sediment transport (e.g., channel opening, spring freshet) more frequent (e.g., daily, every 2-3 days, or weekly, as appropriate) sampling occurred.

3.2.3 Sampling Methods

In situ water quality data was measured during each sample event at each sample site using a handheld multi-meter (YSI or Horiba). *In situ* turbidity was also measured during each sampling event using a handheld Oakton turbidity meter. The handheld multi-meter was calibrated prior to each sample event to maximize accuracy. However, these probes do not always function properly when operated under freezing conditions. On several occasions during the winter months, the probe froze and or became encased in ice and it was not possible to complete *in situ* data collections. In 2011, samples were collected from the water's edge, whereas from 2012 through 2015 most samples were collected by a device lowered from a helicopter. Exceptions included: winter sampling when all sites were accessed by snowmobile and samples collected from holes drilled in the ice; and, the Lake St. Martin which was sampled by boat during open water periods. Safety protocols were developed for all methods used during the 2012 and 2013 water quality monitoring programs.

When sampling from helicopter, one staff harnessed into the helicopter lowered a weighted sampling device to the water surface. Samples were retrieved from just below the surface of the water (approximately 0.3 m) and examined to ensure water was free of excess sediment resulting from sampling error. Water from the sampler was used to fill sample bottles and take *in situ* measurements. The weighted sampler was rinsed at each site prior to sample collection.

When sampling through the ice, a hole was drilled using a hand auger. Samples were collected by lowering a Kemmerer sampler approximately 1.0 m below the ice. The Kemmerer was site rinsed before samples were collected. *In situ* measurements were collected from under the ice. When sampling from a boat, samples were collected from just below the surface (0.3 m) directly into laboratory supplied sample bottles.

Where necessary, samples were preserved according to instructions provided by the analytical laboratory. After collection, samples were placed in a cooler and kept cool using ice packs until submission (within 48 hours) to ALS Laboratories in Winnipeg, MB (a Canadian Association for Laboratory Accreditations, Inc. [CALA] accredited laboratory) for analysis.

QA/QC samples were included during each sampling event, including: a field blank; a trip blank provided by the laboratory; and, a duplicate sample. A detailed description of QA/QC procedures followed is provided in Section 3.4.1

3.3 IN SITU MONITORING PROGRAM

The *in situ* monitoring program was conducted in Sturgeon Bay in fall 2011, and in February and March, 2012. The primary objective of the program was to gather spatial information on the water quality of Sturgeon Bay This program included the collection of *in situ* measurements of pH, specific conductance, DO, turbidity, and water temperature; as well as, sample collection for laboratory analysis of TSS and turbidity.

3.4 ANALYSIS

3.4.1 Quality Assurance and Quality Control (QA/QC)

For both the RWQMP and LSMEOC monitoring program standard QA/QC measures were followed during sample collection (e.g., use of latex gloves, standard labelling practices, meter calibration, etc.). Additionally, QA/QC samples were collected, including field blanks, trip blanks, and replicate samples.

3.4.1.1 Field Blanks

Field blanks are intended to provide information on sample contamination from atmospheric exposure and sample handling techniques (i.e., cleanliness of sampling equipment, carry-over contamination from site to site), as well as potential laboratory contamination and/or error (British Columbia Ministry of Environment, Lands, and Parks (BCMELP) 1998). Field blanks were prepared by filling sample bottles with deionized water (both provided by the analytical laboratory) in the field and submitting the blanks along with the environmental samples.

3.4.1.2 Trip Blanks

Trip blanks are used for evaluating the potential for sample contamination that may occur from the container or preservatives through transport and storage of the sample, as well as laboratory precision (BCMELP 1998). Trip blanks were prepared in the laboratory by filling sample bottles with deionized water. Trip blanks were transported to the field sampling sites, but remained sealed, and were then submitted to the analytical laboratory in conjunction with environmental samples for analysis.

3.4.1.3 Replicate Samples

Replicate samples were collected at randomly selected sites to provide a measure of variability of environmental conditions and the overall precision associated with field methods and laboratory analyses.

3.4.1.4 QA/QC Assessment

All water quality data were examined qualitatively for potential outliers and/or transcription or analytical errors. Where one replicate sample differed notably from the others, the measurement was flagged as “suspect”.

QA/QC samples were assessed according to standard criteria to evaluate precision and identify potential sample contamination issues (BCMELP 1998). Percent relative standard deviation (PRSD) was calculated for triplicate samples as follows:

PRSD (%) = standard deviation of the triplicate values / mean of the triplicate values x 100

The relative percent mean difference (RPMD) was calculated for duplicate samples as follows:

$$\text{RPMD (\%)} = \left| (\text{value 1} - \text{value 2}) / ((\text{value 1} + \text{value 2}) / 2) \right| \times 100$$

Precision of replicate samples was evaluated using the “rule of thumb” criteria for precision of 18% for triplicate samples and 25% for duplicate samples (BCMELP 1998). Where one or more of the replicate values were less than five times the analytical detection limit (DL), an analysis of precision was not undertaken, in accordance with guidance provided in BCMELP (1998).

Field and trip blank results were also evaluated for evidence of sample contamination. Values for any parameter that exceeded five times the DL were considered to be indicative of sample contamination and/or laboratory error.

3.4.2 Comparison to Water Quality Objectives and Guidelines

Results were compared to the MWQSOGs (MWS 2011) for the protection of aquatic life (PAL) as well as the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of freshwater aquatic life (CCME 1999; updated to 2015). In general, the MWQSOGs for PAL are similar to the CCME guidelines for PAL for parameters measured; however, there are CCME guidelines for some parameters which lack a provincial guideline/objective and others for which the CCME guideline is different from the provincial one; typically the CCME guideline is more stringent than the MWQSOGs.

Drinking water quality objectives and guidelines are intended to be applied to treated or finished water as it emerges from the tap and “are not intended to be applied directly to source waters” (CCME 1999, updated to 2015). However, comparison of water quality in the study area to drinking water quality objectives and guidelines is included to provide context. The MWQSOGs indicate that “all surface waters…are susceptible to uncontrolled microbiological contamination... [and] it is therefore assumed that all raw surface water supplies will be disinfected as the minimum level of treatment prior to consumption” (MWS 2011). Furthermore, it is indicated that the MWQSOGs “apply to finished drinking water, but can be extrapolated to provide protection to raw drinking water sources.”

In general, water quality objectives and guidelines are more stringent for the protection of aquatic life and wildlife, relative to those established to protect various human usages (e.g., drinking water). A summary of relevant water quality objectives and guidelines is presented in Appendix I.

4.0 SUMMARY OF RESULTS

The following section provides a summary of the results of the water quality monitoring programs conducted since 2011 in relation to the Reach 1 operational phases. The intent is to provide an overview of observed change/lack of change in water quality of Lake St. Martin, Reach 1 and the Buffalo Creek watershed, the lower Dauphin River, and Sturgeon Bay. A detailed assessment of effects for the Project which included data collected from 2011-2014 is provided in NSC and KGS (2015a) with greater detail for the water quality program provided in the water quality supporting volume (NSC and KGS 2015b). This assessment was later updated with data collected in 2015 in NSC and KGS (2015c).

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 Reach 1 operation.

Water quality data are discussed in relation to the Reach 1 operational phases, defined as follows:

- Historical – The 10-year period prior to the 2011 flood;
- Flood – April 2011 to October 31, 2011;
- 2011/2012 Operation – 01 November 2011 to 27 November 2012;
- 2011/2012 Closure – 28 November 2012 to 30 June 2014; and,
- 2014/2015 Operation – 01 July 2014 to 13 August 2015.
- 2014/2015 Closure – 15 August 2015 to 14 September 2015

Water quality data gathered during Project-related monitoring programs (presented in Appendices A to H) are the main sources of information used to assess the effects of the Project on water quality. However, water quality data collected by MCWS were also used in order to provide historical context and to supplement data collected for the Project. A qualitative assessment of effects was conducted for key water quality parameters and was described in relation to Project phases. Changes in water quality that were linked to the Project, which resulted in the exceedance or a change in the frequency of exceedance of water quality guidelines and objectives were given more weight.

4.1 LAKE ST. MARTIN

During dredging related to construction activities in October. 2011) , TSS in the vicinity of the Reach 1 inlet exceeded the 30 day MWQSOGs/CCME long-term PAL (average of 5 mg/L above background), and periodically exceeded the 1-day MWQSOGs/CCME short-term PAL (25 mg/L above background).

There was no linkage to operation of Reach 1 and effects to water quality in Lake St. Martin.

4.2 REACH 1 AND THE BUFFALO CREEK WATERSHED

4.2.1 Routine

The water quality of the Buffalo Creek watershed changed as water from Lake St. Martin was introduced and then withheld from the system. During operation, conductivity, TDS, and hardness increased substantially, pH increased slightly, and colour decreased. The reverse took place during closure. During operation and closure, TDS exceeded the aesthetic objective for drinking water (≤ 500 mg/L) and was well below this objective during the Flood.

4.2.2 Dissolved Oxygen

DO concentrations below the PAL guidelines for cool and cold-water species were observed throughout the watershed during each phase of the Project and during baseline, particularly in winter. At the onset of 2014/2015 Operation, DO temporarily (for 1-10 days depending upon location) decreased below PAL guidelines throughout the watershed (this was not observed in 2011). This change in DO may be attributable to the Project, or it may be due to seasonal changes that are coincident with the timing of operation. Baseline data are too limited to determine if the changes to DO that were observed in the Buffalo Creek watershed can be attributed to the Project.

4.2.3 TSS

Baseline TSS concentrations in Buffalo Creek were low (< 2-6 mg/L). At the onset of operation in both 2011 and 2014, TSS increased in the Buffalo Creek watershed, ranging from 10-60 mg/L and from 3.2-180 mg/L, respectively. The magnitude of the increase at the downstream end of Buffalo Creek was three times greater in 2014 than in 2011. During 2011/2012 Closure, TSS was high in the spring and remained higher than baseline at the downstream end of Buffalo Creek. Similarly, TSS concentrations increased slightly following closure activities in 2015. After 02 November 2011, TSS was consistently higher at the downstream end of Buffalo Creek than at the upstream end of the creek, this was not observed during baseline. At the onset of operation in both 2011 and 2014, TSS exceeded the 1-day MWQSOGs/CCME short-term PAL (25 mg/L above background) throughout the watershed for more than a day. Exceedances of this guideline occurred at varying locations within the watershed on 04, 07, 17 and 25 November in 2011, and from 03 to 11 July in 2014. Additionally, during operation, TSS was frequently above the 30 day MWQSOGs/CCME long-term PAL (average of 5 mg/L above background) throughout the watershed and, during 2011/2012 Closure, consistently exceeded the 30-day MWQSOGs/CCME long-term PAL at the downstream end of Buffalo Creek.

4.2.4 Nutrients

At the onset of operation in 2011 and 2014, total phosphorus (TP) increased in Buffalo Creek above the MWQSOGs narrative guideline for streams (0.050 mg/L), but returned to baseline within a week of onset in both years. In winter and spring following the closure of Reach 1 in 2012, TP increased from 2011/2012 Operation and was above baseline. Following the freshet, TP returned to baseline in most of the watershed, but remained high at the downstream end of Buffalo Creek throughout 2013. In the spring of 2014, there was another spike in TP. TP occasionally exceeded the narrative guideline for streams during 2011/2013 Closure.

Similar to phosphorus, nitrogen increased in the watershed in the winter and spring following the closure of Reach 1. During closure, ammonia occasionally exceeded the CCME PAL guideline in Big Buffalo Lake. Baseline data are too limited to determine if the ammonia exceedances observed in Big Buffalo Lake can be attributed to the Project.

4.2.5 Chlorophyll *a*

Chlorophyll *a* concentrations in Buffalo Creek were consistently higher than baseline (0.37-0.52 µg/L) from spring 2012 to August 2015 (0.61-5.64 µg/L), though baseline data are limited. There are no MWQSOGs or CCME guidelines for chlorophyll *a*.

4.2.6 Metals and Major Ions

Several metals and major ions increased in Buffalo Creek during operation in 2011/2012 and 2014/2015, including: arsenic, barium, boron, calcium, chloride, fluoride, magnesium, molybdenum, potassium, sodium, sulphate, and uranium. Additionally, copper increased during 2011/2012 Operation, but decreased during 2014/2015 Operation. At the onset of 2014/2015 Operation there was a small increase in mercury and methyl mercury in Buffalo Creek, but both returned to baseline by October 2014. The analytical detection limit used for mercury in 2011 was too high to detect if mercury changed at the onset of 2011/2012 Operation and methyl mercury was not measured at that time.

Metals and major ions that had increased in Buffalo Creek during operation showed a decreasing trend during 2011/2012 Closure, though some remained higher than baseline prior to 2014/2015 Operation.

During operation in 2011/2012 and 2013/2014, chloride and fluoride exceeded the CCME PALs (120 and 0.12 mg/L, respectively) in the Buffalo Creek watershed. These guidelines were occasionally exceeded in Big Buffalo Lake during 2011/2012 Closure, but no longer in Buffalo Creek. During 2011/2012 Operation, selenium was frequently above the MWQSOGs/CCME PAL (0.001 mg/L) in the Buffalo Creek watershed. During 2011/2012 Closure, iron frequently exceeded the PAL/aesthetic objective for drinking water (0.3 mg/L), and chromium occasionally exceeded the CCME PAL (0.0089 mg/L) at the downstream end of Buffalo Creek. There were no other exceedances of MWQSOGs/CCME PAL and or drinking water for metals or major ions that could be attributed to the Project.

4.3 LOWER DAUPHIN RIVER

4.3.1 Routine

Conductivity, TDS, laboratory pH, true colour and hardness were similar upstream and downstream of Buffalo Creek during baseline, operation, and closure.

No changes to routine water quality of the Dauphin River were observed that can be attributed to the Project.

4.3.2 Dissolved Oxygen

The Dauphin River was generally well-oxygenated. A small decrease (<2 mg/L) in DO was observed downstream of Buffalo Creek during operation in 2015. However, DO concentrations below the MWQSOGs/CCME PAL have been observed throughout monitoring for the Project both upstream and downstream of Buffalo Creek during both the open-water and ice covered seasons.

4.3.3 TSS

At the onset of operation in 2011 and 2014, TSS increased in the lower Dauphin River such that a plume of sediment was visible along the shoreline. After approximately one month of operation in 2011 and two weeks of operation in 2014, TSS in the lower Dauphin River returned to background. However, during 2014/2015 Operation in March and spring 2015, TSS was again elevated downstream of Buffalo Creek. At the onset of operation in both 2011 and 2014, TSS concentrations in the lower Dauphin River exceeded the MWQSOGs 1 day/CCME long-term PAL as far downstream as Sturgeon Bay for more than a day. Additionally, TSS was consistently above the MWQSOGs 30 day/CCME short-term PAL from 04-25 November 2011, 05-16 July 2014, 27 March 2015; and, along the shoreline downstream of Buffalo Creek 01 May 2015 and 11 June 2015.

TSS also increased along the Dauphin River shoreline downstream of Buffalo Creek in spring 2013 during closure. During 2011/2012 Closure, TSS concentrations in the lower Dauphin River occasionally exceeded MWQSOGs 30 day/CCME short-term PAL.

4.3.4 Nutrients

At the onset of operation in 2011 and 2014, in the spring of 2013, and in March and spring of 2015, phosphorus concentrations increased in the lower Dauphin River as far downstream as Sturgeon Bay. At the onset of operation, TP exceeded the MWQSOGs narrative guidelines. No other changes to nutrient concentrations in the Dauphin River were observed that can be attributed to the Project.

4.3.5 Chlorophyll *a*

Chlorophyll *a* was similar throughout the Dauphin River and was within the baseline range during operation and closure. There are no MWQSOGs or CCME guidelines for chlorophyll *a*.

No changes to chlorophyll *a* concentrations in the Dauphin River were observed that can be attributed to the Project.

4.3.6 Metals and Major Ions

There were no observed changes to most metals or major ions in the Dauphin River that can be attributed to the Project. However, at the onset of 2014/2015 Operation, mercury and methyl mercury increased in the Dauphin River downstream of Buffalo Creek. At the onset of 2011/2012 Operation, the analytical detection limited used for mercury was too high to detect any changes in mercury concentrations that may have occurred and methyl mercury was not measured at this time. Mercury and methyl mercury remained well below the MWQSOGs/CCME PALs (26 and 4 ng/L, respectively) in the lower Dauphin River during 2014/2015 Operation.

4.4 STURGEON BAY

4.4.1 Routine

The extent of the mixing zone between the Dauphin River and Lake Winnipeg increased during 2011/2012 Operation. During 2011/2012 Closure, the size of the mixing zone decreased, but it remained larger than baseline. As a result of the mixing zone changes, TDS was more frequently above the aesthetic objective for drinking water (≤ 500 mg/L) in areas of Sturgeon Bay away from the Dauphin River than baseline.

No changes to routine water quality in Sturgeon Bay were observed during 2014/2015 Operation that can be attributed to the Project.

4.4.2 Dissolved Oxygen

Sturgeon Bay was well-oxygenated during baseline, operation and closure. DO was consistently within PAL guidelines for cool and cold-water species.

No changes to DO in the Sturgeon Bay were observed that can be attributed to the Project.

4.4.3 TSS

In the spring of 2011/2012 Operation, TSS increased in Sturgeon Bay near the Dauphin River and, at the onset of 2014/2015 Operation, TSS increased in Sturgeon Bay near the Dauphin River mouth and remained higher near the river for about a month. No data are available for Sturgeon Bay at the onset of 2011/2012 Operation, so an assessment of effects of operation in 2011 cannot be conducted.

No changes to TSS in Sturgeon Bay were observed during 2011/2012 Closure that can be attributed to the Project.

4.4.4 Nutrients

There was a spike in nitrogen and phosphorus near the mouth of the Dauphin River in the spring of 2011/2012 Operation. This resulted in a guideline exceedance for TP; however, TP exceedances were frequently observed in Sturgeon Bay from 2011-2015.

No other changes to nutrient concentrations in Sturgeon Bay were observed that can be attributed to the Project.

4.4.5 Chlorophyll *a*

From 2012-2015, chlorophyll *a* was typically lower than baseline. Chlorophyll *a* concentrations near the Dauphin River were higher in spring 2012 and lower in October 2014, compared with the rest of

Sturgeon Bay. At other times, chlorophyll *a* was generally similar throughout the bay. There are no MWQSOGs or CCME guidelines for chlorophyll *a*.

Baseline data are too limited to determine if any changes to chlorophyll *a* concentrations that were observed can be attributed to the Project.

4.4.6 Metals and Major Ions

During 2011/2012 and 2014/2015 Operation, aluminum and iron increased in Sturgeon Bay near the Dauphin River; however, concentrations remained within the baseline range for Sturgeon Bay. During 2011/2012 Operation, methyl mercury was more frequently detected and at higher concentrations near the Dauphin River than in the rest of Sturgeon Bay. Similarly, In March 2015, during 2014/2015 Operation, methyl mercury was detected near the Dauphin River and Willow Point but not at other sites in Sturgeon Bay; concentrations were well below the MWQSOGs/CCME PAL (4 ng/L). From 2012-2014, chloride concentrations were more frequently above the CCME long-term PAL (120 mg/L) in areas of Sturgeon Bay away from the Dauphin River than during baseline (i.e., the area of high chloride concentrations in the bay increased). There were no other exceedances of MWQSOGs/CCME PAL and/or drinking water for metals or major ions that could be attributed to the Project.

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Appendix D. LSMEOC Species Lists

MBCDC List of Known Plants for the Interlake Plain Ecoregion

Common Name	Scientific Name	MBCDC Listing
Alternate-leaved dogwood	*Cornus alternifolia*	S3
American germander	*Teucrium canadense*	S3S4
Arethusa	*Arethusa bulbosa*	S2
Beggar's-lice	*Desmodium canadense*	S2
Black ash	*Fraxinus nigra*	S3
Bog adder's-mouth	*Malaxis paludosa*	S1
Bristly buttercup	*Ranunculus hispidus* var. *caricetorum*	S2
Canada yew	*Taxus canadensis*	S3
Canada brome grass	*Bromus pubescens*	SNA
Cliff-brake	*Pellaea glabella* ssp. *occidentalis*	S2
Closed gentian	*Gentiana rubricaulis*	S2S3
Common agrimony	*Agrimonia gryposepala*	S1S2
Common moonwort	*Botrychium lunaria*	S3S4
Culver's-root	*Veronicastrum virginicum*	S1
Cynthia	*Krigia biflora*	S2
Daisy-leaf moonwort	*Botrychium matricariifolium*	S1?
Dioecious sedge	*Carex sterilis*	S2
Ditch-stonecrop	*Penthorum sedoides*	S1S2
Dog violet	*Viola conspersa*	S3?
Douglas sedge	*Carex douglasii*	S3?
Dwarf bilberry	*Vaccinium caespitosum*	S3
False dragonhead	*Physostegia virginiana*	SU
False heather	*Hudsonia tomentosa*	S3
False indigo	*Amorpha fruticosa*	S1S2
Field sedge	*Carex conoidea*	S1
Fox sedge	*Carex vulpinoidea*	S3?
Foxtail muhly	*Muhlenbergia andina*	S1
Great plains ladies'-tresses	*Spiranthes magnicamporum*	S1S2
Gastony's cliffbrake	*Pellaea gastonyi*	S1
Green adder's-mouth	*Green adder's-mouth*	S2?
Green needle grass	*Nassella viridula*	S3
Grooved yellow flax	*Linum sulcatum*	S3
Hairy bugseed	*Corispermum villosum*	S1S2
Hairy-fruited parsley	*Lomatium foeniculaceum*	S3
Hooker's orchid	*Platanthera hookeri*	S2
Horned beakrush	*Rhynchospora capillacea*	S2
Horned bladderwort	*Utricularia cornuta*	S3
Houghton's umbrella-sedge	*Cyperus houghtonii*	S2
Indian milkvetch	*Astragalus australis*	S1?
Interrupted fern	*Osmunda claytoniana*	S3

Common Name	Scientific Name	MBCDC Listing
Iowa golden-saxifrage	*Chrysosplenium iowense*	S1?
Large northern aster	*Canadanthus modestus*	S2
Large white-flowered ground-cherry	*Leucophysalis grandiflora*	S3
Leathery grape-fern	*Botrychium multifidum*	S3
Lesser Bladderwort	*Utricularia minor*	S3
Livid sedge	*Carex livida*	S3
Long-fruited parsley	*Lomatium macrocarpum*	S3
Louisiana broom-rape	*Orobanche ludoviciana*	S2
Lyre-leaved rock cress	*Arabis lyrata*	S2?
Milkvetch	*Astragalus neglectus*	S1
Narrow-leaved milkvetch	*Astragalus pectinatus*	S2S3
Narrow-leaved gerardia	*Agalinis tenuifolia*	S2S3
Narrow-leaved water-plantain	*Alisma gramineum*	S1
New Jersey tea	*Ceanothus herbaceus*	S3
Northern adder's-tongue	*Ophioglossum pusillum*	S1
Northern spike-moss	*Selaginella selaginoides*	S4
Oblong-leaved sundew	*Drosera anglica*	S3
Papoose-root	*Caulophyllum thalictroides*	S2
Parry's sedge	*Carex parryana*	S3?
Pinweed	*Lechea intermedia*	S1
Plains rough fescue	*Festuca hallii*	S3
Prairie moonwort	*Botrychium campestre*	S1
Prairie spike-moss	*Selaginella densa*	S3
Porcupine Sedge	*Carex hystericina*	S3?
Porter's chess	*Bromus porteri*	S3?
Purple locoweed	*Oxytropis lambertii*	S3S4
Ram's head lady's-slipper	*Cypripedium arietinum*	S2S3
Red-root flatsedge	*Cyperus erythrorhizos*	S1
Richardson needle grass	*Achnatherum richardsonii*	S1S2
Riddell's goldenrod	*Solidago riddellii*	S2
Rigid sedge	*Carex tetanica*	S2
Riverbank Grape	*Vitis riparia*	S3S4
Rough purple false-foxglove	*Agalinis aspera*	S1S2
Round-leaved bog orchid	*Platanthera orbiculata*	S3
Round-leaved pyrola	*Pyrola americana*	S2
Sensitive fern	*Onoclea sensibilis*	S3S4
Sharp-toothed goldenrod	*Solidago juncea*	S2
Side-oats grama	*Bouteloua curtipendula*	S2S3
Small grass-of-parnassus	*Parnassia palustris* var. *parviflora*	S1
Small white lady's-slipper	*Cypripedium candidum*	S2
Spikenard	*Aralia racemosa*	S2
Spring cress	*Cardamine bulbosa*	SH
Stalked sedge	*Carex pedunculata*	S3?
Stiff sunflower	*Helianthus pauciflorus ssp*	SU
Striped coralroot	*Corallorhiza striata*	S3S4

Common Name	Scientific Name	MBCDC Listing
Sundrops	*Oenothera perennis*	S1S2
Swamp-pink	*Calopogon tuberosus*	S2
Twig rush	*Cladium mariscoides*	S2
Virgin's-bower	*Clematis virginiana*	S2
Waxleaf meadow-rue	*Thalictrum revolutum*	S1
Weak sedge	*Carex supina* var. *spaniocarpa*	S2?
Western prairie fringed orchid	*Platanthera praeclara*	S1
Western silvery aster	*Symphyotrichum sericeum*	S2S3
Western virgin's-bower	*Clematis ligusticifolia*	S1
White adder's-mouth	*Malaxis monophyllos*	S2?
White beakrush	*Rhynchospora alba*	S3?
White boltonia	*Boltonia asteroides* var. *recognita*	S2S3
White-eyed grass	*Sisyrinchium campestre*	SU
White heath aster	*Symphyotrichum ericoides* var. *ericoides*	S3?
Whorled loosestrife	*Lysimachia quadriflora*	S2
Whorled milkweed	*Asclepias verticillata*	S3
Whorled milkwort	*Polygala verticillata*	S2
Wild crane's-bill	*Geranium maculatum*	S1
Wild ginger	*Asarum canadense*	S3S4
Woodland lettuce	*Lactuca floridana*	SH
Yellow sedge	*Carex flava*	S2S3
Yellow stargrass	*Hypoxis hirsuta*	S4
Yellow twayblade	*Liparis loeselii*	S3S4

Source: MBCDC (2015)

MBCDC (2015) Definitions for Status Listing:

1 Very rare throughout its range or in the province (5 or fewer occurrences, or very few remaining individuals). May be especially vulnerable to extirpation.

2 Rare throughout its range or in the province (6 to 20 occurrences). May be vulnerable to extirpation.

3 Uncommon throughout its range or in the province (21 to 100 occurrences).

4 Widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (>100 occurrences).

5 Demonstrably widespread, abundant, and secure throughout its range or in the province, and essentially impossible to eradicate under present conditions.

U Possibly in peril, but status uncertain; more information needed.

H Historically known; may be rediscovered.

X Believed to be extinct; historical records only, continue search.

SNR A species not ranked. A rank has not yet assigned or the species has not been evaluated.

SNA A conservation status rank is not applicable to the element.

S#S# Numeric range rank: A range between two of the numeric ranks. Denotes range of uncertainty about the exact rarity of the species.

?* Inexact or uncertain; for numeric ranks, denotes inexactness.

List of Known Mammals for the Interlake Plain Ecoregion

Common Name	Scientific Name	Conservation Listing (SARA, MBESEA, MBCDC)
American beaver	*Castor canadensis*	Not Listed
American black bear	*Ursus americanus*	Not Listed
American deer mouse	*Peromyscus maniculatus*	Not Listed
American elk	*Cervus canadensis*	Not Listed
American marten	*Martes americana*	Not Listed
American mink	*Neovison vison*	Not Listed
American water shrew	*Sorex palustris*	Not Listed
Arctic shrew	*Sorex arcticus*	Not Listed
Big brown bat	*Eptesicus fuscus*	Not Listed
Canada lynx	*Lynx canadensis*	Not Listed
Coyote	*Canis latrans*	Not Listed
Eastern heather vole	*Phenacomys ungava*	Not Listed
Eastern fox squirrel	*Sciurus niger*	Not Listed
Eastern-red bat	*Lasiurus borealis*	Not Listed
Ermine (short-tailed weasel)	*Mustela erminea*	Not Listed
Fisher	*Martes pennanti*	Not Listed
Grey wolf	*Canis lupus*	Not Listed
Hoary bat	*Lasiurus cinereus*	Not Listed
House mouse	*Mus musculus*	Not Listed
Least chipmunk	*Eutamias minimus*	Not Listed
Least weasel	*Mustela nivalis*	Not Listed
Little brown myotis	*Myotis lucifugus*	Endangered- Schedule 1- S2N
Long-tailed weasel	*Mustela frenata*	Not Listed
Masked shrew	*Sorex cinereus*	Not Listed
Meadow jumping mouse	*Zapus hudsonius*	Not Listed
Meadow vole	*Microtus pennsylvanicus*	Not Listed
Moose	*Alces alces*	Not Listed
Muskrat	*Ondatra zibethicus*	Not Listed
North American porcupine	*Erethizon dorsatum*	Not Listed
Northern bog lemming	*Synaptomys borealis*	Not Listed
Northern flying squirrel	*Glaucomys sabrinus*	Not Listed
Northern long-eared (northern myotis)	*Myotis septentrionalis*	Endangered- Schedule 1- not listed by MCDC for Interlake Plain Ecoregion
Plains pocket gopher	*Geomys bursarius*	S3
Pygmy shrew	*Sorex hoyi*	Not Listed

Common Name	Scientific Name	Conservation Listing (SARA, MBESEA, MBCDC)
Raccoon	*Procyon lotor*	Not Listed
Red fox	*Vulpes vulpes*	Not Listed
Red squirrel	*Tamisciurus hudsonicus*	Not Listed
River otter	*Lontra canadensis*	Not Listed
Short-tailed shrew	*Blarina brevicauda*	Not Listed
Silver-haired bat	*Lasionycteris noctivagans*	Not Listed
Snowshoe hare	*Lepus americanus*	Not Listed
Star-nosed mole	*Condylura cristata*	S3
Striped skunk	*Mephitis mephitis*	Not Listed
White-tailed deer	*Odocoileus virginianus*	Not Listed
Woodchuck	*Marmota monax*	Not Listed
Wood bison	*Bos bison athabascae*	Special Concern-Schedule 1- SNA

Sources: Caras (1967); Reid (2006); MBCDC (2015); and SARA (2015)

MBCDC (2015) Definitions for Status Listing:

1 Very rare throughout its range or in the province (5 or fewer occurrences, or very few remaining individuals). May be especially vulnerable to extirpation.

2 Rare throughout its range or in the province (6 to 20 occurrences). May be vulnerable to extirpation.

3 Uncommon throughout its range or in the province (21 to 100 occurrences).

4 Widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (>100 occurrences).

5 Demonstrably widespread, abundant, and secure throughout its range or in the province, and essentially impossible to eradicate under present conditions.

U Possibly in peril, but status uncertain; more information needed.

H Historically known; may be rediscovered.

X Believed to be extinct; historical records only, continue search.

SNR A species not ranked. A rank has not yet assigned or the species has not been evaluated.

SNA A conservation status rank is not applicable to the element.

S#S# Numeric range rank: A range between two of the numeric ranks. Denotes range of uncertainty about the exact rarity of the species.

?* Inexact or uncertain; for numeric ranks, denotes inexactness.

SARA (2015) Definitions for Status Listing:

Schedule 1: is the official list of species that are classified as extirpated, endangered, threatened, and of special concern.

Threatened: a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.

Special Concern: a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.

Endangered: A wildlife species facing imminent extirpation or extinction.

List of Known Amphibians and Reptiles for the Interlake Plain Ecoregion

Common Name	Scientific Name	Conservation Status (SARA, MBESEA, MBCDC)
Blue-spotted salamander	*Ambystoma laterale*	S3S4
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	S2
Canadian Toad	*Anaxyrus hemiophrys*	Not Listed
Grey tree frog	*Hyla versicolor*	Not Listed
Boreal chorus frog	*Pseudacris maculata*	Not Listed
Wood frog	*Rana sylvatica*	Not Listed
Smooth green snake	*Liochlorophis vernalis*	S3S4
Northern Leopard Frog	*Lithobates pipiens*	Special Concern - Schedule 1 - S4
Western plains garter snake	*Thamnophis radix haydenii*	Not Listed
Red-sided garter snake	*Thamnopis sirtalis parietalis*	Not Listed

Sources: Conant and Collins (1991); Science Team Report (2002); MBCDC (2015); Nature North (2014); and SARA (2015)

MBCDC (2013) Definitions for Status Listing:

1 Very rare throughout its range or in the province (5 or fewer occurrences, or very few remaining individuals). May be especially vulnerable to extirpation.

2 Rare throughout its range or in the province (6 to 20 occurrences). May be vulnerable to extirpation.

3 Uncommon throughout its range or in the province (21 to 100 occurrences).

4 Widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (>100 occurrences).

5 Demonstrably widespread, abundant, and secure throughout its range or in the province, and essentially impossible to eradicate under present conditions.

U Possibly in peril, but status uncertain; more information needed.

H Historically known; may be rediscovered.

X Believed to be extinct; historical records only, continue search.

SNR A species not ranked. A rank has not yet assigned or the species has not been evaluated.

SNA A conservation status rank is not applicable to the element.

S#S# Numeric range rank: A range between two of the numeric ranks. Denotes range of uncertainty about the exact rarity of the species.

?* Inexact or uncertain; for numeric ranks, denotes inexactness.

SARA (2015) Definitions for Status Listing:

Schedule 1: is the official list of species that are classified as extirpated, endangered, threatened, and of special concern.

Threatened: a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.

Special Concern: a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.

List of Known Birds for the Interlake Plain Ecoregion

Common Name	*Scientific Name*	Conservation Listing (SARA, MBESEA, MBCDC)
Alder flycatcher	*Empidonax alnorum*	Not Listed
American avocet	*Recurvirostra americana*	Not Listed
American bittern	*Botaurus lentiginosus*	Not Listed
American coot	*Fulica americana*	Not Listed
American crow	*Corvus brachyrhynchos*	Not Listed
American golden-plover	*Pluvialis dominica*	Not Listed
American goldfinch	*Carduelis tristis*	Not Listed
American kestrel	*Falco sparverius*	Not Listed
American redstart	*Setophaga ruticilla*	Not Listed
American robin	*Turdus migratorius*	Not Listed
American three-toed woodpecker	*Picoides dorsalis*	Not Listed
American tree sparrow	*Spizella arborea*	Not Listed
American white pelican	*Pelecanus erythrorhynchos*	S3S4B
American wigeon	*Anas americana*	Not Listed
American woodcock	*Scolopax minor*	Not Listed
Bald eagle	*Haliaeetus leucocephalus*	Not Listed
Baltimore oriole	*Icterus galbula*	Not Listed
Bank swallow	*Riparia riparia*	Threatened – no schedule
Barn swallow	*Hirundo rustica*	Threatened – no schedule – S4B
Barred owl	*Strix varia*	S4B
Bay-breasted warbler	*Setophaga castanea*	Not Listed
Belted kingfisher	*Megaceryle alcyon*	Not Listed
Black tern	*Chlidonias niger*	S4B
Black-and-white warbler	*Mniotilta varia*	Not Listed
Black-billed cuckoo	*Coccyzus erythropthalmus*	Not Listed
Black-billed magpie	*Pica hudsonia*	Not Listed
Blackburnian warbler	*Setophaga fusca*	Not Listed
Black-capped chickadee	*Poecile atricapillus*	Not Listed
Black-crowned night heron	*Nycticorax nycticorax*	S3S4B
Blackpoll warbler	*Setophaga striata*	Not Listed
Black-throated blue warbler	*Setophaga caerulescens*	Not Listed
Black-throated green warbler	*Setophaga virens*	Not Listed
Blue jay	*Cyanocitta cristata*	Not Listed
Blue-headed vireo	*Vireo solitarius*	Not Listed
Blue-winged teal	*Anas discors*	Not Listed

Common Name	*Scientific Name*	Conservation Listing (SARA, MBESEA, MBCDC)
Bobolink	*Dolichonyx oryzivorus*	Threatened – no Schedule– S4B
Bonaparte’s gull	*Chroicocephalus philadelphia*	Not Listed
Boreal owl	*Aegolius funereus*	Not Listed
Brewer’s blackbird	*Euphagus cyanocephalus*	Not Listed
Broad-winged hawk	*Buteo platypterus*	Not Listed
Brown creeper	*Certhia americana*	Not Listed
Brown thrasher	*Toxostoma rufum*	Not Listed
Brown-headed cowbird	*Molothrus ater*	Not Listed
Bufflehead	*Bucephala albeola*	Not Listed
Cackling goose	*Branta hutchinsii*	Not Listed
California gull	*Larus californicus*	Not Listed
Canada goose	*Branta canadensis*	Not Listed
Canada warbler	*Cardellina canadensis*	Threatened – Schedule 1 – S4B
Canvasback	*Aythya valisineria*	Not Listed
Cape may warbler	*Setophaga tigrina*	Not Listed
Caspian tern	*Sterna caspia*	S3S4B
Cedar waxwing	*Bombycilla cedrorum*	Not Listed
Chestnut-sided warbler	*Setophaga pensylvanica*	Not Listed
Chimney swift	*Chaetura pelagica*	Threatened – Schedule 1 – S2B
Chipping sparrow	*Spizella passerina*	Not Listed
Clay-colored sparrow	*Spizella pallida*	Not Listed
Cliff swallow	*Petrochelidon pyrrhonota*	Not Listed
Common goldeneye	*Bucephala clangula*	Not Listed
Common grackle	*Quiscalus quiscula*	Not Listed
Common loon	*Gavia immer*	Not Listed
Common merganser	*Mergus merganser*	Not Listed
Common nighthawk	*Chordeiles minor*	Threatened – Schedule 1 – S3B
Common raven	*Corvus corax*	Not Listed
Common redpoll	*Acanthus flammea*	Not Listed
Common tern	*Sterna hirundo*	Not Listed
Common yellowthroat	*Geothlypis trichas*	Not Listed
Connecticut warbler	*Oporornis agilis*	Not Listed
Cooper's hawk	*Accipiter cooperii*	S4S5B
Dark-eyed junco	*Junco hyemalis*	Not Listed
Double-crested cormorant	*Phalacrocorax auritus*	S5B
Downy woodpecker	*Picoides pubescens*	Not Listed
Eared grebe	*Podiceps nigricollis*	S4S5B
Eastern bluebird	*Sialia sialis*	Not Listed

Common Name	*Scientific Name*	Conservation Listing (SARA, MBESEA, MBCDC)
Eastern kingbird	*Tyrannus tyrannus*	Not Listed
Eastern phoebe	*Sayornis phoebe*	Not Listed
Eastern towhee	*Pipilo erythrophthalmus*	S4B
Eastern whip-poor-will	*Antrostomus vociferus*	Threatened – Schedule 1 – S3B
Eastern wood-pewee	*Contopus virens*	Special Concern – no schedule
Eastern-screech owl	*Megascops asio*	Not Listed
Eurasian collared dove	*Streptopelia decaocto*	Not Listed
European starling	*Sturnus vulgaris*	Not Listed
Evening grosbeak	*Coccothraustes vespertinus*	Not Listed
Forster's tern	*Sterna forsteri*	S4B
Fox sparrow	*Passerella iliaca*	Not Listed
Franklin's gull	*Leucophaeus pipixcan*	Not Listed
Gadwell	*Anas strepera*	Not Listed
Golden-winged warbler	*Vermivora chrysoptera*	Threatened – Schedule 1 – S3B
Grasshopper sparrow	*Ammodramus savannarum*	S2B
Gray jay	*Perisoreus canadensis*	Not Listed
Gray partridge	*Perdix perdix*	Not Listed
Great blue heron	*Ardea herodias*	S4S5B
Great crested flycatcher	*Myiarchus crinitus*	Not Listed
Great egret	*Ardea alba*	Not Listed
Great grey owl	*Strix nebulosa*	Not Listed
Great horned owl	*Bubo virginianus*	Not Listed
Greater scaup	*Aythya marila*	Not Listed
Greater white-fronted goose	*Anser albifrons*	Not Listed
Greater yellowlegs	*Tringa melanoleuca*	Not Listed
Green winged teal	*Anas carolinensis*	Not Listed
Grey catbird	*Dumetella carolinensis*	Not Listed
Hairy woodpecker	*Leuconotopicus villosus*	Not Listed
Harris's sparrow	*Zonotrichia querula*	Not Listed
Hermit thrush	*Catharus guttatus*	Not Listed
Herring gull	*Larus argentatus*	Not Listed
Hooded merganser	*Lophodytes cucullatus*	Not Listed
Horned grebe	*Podiceps auritus*	Special concern – no Schedule - S3B
Horned lark	*Eremophila alpestris*	Not Listed
House finch	*Carpodacus mexicanus*	Not Listed
House sparrow	*Passer domesticus*	Not Listed
Indigo bunting	*Passerina cyanea*	Not Listed

Common Name	*Scientific Name*	Conservation Listing (SARA, MBESEA, MBCDC)
Killdeer	*Charadrius vociferus*	Not Listed
Lapland longspur	*Calcarius lapponicus*	Not Listed
Lark sparrow	*Chondestes grammacus*	Not Listed
Le Conte's sparrow	*Ammodramus leconteii*	Not Listed
Least bittern	*Ixobrychus exilis*	Threatened – Schedule 1 – S2S3B
Least flycatcher	*Empidonax minimus*	Not Listed
Least sandpiper	*Calidris minutilla*	Not Listed
Lesser scaup	*Aythya affinis*	Not Listed
Lesser yellowlegs	*Tringa flavipes*	Not Listed
Lincoln's sparrow	*Melospiza lincolnii*	Not Listed
Loggerhead Shrike	*Lanius ludovicianus excubitorides*	Threatened – Schedule 1 – S1B
Long-eared owl	*Asio otus*	Not Listed
Magnolia warbler	*Setophaga magnolia*	Not Listed
Mallard	*Anas platyrhynchos*	Not Listed
Marbled godwit	*Limosa fedoa*	Not Listed
Marsh wren	*Cistothorus palustris*	Not Listed
Merlin	*Falco columbarius*	Not Listed
Mountain bluebird	*Sialia currucoides*	Not Listed
Mourning dove	*Zenaida macroura*	Not Listed
Mourning warbler	*Geothlypis philadelphia*	Not Listed
Nashville warbler	*Leiothlypis ruficapilla*	Not Listed
Nelson's sparrow	*Ammodramus nelsoni*	Not Listed
Northern flicker	*Colaptes auratus*	Not Listed
Northern goshawk	*Accipiter gentilis*	Not Listed
Northern harrier	*Circus cyaneus*	Not Listed
Northern hawk owl	*Surnia ulula*	Not Listed
Northern parula	*Setophaga americana*	Not Listed
Northern pintail	*Anas acuta*	Not Listed
Northern rough-winged swallow	*Stelgidopteryx serripennis*	Not Listed
Northern saw-whet owl	*Aegolius acadicus*	Not Listed
Northern shoveler	*Anas clypeata*	Not Listed
Northern waterthrush	*Parkesia noveboracensis*	Not Listed
Olive-sided flycatcher	*Contopus cooperi*	Threatened – Schedule 1 – S3S4B
Orange-crowned warbler	*Vermivora celata*	Not Listed
Orchard oriole	*Icterus spurius*	Not Listed
Osprey	*Pandion haliaetus*	Not Listed

Common Name	*Scientific Name*	Conservation Listing (SARA, MBESEA, MBCDC)
Ovenbird	*Seiurus*	Not Listed
Palm warbler	*Setophaga palmarum*	Not Listed
Pectoral sandpiper	*Calidris melanotos*	Not Listed
Peregrine falcon	*Falco peregrinus anatum*	Special Concern- no Schedule – S1B
Philadelphia vireo	*Vireo philadelphicus*	Not Listed
Piebald grebe	*Podilymbus podiceps*	Not Listed
Pileated woodpecker	*Hylatomus pileatus*	Not Listed
Pine grosbeak	*Pinicola enucleator*	Not Listed
Pine siskin	*Carduelis pinus*	Not Listed
Pine warbler	*Setophaga pinus*	Not Listed
Piping plover	*Charadrius melodus*	Endangered – Schedule 1 – S1B
Purple finch	*Haemorhous purpureus*	Not Listed
Purple martin	*Progne subis*	Not Listed
Red crossbill	*Loxia curvirostra*	Not Listed
Red-breasted merganser	*Mergus serrator*	Not Listed
Red-breasted nuthatch	*Sitta canadensis*	Not Listed
Red-eyed vireo	*Vireo olivaceus*	Not Listed
Redhead	*Aythya americana*	Not Listed
Red-headed woodpecker	*Melanerpes erythrocephalus*	Threatened – Schedule 1 – S2B
Red-necked grebe	*Podiceps grisegena*	Not Listed
Red-tailed hawk	*Buteo jamaicensis*	Not Listed
Red-winged blackbird	*Agelaius phoeniceus*	Not Listed
Ring-billed gull	*Larus delawarensis*	Not Listed
Ring-necked duck	*Aythya collaris*	Not Listed
Rock pigeon	*Columba livia*	Not Listed
Rose-breasted grosbeak	*Pheucticus ludovicianus*	Not Listed
Rough-legged hawk	*Buteo lagopus*	Not Listed
Ruby-crowned kinglet	*Regulus calendula*	Not Listed
Ruby-throated hummingbird	*Archilochus colubris*	Not Listed
Ruddy duck	*Oxyura jamaicensis*	Not Listed
Ruffed grouse	*Bonasa umbellus*	Not Listed
Rusty blackbird	*Euphagus carolinus*	Special Concern –Schedule 1 – not ranked by MBCDC for Interlake Plain EcoRegion
Sanderling	*Calidris alba*	Not Listed
Sandhill crane	*Grus canadensis*	Not Listed
Savannah sparrow	*Passerculus sandwichensis*	Not Listed
Scarlet tanager	*Piranga olivacea*	Not Listed

Common Name	*Scientific Name*	Conservation Listing (SARA, MBESEA, MBCDC)
Sedge wren	*Cistothorus platensis*	Not Listed
Semi-palmated sandpiper	*Calidris pusilla*	Not Listed
Sharp-skinned hawk	*Accipiter striatus*	Not Listed
Sharp-tailed grouse	*Tympanuchus phasianellus*	Not Listed
Short-billed dowitcher	*Limnodromus griseus*	Not Listed
Short-eared owl	*Asio flammeus*	Special Concern –Schedule 1 – S2S3B
Snow bunting	*Plectrophenax nivalis*	Not Listed
Snow goose	*Chen caerulescens*	Not Listed
Solitary sandpiper	*Tringa solitaria*	Not Listed
Song sparrow	*Melospiza melodia*	Not Listed
Sora	*Porzana carolina*	Not Listed
Spotted sandpiper	*Actitis macularius*	Not Listed
Sprague's pipit	*Anthus spragueii*	Threatened – Schedule 1 – S2B
Spruce grouse	*Falcipennis canadensis*	Not Listed
Swainson's hawk	*Buteo swainsoni*	Not Listed
Swainson's thrush	*Catharus ustulatus*	Not Listed
Swamp sparrow	*Melospiza georgiana*	Not Listed
Tennessee warbler	*Leiothlypis peregrina*	Not Listed
Tree swallow	*Tachycineta bicolor*	Not Listed
Trumpeter Swan	*Cygnus buccinator*	S1S2B
Tundra swan	*Cygnus columbianus*	Not Listed
Turkey vulture	*Cathartes aura*	Not Listed
Upland sandpiper	*Bartramia longicauda*	Not Listed
Veery	*Catharus fuscescens*	Not Listed
Vesper sparrow	*Pooecetes gramineus*	Not Listed
Virginia rail	*Rallus limicola*	Not Listed
Warbling vireo	*Vireo gilvus*	Not Listed
Western grebe	*Aechmophorus occidentalis*	S4B
Western kingbird	*Tyrannus verticalis*	Not Listed
Western meadowlark	*Sturnella neglecta*	Not Listed
White-breasted nuthatch	*Sitta carolinensis*	Not Listed
White-crowned sparrow	*Zonotrichia leucophrys*	Not Listed
White-throated sparrow	*Zonotrichia albicollis*	Not Listed
White-winged crossbill	*Loxia leucoptera*	Not Listed
Willet	*Tringa semipalmata*	Not Listed
Wilson's phalarope	*Phalaropus tricolor*	Not Listed
Wilson's snipe	*Gallinago delicata*	Not Listed

Common Name	*Scientific Name*	Conservation Listing (SARA, MBESEA, MBCDC)
Wilson's warbler	*Cardellina pusilla*	Not Listed
Winter wren	*Troglodytes hiemalis*	Not Listed
Wood duck	*Aix sponsa*	Not Listed
Yellow rail	*Coturnicops noveboracensis*	Special Concern –Schedule 1 – S3S4B
Yellow warbler	*Setophaga petechia*	Not Listed
Yellow-bellied flycatcher	*Empidonax flaviventris*	Not Listed
Yellow-bellied sapsucker	*Sphyrapicus varius*	Not Listed
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	Not Listed
Yellow-rumped warbler	*Setophaga coronata*	Not Listed
Yellow-throated vireo	*Vireo flavifrons*	Not Listed

Sources: Bezener and De Smet (2000); Peterson and Peterson (2002); Manitoba Avian Research Committee (2003); MBCDC (2015); SARA (2015); and MBBA (2015)

MBCDC (2015) Definitions for Status Listing:

1 Very rare throughout its range or in the province (5 or fewer occurrences, or very few remaining individuals). May be especially vulnerable to extirpation.

2 Rare throughout its range or in the province (6 to 20 occurrences). May be vulnerable to extirpation.

3 Uncommon throughout its range or in the province (21 to 100 occurrences).

4 Widespread, abundant, and apparently secure throughout its range or in the province, with many occurrences, but the element is of long-term concern (>100 occurrences).

5 Demonstrably widespread, abundant, and secure throughout its range or in the province, and essentially impossible to eradicate under present conditions.

U Possibly in peril, but status uncertain; more information needed.

H Historically known; may be rediscovered.

X Believed to be extinct; historical records only, continue search.

SNR A species not ranked. A rank has not yet assigned or the species has not been evaluated.

SNA A conservation status rank is not applicable to the element.

S#S# Numeric range rank: A range between two of the numeric ranks. Denotes range of uncertainty about the exact rarity of the species.

?* Inexact or uncertain; for numeric ranks, denotes inexactness.

B Breeding status of a migratory species. Example: S1B,SZN - breeding occurrences for the species are ranked S1 (critically imperilled) in the province, nonbreeding occurrences are not ranked in the province.

SARA (2015) Definitions for Status Listing:

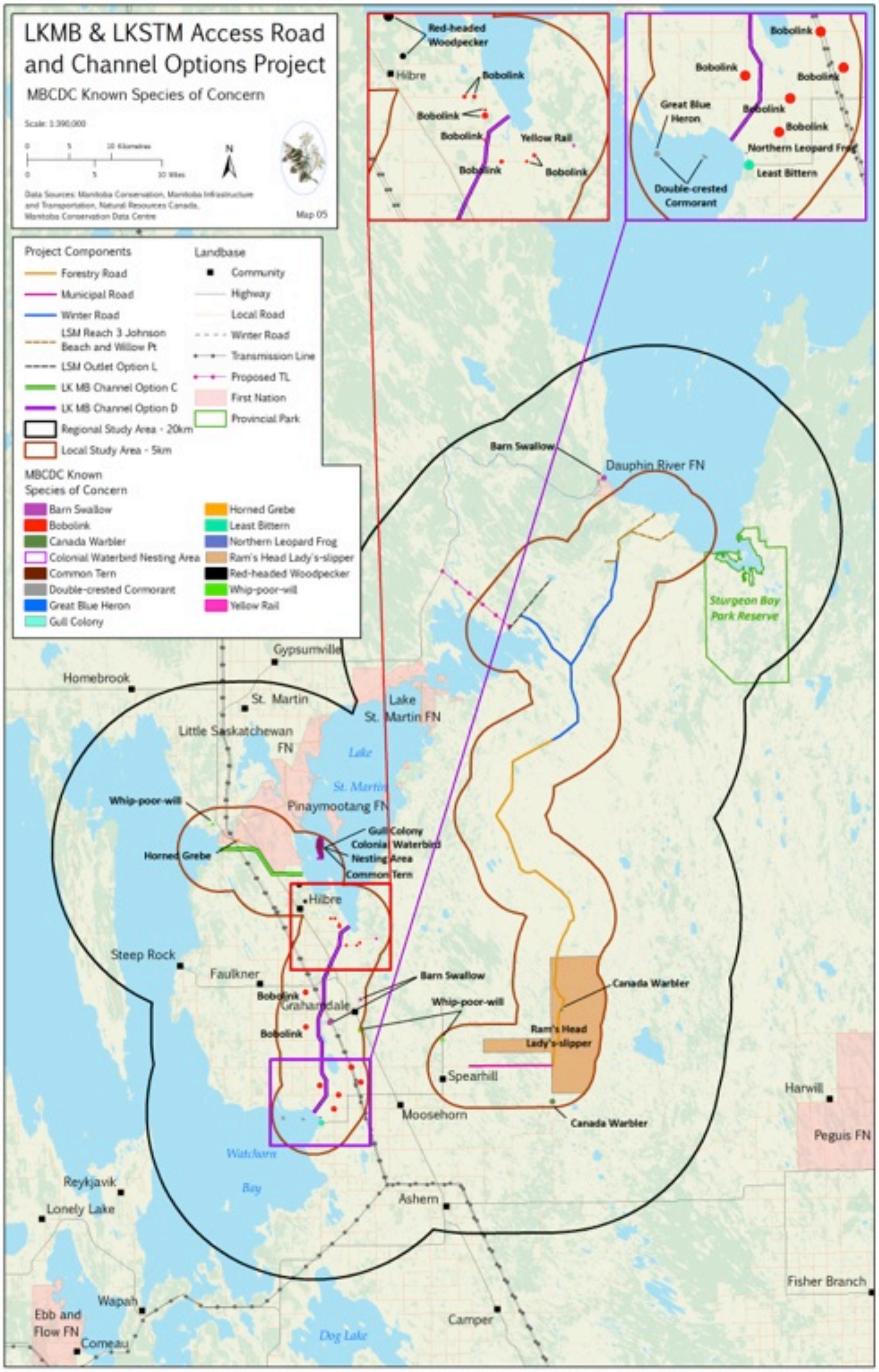
Schedule 1: is the official list of species that are classified as extirpated, endangered, threatened, and of special concern.

Schedule 2: species listed in Schedule 2 are species that had been designated as endangered or threatened, and have yet to be re-assessed by COSEWIC using revised criteria. Once these species have been re-assessed, they may be considered for inclusion in Schedule 1.

Schedule 3: species listed in Schedule 3 are species that had been designated as special concern, and have yet to be re-assessed by COSEWIC using revised criteria. Once these species have been re-assessed, they may be considered for inclusion in Schedule 1.

Special Concern: a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.

Threatened: a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.



Map 5 MBCDC Known Species of Concern within the RSA

Appendix E. LSMEOC Summary of Debris Monitoring

The following sections have been taken from Lake St. Martin Emergency Outlet Channel Monitoring Report – Debris Monitoring Draft Report 2016. (North/South, 2016)

4.17 Comparison of 2011/2012 Closure and 2014/2015 Operation data

4.1.7.1 Debris Levels and Composition

When the debris monitoring data from 2011/2012 Operation (spring and fall 2013 and spring 2014) are compared to the data from 2014/2015 Operation (summer and fall 2014 and spring 2015), the most obvious difference between the two Project phases is that all nets monitored during 2011/2012 Closure accumulated some level of debris (except for two that were tailed back to the dock), while 54% (n=36) of the nets monitored during 2014/2015 Operation contained none (Table 7). As described above, commercial fishers avoid fishing in areas of Sturgeon Bay that are known to accumulate large amounts of debris in the water column, and they will also move their nets either up or down in the water column to avoid debris. When the net set locations during 2011/2012 Closure are compared to the locations fished during 2014/2015 Operation, it is obvious that fewer nets were set in the vicinity of the Dauphin River outflow during 2104/2015 Operation (Figures 6, 8, 10, 12, 14 and 16). This may be because the commercial fishermen expected increased amounts of debris to be washed downstream out of Buffalo Creek and into Sturgeon Bay during 2014/2015 Operation and not a decision based on time of year, distribution of target species, or other factor.

While the data from summer/fall 2014 and spring 2015 do indicate that nets set in the vicinity of the Dauphin River outflow were more likely to accumulate debris than nets set in other parts of Sturgeon Bay (Tables 10, 15, 20, 25, 30 and 35), it is possible that debris is always more likely to accumulate in nets set in the vicinity of the Dauphin River outflow. Unfortunately, because nets were almost exclusively set in the vicinity of the Dauphin River outflow during 2011/2012 Closure, there are no debris data from remote sites during Reach 1 closure that can be used to make this comparison. Nonetheless, the debris monitoring results from 2014/2015 Operation suggest that debris is in fact more likely to accumulate in nets set in the vicinity of the Dauphin River outflow because nets set during 2011/2012 Closure always contained some level of debris, while the majority of nets set during 2014/2015 Operation contained no debris.

Debris composition was also more variable during 2014/2015 Operation than 2011/2012 Closure (Figures 7, 9, 11, 13, 15 and 17). While the debris observed during 2011/2012 Operation was almost entirely aquatic vegetation with small numbers of sticks interspersed, algae, grass and silt were frequently observed in nets monitored during 2014/2015 Operation, and each of these debris types were dominant in some of the nets. This difference is likely due to the wider variety of gillnetting locations fished during 2014/2015 Operation.

4.1.7.2 Fishing Effort and Catch

As described in Section 3.2.3.2, when the commercial fishing debris monitoring program was initiated in 2013, the amount of time that it took commercial fishermen to complete six different tasks was recorded by an observer in the boat. Tables that present the 2013 data that were recorded for all six tasks can be found in Appendix B. Based on the results of monitoring in spring and fall 2013, it was decided that only the amount of time it took to service the net (a debris-dependent activity) and the amount of time it took to clean each net's catch (a debris-independent activity when divided by the number of fish captured) were relevant and would be recorded. For the purpose of comparing between monitoring years, only the net service times and the fish cleaning times from 2013 will be discussed in detail here.

While a total of 135 net sets were monitored for debris between spring 2013 and spring 2015 (Table 7), roughly a quarter of these nets will not be considered here because they either remained in the water for more than one overnight (usually due to high winds or storms, which can further increase debris transport and accumulation, particularly large woody debris), the number of fish captured was not recorded, or net servicing time was not recorded or was recorded improperly. After these net sets were excluded, 105 net sets across six monitoring seasons remained. The majority of these nets contained either no debris (n = 32) or a low level of debris (n = 56), while a smaller number contained either a medium (n =-14) or high level (n = 2) of debris. The three net sets with very high debris were excluded because a net servicing time was not recorded for DN-06(c) and because DN-29(c) and DN-30(c) remained in the water for 48 hours. Of the four nets that contained high levels of debris, only DN-29(b) and DN-46 were examined further because the net servicing time for DN-01(c) included the fish cleaning time and therefore could not be used, and DN-65 remained in the water for approximately 72 hours.

Initially, each season's effort data were analyzed separately, but trends were not obvious because of the small sample size for each level of debris accumulation (see Appendix C for each season's individual results). Even when the data were divided into monitoring conducted during 2011/2012 Closure (spring and fall 2013, spring 2014) and 2014/2015 Operation (summer and fall 2014, spring 2015), sample sizes were still too small to reasonably compare the effort required to service nets that had accumulated different levels of debris (Tables 40 and 41).

When the total data set of 105 net sets was combined (Table 42), a reasonable sample size was attained for nets that accumulated no debris, a low level of debris, and a medium level of debris, but the available data only included two nets with a high level of debris. As the sample size for a high level of debris was too small to provide meaningful insight, the two nets were excluded from further discussion of the results. It should be noted that the mean CPUE for the two nets with a high level of debris was slightly lower than the mean catch for nets that had accumulated low and medium levels of debris, and the amount of time required to service each panel was much higher.

The combined results from all monitoring seasons (n=103) suggest that the number of fish caught was fairly consistent regardless of the amount of debris (none, a low level, or a medium level) that accumulated in the net (Table 42), although nets that contained no debris had a lower CPUE than nets that had accumulated low and medium levels of debris. The amount of time spent servicing their nets (per fish) was almost identical across the three debris level categories, and the amount of time that it took to service an individual panel was similar across different levels of debris accumulation, although it took longer to reset nets that had accumulated debris. As was expected, the average amount of time that it took to clean each fish was similar across all levels of debris accumulation.

While fishing effort does not appear to increase with increased levels of debris (Table 42), mean CPUE did decrease slightly as debris level increased, although mean CPUE was lowest for nets with no debris (Tables 40, 41 and 42). When mean CPUE is examined by Project phase, it was much higher during 2011/2012 Operation than 2014/2015 Operation. Some of this variation appears to be a result of the commercial fishermen setting their nets in different areas of Sturgeon Bay during 2014/2015 Operation, as the highest CPUEs observed during 2011/2012 Operation were at sites in the vicinity of the Dauphin River and/or closer to shore than the sites fished during 2014/2015 Operation. It should be noted that areas that were fished in both phases of the Project had higher CPUEs during 2011/2012 Closure, indicating a potentially higher abundance of fish during this Project phase. Whether this difference was a result of seasonal differences in water temperature (monitoring was conducted on similar dates between years), or some other environmental factor such as Reach 1 being inoperative, is not known.

The number of species of fish captured was consistently higher in fall (n = 11-13) than spring or summer (n = 8-9) (Tables 11, 16, 21, 31 and 36), and the increased variety of locations fished in fall 2014 is the likely reason for the highest number of species being captured during that season. Regardless of Project phase, Walleye and White Sucker were the dominant species in the spring catch, although CPUE decreased from 2011/2012 Closure to 2014/2015 Operation (possibly as a result of different fishing locations between Project phases; see above) (Tables 11, 21 and 36). Species composition for the fall catch was also consistent between years, but the dominant species in the fall 2013 catch differed from the fall 2014 catch: Lake Whitefish and White Sucker were dominant in 2013, while Walleye and Northern Pike were dominant in 2014 (Tables 16 and 31) . Differences in species dominance are probably explained by the fact that debris monitoring was conducted in two phases: it started at the beginning of October (when Lake Whitefish and White Sucker dominated the catch, as they had in fall 2013), was halted for approximately two weeks due to inclement weather, and then resumed (and Walleye and Northern Pike began to dominate the catch) (Table 32).

Table 40. Comparison of mean fish catch, pull time and fish cleaning time by debris level, 2011/2012 Closure.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
Low	35	123	42.09	64.9	20.45	0.68	48.9 [2]	0.58 [2]
Medium	9	98	39.27	62.3	21.37	0.71	45.3	0.44
High	1	70	36.79	70.0	35.00	1.00	10.0	0.14
Total	45	117	41.41	64.5	20.96	0.69	46.3 [3]	0.52 [3]

1 - CPUE is calculated as # fish/100m/24hr
2 - n = 17
3 - n = 27

Table 41. Comparison of mean fish catch, pull time and fish cleaning time by debris level, 2014/2015 Operation.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
None	32	75	24.11	40.5	13.04	0.62	24.6 [2]	0.32 [2]
Low	21	88	36.50	45.5	19.88	0.61	13.6 [3]	0.23 [3]
Medium	6	67	30.78	34.8	8.98	0.52	9.2 [4]	0.13 [4]
High	1	40	28.50	121.0	60.50	3.03	30.0	0.75
Total	60	78	31.76	43.0	13.83	0.65	19.71 [5]	0.28 [5]

1 - CPUE is calculated as # fish/100m/24hr
2 - n = 31
3 - n = 18
4 - n = 5
5 - n = 55

Table 42. Comparison of mean fish catch, pull time and fish cleaning time by debris level, 2011/2012 Closure and 2014/2015 Operation combined.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
None	32	75	24.11	40.5	13.04	0.62	24.6 [2]	0.32 [2]
Low	56	110	36.50	56.3	18.11	0.64	30.7 [3]	0.40 [3]
Medium	15	85	30.78	51.3	16.41	0.63	32.4 [4]	0.33 [4]
Total	103	96	31.82	51.4	16.29	0.64	28.7 [5]	0.36 [5]

1 - CPUE is calculated as # fish/100m/24hr
2 - n = 31
3 - n = 35
4 - n = 14
5 - n = 80

4.1.8 Anecdotal Information

Once debris monitoring during the commercial fishery was initiated, commercial fishers would occasionally share additional information or express their opinions regarding Reach 1 and its potential effects on the Sturgeon Bay fishery with field technicians. These are summarized here.

- "There is not much debris in nets once you get 3-5 km out from the mouth of the Dauphin River."
- "There is lots of debris in my nets near Halfway Point."
- "My nets are being destroyed by debris."
- "We are not catching many fish this year."
- "The pickerel (Walleye) are bigger this year, there are no smaller fish."
- "Much of the debris that came out of Buffalo Creek has already been buried by sediment."

4.2 TIME-LAPSE PHOTOGRAPHY

A cursory review of images collected by each camera indicated that debris abundance was greatest at the onset of Reach 1 operation and declined shortly after operation began. Consequently, detailed examination of photographs focused on the first six days following the onset of operation. Abundance of observable debris was negligible in subsequent days.

A total of 9,023 photographs were examined for the presence of surface debris from 04-09 July (Appendix E). Camera DR-1 (looking upstream into Buffalo Creek) captured 393 images of debris while camera DR-2 (looking at the confluence) captured 437. No surprisingly, the observed hourly trends for debris flowing out of Buffalo Creek were similar between the two cameras (Figures 18 and 19). The majority of debris was observed from 04-06 July with at least some debris noted every hour photographs were taken. The proportion of images with debris during the first three days ranged from approximately 35-45% on the morning of 05 July shortly after the opening of Reach 1 to 5% by the end of 06 July. Furthermore, greater amounts of debris were observed before noon each day than after. Flows in Buffalo Creek generally did not exhibit diel trends in discharge, so this trend may be due to the changing angle of the sun's glare on the water which could affect the ability to identify debris in a photograph. From 07-09 July, observations of debris were less frequent, ranging from 0-6.7% (Figures 18 and 19). Only five total images contained debris on 09 July. These data suggest that most debris flow occurred within the first 24-48 hours of Reach 1 opening in 2014.

The type of debris generally ranged from small sticks and branches, to larger logs, to entire trees (Figures 20 and 21; Appendix E). Most debris (approximately 65-70%) was observed along the right-hand bank (looking upstream) of Buffalo Creek. Water velocity in this stretch of Buffalo Creek was higher along the right-hand bank. Additionally, the cameras were installed on the right-hand shoreline, so debris on the left-hand bank was farther away in the images and may have been more difficult to observe.

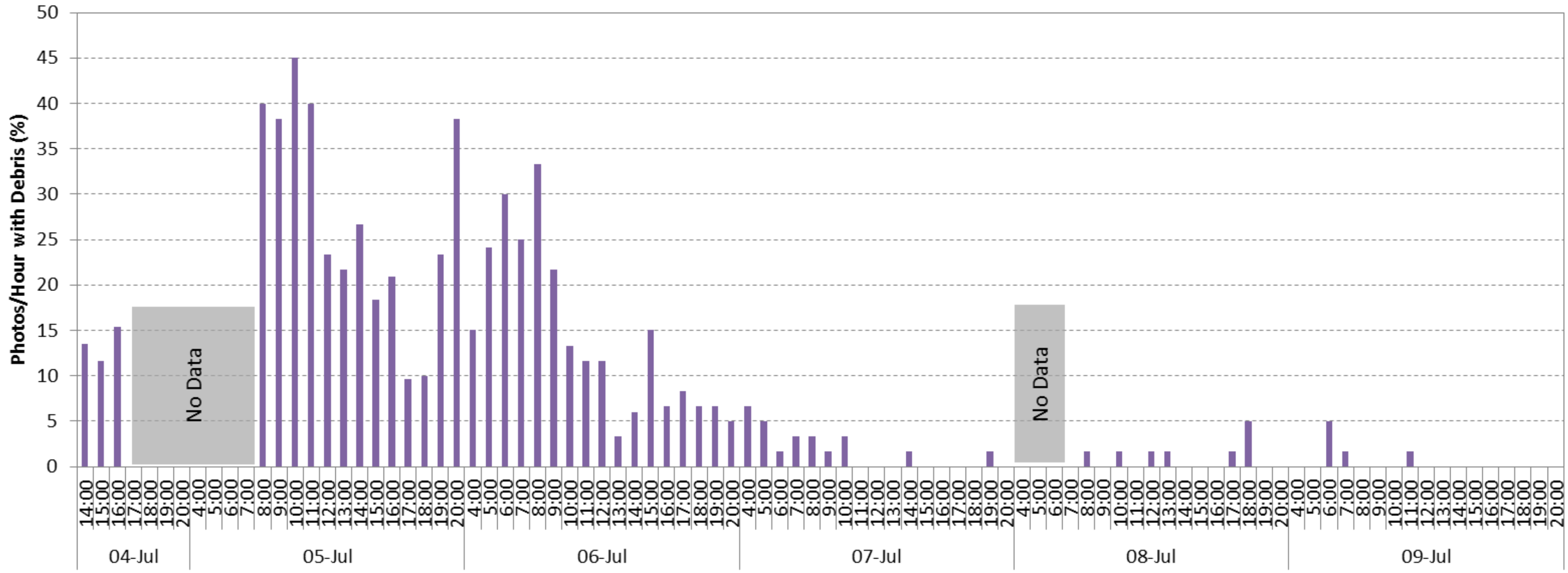


Figure 18. Hourly transport of surface debris in Buffalo Creek following the opening of Reach 1. These data were collected from time-lapse camera DR-1 oriented to take photographs facing upstream into Buffalo Creek from its confluence with the Dauphin River. Note: hours with no data include periods when the camera was not functioning or the images were not clear enough to assess, usually due to weather conditions).

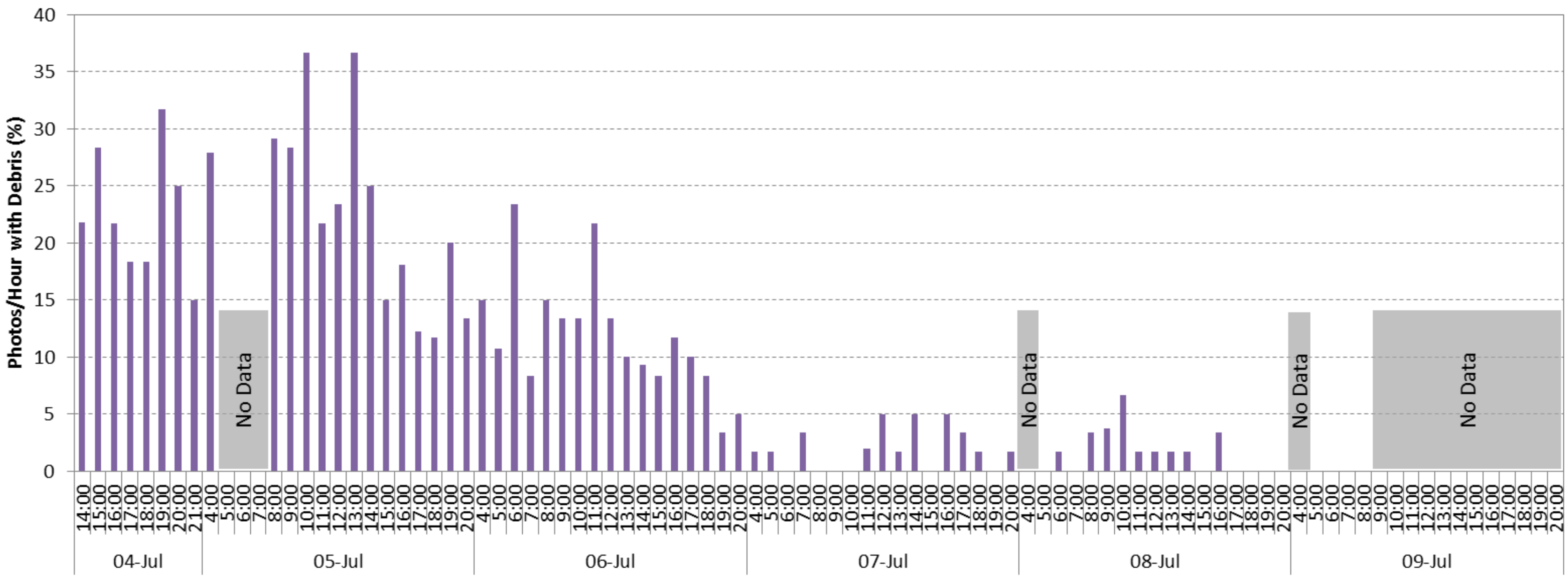


Figure 19. Hourly transport of surface debris in Buffalo Creek following the opening of Reach 1. These data were collected from time-lapse camera DR-2 oriented to take photographs of the Buffalo Creek/Dauphin River confluence. Note: hours with no data include periods when the camera was not functioning or the images were not clear enough to assess, usually due to weather conditions).

Figure 20. Time-lapse photograph from camera DR-1 showing large tree debris flowing downstream in Buffalo Creek.

Figure 21. Time-lapse photograph from camera DR-2 showing small sticks and branches flowing downstream towards the Dauphin River.

4.3 SHORELINE DEBRIS MONITORING IN STURGEON BAY

A detailed description of the results from the 2012 boat-based inventory of shoreline debris in Sturgeon Bay can be found in Appendix F. Generally, observations in early spring 2012 suggested debris that could have originated in the Buffalo Creek watershed and been washed into Sturgeon Bay were accumulating in low levels along the shoreline to the south and east of the Dauphin River.

Shoreline debris monitoring following opening in 2014 was less intensive than in spring 2012, and included anecdotal observations of debris distributed along the Sturgeon Bay shoreline. In general, very little debris was observed along the shoreline that may have originated in the Buffalo Creek watershed. This may be due to an MIT initiative to remove debris from the Buffalo Creek channel prior to the onset of Reach 1 operation, lesser amounts of debris leaving the creek relative to the 2011/2012 operation, or reduced dedicated sampling effort.

In general, it is thought that most debris (possibly excluding large trees that wash up onto the shoreline) is distributed throughout the bay by wind and wave action. A commercial fisher reported large amounts of woody debris had accumulated on an island in the northern part of Sturgeon Bay. Whether the observed debris originated from Buffalo Creek is not known (although the fisher claimed it was), but does further suggest that debris is well distributed throughout the bay.

5 SUMMARY

1) This report provides a summary of debris monitoring data collected during the 2013 (spring and fall) 2014 (spring, summer and fall) and 2015 (spring) commercial fishing seasons on Sturgeon Bay.

2) Field methods differed between 2013 and 2014/2015, but sufficient data were collected to examine the effect of Reach 1 operation on debris accumulation and fish capture rates in commercial fishing nets in Sturgeon Bay.

3) A total of 66 nets were monitored for debris accumulation during 2011/2012 Closure. The majority of these nets (70%) contained a low level of debris, while 13 contained a medium level of debris, two contained a medium level of debris, and three nets contained a very high level of debris. The two nets that contained no debris had been tailed back to the dock (dragged back while still in the water) so they were excluded from additional analyses. Aquatic vegetation was by far the dominant debris type during this phase of the Project, with a few sticks regularly present. Small amounts of silt and algae also accumulated occasionally.

4) In summer 2014, Reach 1 was re-opened, and 69 nets were monitored for debris accumulation during 2014/2015 Operation. Commercial fishermen were less likely to set their nets in the vicinity of the Dauphin River outflow during this phase of the Project (as compared to 2011/2012 Operation). The majority of nets (52%) did not accumulate any debris, and fewer nets accumulated low and medium levels of debris than during 2011/2012 Operation. Debris composition was more variable during 2014/2015 Operation, and aquatic vegetation was not always the dominant type of debris that accumulated in the commercial nets that were monitored; grass, algae and silt also frequently comprised a large proportion of the debris observed in nets.

5) Dominant species in the fish catch were consistent by season: Walleye and White Sucker dominated the spring catch while Lake Whitefish and White Sucker dominated the fall catch (although a dominant species shift to Walleye and Northern Pike was observed later in fall 2014). The number of species captured in fall was higher than the number captured in spring, with the highest number of species captured in fall 2014 (likely because a wider variety of locations were fished in this year).

6) Catch-per-unit-effort appeared to decrease as the level of debris increased. Net sets that contained no debris do not follow this pattern; they had a lower mean CPUE than nets that had accumulated a low, medium or high level of debris. This may be due to differences in net set location (see #7 below).

7) During 2014/2015 Operation most of the fishermen chose to set their nets away from the Dauphin River outflow. While site-specific CPUEs were similar between fall 2013 (2011/2012 Closure) and fall 2014 (2014/2105 Operation), CPUEs in spring 2015 were much lower than those seen in spring 2013 and 2014. It is likely that different net set locations in spring 2015 (away from the Dauphin River outflow and farther from shore) were at least partially responsible for the lower catch rates, as sites closer to shore generally exhibited higher CPUEs.

8) Sample sizes were too small to compare fishing effort results between different phases of the Project. When the data from all six sampling seasons were combined, the amount of time spent servicing nets (per fish) was similar, regardless of the amount of debris (no debris, a low level or a medium level) that had accumulated in the net. As expected, the amount of time that it took to clean the catch was not affected by different levels of debris accumulation.

9) Time-lapse photography of surface debris flowing out of Buffalo Creek following Reach 1 opening in summer 2014, indicates large amounts of woody debris are transported during the first 24-48 hours of operation. Surface debris levels decreased rapidly and remained low following this initial pulse.

10) Sturgeon Bay shoreline debris surveys in 2012 identified woody debris that was suspected to have originated in the Buffalo Creek watershed and transported downstream during operation of Reach 1. Although the level of survey effort was less following the onset of Reach 1 operation in 2014, observations suggest that debris accumulation along the shorelines of southern Sturgeon Bay may have been less than 2012.

Appendix B

Detailed effort records and analyses by season

Table B-1. Record of fishing effort for each commercial net included in the spring 2013 Sturgeon Bay debris monitoring program.

Site [1]	Date Lifted	Set Duration (hours)	No. of Panels	Debris Level	No. of People on Crew	Preparation Time (minutes)	Travel to Gang Time (minutes)	Net Servicing Activity	Net Servicing Time (minutes)	Travel Back to Camp Time (minutes)	Unload Boat Time (minutes)	Process Catch and Fish Cleaning Time (minutes)	Total Fish Catch		Estimated Fish Catch
													Individual	Tubs	
DN-01(a) [3]	14-Jun-13	41.7	4	Med	2	35	10	run	85	-	-	- [2]	31	2	62
DN-02(a)	14-Jun-13	42.7	3	Low	2	-	8	run	85	14	16	- [2]	14	3	69
DN-01(b)	15-Jun-13	24.0	4	High	2	33	8	run	93	-	-	- [2]	19	3	61
DN-02(b)	15-Jun-13	24.4	3	Low	2	-	11	run	144	8	18	- [2]	43	4	102
DN-01(c)	16-Jun-13	23.9	4	Low	2	30	8	lift	109	-	-	- [2]	35	2	69
DN-02(c)	16-Jun-13	24.1	3	Low	2	-	8	lift	150	12	17	-	14	3	75
DN-03(a)	17-Jun-13	24.0	2	Low	2	30	15	run	18	-	-	-	15	1	27
DN-04(a)	17-Jun-13	24.5	4	Low	2	-	3	run	37	-	-	-	24	1	40
DN-05(a)	17-Jun-13	24.4	4	Low	2	-	6	run	65	11	5	60 [3]	69	6	156
DN-06(a)	18-Jun-13	12.8	4	Low	2	30	8	run	160	-	-	-	64	12	247
DN-05(b)	18-Jun-13	27.8	4	Low	3	-	6	run	115	-	-	-	90	7	201
DN-04(b)	18-Jun-13	30.5	4	Low	3	-	7	run	78	-	-	-	35	4	121
DN-03(b)	18-Jun-13	32.5	2	Low	3	-	8	lift	41	13	22	200 [4]	65	2	108
DN-06(b)	19-Jun-13	23.4	4	Low	3	60	9	run	191	-	-	-	76	14	295
DN-05(c)	19-Jun-13	23.7	4	Low	3	-	8	run	112	-	-	-	56	6	151
DN-04(c)	19-Jun-13	23.7	4	Low	3	-	8	run	122	14	60	180 [5]	40	7	151
DN-06(c)	20-Jun-13	24.3	4	Very High	3	60	-	lift	-	20	-	-	53	7	164
DN-05(d)	20-Jun-13	28.6	4	Med	3	-	-	lift	-	-	-	-	68 [7]	9 [7]	211 [7]
DN-04(d)	20-Jun-13	27.6	4	Med	3	-	-	lift	-	-	-	210 [6]			
DN-07	18-Jun-13	23.9	4	Low	3	15	14	run	85	-	-	- [2]	231	-	231
DN-08	18-Jun-13	25.0	4	Low	3	-	5	run	105	20	10	- [2]	222	-	222

1 - letters denote multiple sets in the same location
2 - fish cleaning time included in net servicing time
3 - combined fish cleaning time for DN-03(a), DN-04(a) and DN-05(a)
4 - combined fish cleaning time for DN-03(b), DN-04(b), DN-05(b) and DN-06(a)
5 - combined fish cleaning time for DN-04(c), DN-05(c) and DN-06(b)
6 - combined fish cleaning time for DN-04(d), DN-05(d) and DN-06(c)
7 - catch for sites DN-05(d) and DN-04(d) are combined

Table B-2. Record of fishing effort for each commercial net included in the fall 2013 Sturgeon Bay debris monitoring program.

Site	Date Lifted	Set Duration (hours)	No. of Panels	Debris Level	No. of People on Crew	Preparation (minutes)	Travel to Gang Time (minutes)	Net Servicing Activity	Net Servicing Time (minutes)	Return to Dock (minutes)	Unload Boat (minutes)	Process Catch and Fish Cleaning Time (minutes)	Total Fish Catch
DN-09	7-Oct-13	24.0	2	Low	1	10	13	run	31	9	1	30	59
DN-10	7-Oct-13	4.1	2	Low	1	5	27	run	24	-	-	-	29
DN-11	7-Oct-13	4.2	2	Low	1	-	9	run	35	36	6	55 [3]	44
DN-12	8-Oct-13	24.8	4	Low	2	21	13	run	94	-	-	-	182
DN-13	8-Oct-13	26.4	4	Low	2	-	5	run	39 [2]	11	30 [2]	131 [4]	- [6]
DN-14	9-Oct-13	24.2	4	Low	1	20	6	run	40	-	-	201 [5]	114
DN-15	9-Oct-13	24.4	4	Low	1	-	2	run	26	-	-	-	59
DN-16	9-Oct-13	24.4	4	Low	1	-	3	run	28	-	-	-	18
DN-17	9-Oct-13	25.0	4	Low	1	-	5	run	31	-	-	-	50
DN-18	9-Oct-13	25.1	4	Low	1	-	5	run	64	5	2	-	218
DN-19	10-Oct-13	24.3	4	Low	2	3	6	lift	98	7	2	80	154
DN-20(a) [1]	9-Oct-13	24.4	2	Low	2	25	30	run	60	-	-	75	95
DN-21(a)	9-Oct-13	24.8	3	Medium	2	-	15	run	95	5	10	90	90
DN-20(b)	10-Oct-13	23.7	2	Low	2	25	30	lift	75	-	-	65	92
DN-21(b)	10-Oct-13	24.3	3	Medium	2	-	20	lift	105	10	15	110	101
DN-22	11-Oct-13	22.9	3	Low	2	25	10	run	35	-	-	35	36
DN-23	11-Oct-13	23.5	3	Low	2	-	5	run	25	-	-	45	44
DN-24	11-Oct-13	24.0	3	Low	2	-	5	run	20	10	15	70	41
DN-25	13-Oct-13	47.8	2	Medium	2	20	20	run	80	20	25	85	85
DN-26	14-Oct-13	24.2	4	Medium	2	25	10	lift	75	-	-	40	114
DN-27	14-Oct-13	25.5	3	Medium	2	-	5	lift	80	10	15	60	119

1 - letters denote multiple sets in the same location
2 - DN-13 pulled but not picked until boat was docked, therefore "net servicing" and "unload boat" times are not typical
3 - combined fish cleaning time for DN-10 and DN-11
4 - combined fish cleaning time for DN-12 and DN-13
5 - combined fish cleaning time for DN-14, -15, -16, -17 and -18
6 - observer did not have time to count fish

Appendix C

Detailed fishing effort records and analyses by season

Table C-1. Comparison of mean pull time and fish catch by debris level, spring 2013. Note: Mean fish cleaning times could not be calculated as fish from multiple nets were cleaned together and a single time was recorded.

Debris Level	n	Estimated Mean Fish Catch	Mean CPUE [1]	Mean Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)
None	0	-	-	-	-	-
Low	10 [2]	150	41.71	93.9	24.9	0.64
Medium	0 [3]	-	-	-	-	-
High	0 [4]	-	-	-	-	-
Very High	0 [5]	-	-	-	-	-
Total	10	150	41.71	93.9	24.9	0.64

1 - CPUE is calculated as # fish/100m/24hr

2 - does not include net DN-01(c), DN-02 (a), (b) or (c), DN-07 or CN-08 because cleaning time was included in net servicing time

3 - does not include net DN-01(a) because cleaning time was included in net servicing time, and does not include DN-04(d) or DN-05(d) since a net servicing time was not recorded for either net and their catch count was combined

4 - does not include net DN-01(b) because cleaning time was included in net servicing time

5 - does not include net DN-06(d) since a net servicing time was not recorded for either net and their catch count was combined

Table C-2. Comparison of mean net servicing time and fish catch by debris level, fall 2013.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Mean Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
None	0	-	-	-	-	-	-	-
Low	13 [2]	89	29.90	48.2	15.76	0.65	57.1 [4]	0.89 [4]
Medium	4 [3]	106	39.43	89.0	33.33	0.86	75.0	0.74
Very High	0	-	-	-	-	-	-	-
Total	17	93	32.14	57.8	18.65	0.7	63.6 [5]	0.83 [5]

1 - CPUE is calculated as # fish/100m/24hr

2 - does not include DN-10 and DN-11 because their set duration was short (~4 hours); also does not include net DN-13 since a count was not obtained for the catch

3 - does not include DN-25 because its set duration was unusually long (~48 hours)

4 - n = 7; does not include net sets DN-10, -11, -12, -13, -14, -15, -16, -17 or -18 because fish from multiple nets were cleaned together and a single time was recorded

5 - n = 11

Table C-3. Comparison of mean net servicing time and fish catch by debris level, spring 2014.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Mean Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
None	0 [1]	-	-	-	-	-	-	-
Low	10 [2]	156	57.22	62.9	23.1	0.71	43.1	0.37
Medium	5	91	42.58	41.2	16.1	0.58	21.6	0.21
High	1	70	36.79	70.0	35.0	1.00	10.0	0.14
Very High	0 [3]	-	-	-	-	-	-	-
Total	16	130	51.37	56.6	21.6	0.69	34.3	0.30

1 - CPUE is calculated as # fish/100m/24hr

2 - does not include DN-36(b) or DN-38(b) because they were tailed in

3 - does not include DN-33(b), DN-34(b), DN-41 or DN-42 because they were in the water for more than one overnight

4 - does not include DN-29(c) or DN-30(c) because they were in the water for more than one overnight

Table C-4. Comparison of mean net servicing time and fish catch by debris level, summer 2014.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Mean Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
None	12	89	26.58	43.7	13.2	0.55	22.5 [1]	0.23
Low	6	114	36.81	9.7	18.1	0.65	5.7 [2]	0.06
Medium	1	49	24.42	22.0	11.0	0.45	- [3]	-
High	1	40	20.21	121.0	60.5	3.03	30.0	0.75
Total	20	92	29.22	49.9	16.9	0.70	19.7	0.23

1 - CPUE is calculated as # fish/100m/24hr

2 - fish cleaning time was only recorded for 11 of 12 sets that accumulated no debris (not recorded for DN-58)

3 - fish cleaning time was only recorded for 3 of 6 sets that accumulated a low level of debris (not recorded for DN-50, -56 and -61)

4 - fish cleaning time was not recorded for the single net set that accumulated a medium level of debris

Table C-5. Comparison of mean net servicing time and fish catch by debris level, fall 2014.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Mean Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
None	2 [2]	115	36.96	35.0	8.8	0.32	17.5	0.15
Low	6 [3]	63	18.50	42.3	11.4	0.69	9.5	0.16
Medium	1 [4]	52	16.00	30.0	7.5	0.58	8.0	0.15
High	0 [5]	-	-	-	-	-	-	-
Total	9	73	22.33	39.3	10.4	0.60	11.1	0.16

1 - CPUE is calculated as # fish/100m/24hr

2 - does not include DN-73(b), DN-76, -77 and -78 because they remained in the water for more than one overnight

3 - does not include DN-62 or DN-75 because they remained in the water for more than one overnight

4 - does not include DN-66 or DN-67 because they remained in the water for more than one overnight

5 - does not include DN-65 because it remained in the water for more than one overnight

Table C-6. Comparison of mean net servicing time and fish catch by debris level, spring 2015.

Debris Level	n	Mean Fish Catch	Mean CPUE [1]	Mean Net Servicing Time (minutes)	Mean Net Servicing Time per Panel (minutes)	Mean Net Servicing Time per Fish (minutes)	Mean Fish Cleaning Time (minutes)	Mean Cleaning Time per Fish (minutes)
None	18	61	21.0	13.4	39.0	0.71	26.7	0.39
Low	9	88	26.6	13.4	41.2	0.53	19.0	0.34
Medium	4	75	17.0	8.8	39.3	0.53	9.5	0.13
Total	31	71	22.1	12.8	39.7	0.63	22.2	0.34

1 - CPUE is calculated as # fish/100m/24hr

Appendix F

Results from the 2012 Sturgeon Bay Shoreline Debris Inventory Survey

The Sturgeon Bay shoreline was surveyed to document the presence of recently deposited debris that may have originated from Reach 1 or the Buffalo Creek Drainage System, or washed downstream from upstream areas via Reach 1 and Buffalo Creek or the Dauphin River. The area surveyed and distribution of observed debris is illustrated in Figure F-1. The survey was divided into five areas based on proximity to the Dauphin River mouth. These included the following:

1. The western shoreline of Sturgeon Bay from Hay Point south to the mouth of the Dauphin River;
2. The mouth of the Dauphin River south to Halfway Point;
3. Halfway Point east to Willow Point;
4. Mantagao Bay; and,
5. The eastern shoreline of Sturgeon Bay north of Mantagao Bay.

Debris observations are summarized by area in Table F-1, and discussed in the following sections. An inventory of shoreline debris photos is provided in Table F-1, and all photographs are provided in the attached CD.

Section 1: Hay Point South to the Dauphin River

Old, rafted debris and poplars that appeared to have been felled by wind or shoreline erosion were observed in this section. There was no noticeably new natural debris or any evidence of anthropogenic debris along this section of shoreline.

Section 2: The Dauphin River South to Halfway Point

Woody debris was abundant along the shoreline in this section, but most appeared to be locally fallen trees or old rafted debris deposited at the existing tree line along the beach ridge (Figure F-2). At least one large spruce was observed on the beach near Halfway Point (at point # 2741 in Figure F-1) and had been more recently deposited. This tree may have originated from the Buffalo Creek watershed (Figure F-3). Although fresh peat deposits were observed at the water's edge along this reach of shoreline during spring, none remained at the time of this survey. Old, anthropogenic debris in the form of fish tubs and nets were observed along the tree line and an old dock had washed ashore (at point # 2746 in Figure F-1), but no recently deposited anthropogenic debris was observed.

Section 3: Halfway Point East to Willow Point

As between the Dauphin River and Halfway Point, woody debris was abundant along the shoreline between Halfway Point and Willow Beach, but consisted of local trees knocked over by the wind or old, rafted material (Figure F-4). Fresh peat deposits were observed in this section during spring, in smaller quantities than the section closer to the Dauphin River mouth, but were not evident during this survey. Old fish tubs and nets were observed along the tree line, but there was no evidence of any recently deposited anthropogenic debris.

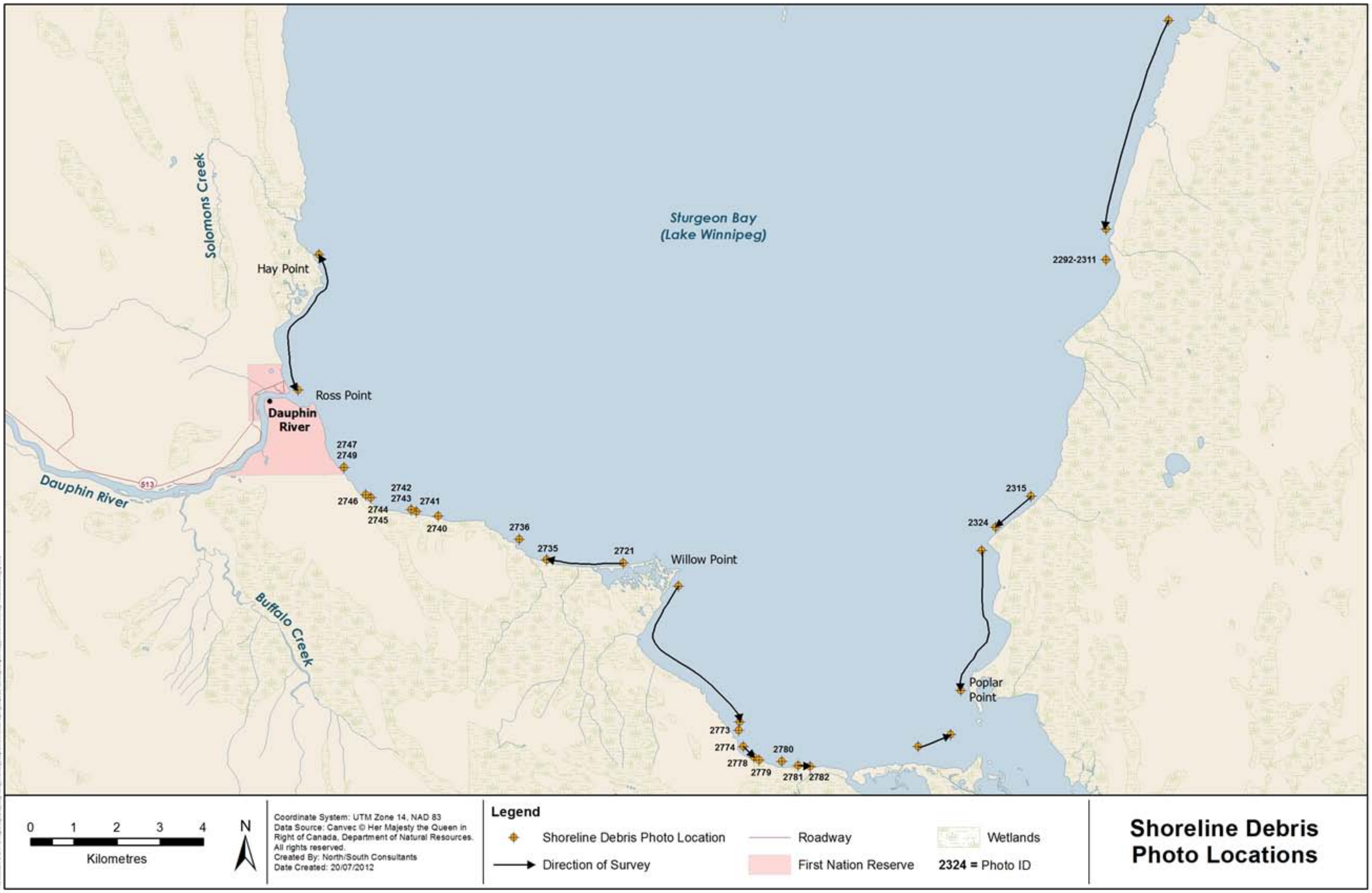


Figure F-1. Location of shoreline debris surveys in Sturgeon Bay, summer 2012. Includes point locations for geo-referenced photographs.

Table F-1. Shoreline debris observed at five regions of Sturgeon Bay, spring 2012.

Section	Start Coordinates		End Coordinates		Debris Categories				Comments
	Easting	Northing	Easting	Northing	Trees	Peat	Anthropogenic (fishing equip.)	Anthropogenic (other)	
Hay Point to Dauphin River	-	-	-	-	majority of tree line near Dauphin River mouth contains old rafted debris	-	no evidence of old nets, fish tubs present	-	no noticeable debris
	-	-	-	-	several sections with fallen poplars (either wind or shoreline erosion)	-	-	-	-
Dauphin River to Halfway Point	568121	5754310	-	-	Tree line littered with old (>1yr) trees (photo 2740)	-	fish tubs and old nets on shore	-	2 fish tubs observed – no photos taken
	567622	5754416	-	-	big spruce tree on shore (photo 2741)	-	-	-	-
	567504	5754458	-	-	trees (photos 2742-2743)	-	-	dock panels	-
	566567	5754743	-	-	downed poplars (photos 2744-2745)	-	-	-	-
	566447	5754801	-	-	-	-	-	dock washed up on shore (photo 2746)	-
	565942	5755440	-	-	fallen trees (photos 2747-2749)	-	-	-	-
Halfway Point to Willow Point	572417	5753223	-	-	trees along shoreline (>1yr) (photos 2721-2722)	-	old fish nets and tubs on shore	-	3 fish tubs observed – no photos taken
	572180	5753223	570644	5753301	trees and branches along ~60 m of shoreline (photos 2723-2724)	-	-	-	-
	571308	5753214	570644	5753301	downed trees along shoreline (photos 2725-2735)	-	-	-	-
	570000	5753775	-	-	large pile of downed trees and branches ~40 m long (photo 2736)	-	-	-	-

Table F-1. (continued).

Section	Start Coordinates		End Coordinates		Debris Categories				Comments
	Easting	Northing	Easting	Northing	Trees	Peat	Anthropogenic (fishing equip.)	Anthropogenic (other)	
Mantagao Bay	573696	5752688	575115	5449534	-	-	no evidence of old nets or fish tubs on shore	-	No debris visible
	574961	5749547	575092	5749344	-	-	-	-	rafted debris (Photo 2773)
	575194	5748965	575445	5748719	-	-	-	-	rafted debris (Photo 2774-2778)
	575559	5748652	-	-	-	-	-	-	Photo 2779
	576094	5748622	-	-	-	-	-	-	Photo 2780
	576470	5748522	576744	5748509	-	-	-	-	Photo 2781-2782
	580725	5753511	580237	5750272	-	-	-	-	No debris visible
	579249	5748963	579998	5749242	-	-	-	-	No debris visible
	579092	5748937	579087	5748913	-	-	-	-	No debris visible
Eastern Shoreline	585055	5765808	583600	5760960	-	-	no evidence of fish nets or tubs on shore		No debris, clean shorelines
	583609	5760259	583633	5760259	downed trees along shoreline (wind)	-	-	-	All rafted debris >1yr
	583609	5760259	583639	5760260	downed trees along shoreline appear >1yr (photos 2292-2311)	-	-	-	-
	582282	5755645	-	-	fallen trees	-	-	-	-
	582100	5755101	581866	5754772	fallen trees	-	-	-	-
	581866	5754772	581041	5754050	-	-	old washed up material >1yr	old washed up material >1yr	photos 2315-2324

Figure F-2. Example of fallen trees and old, rafted debris along the shoreline from the Dauphin River to Halfway Point, summer 2012.

Figure F-3. A spruce deposited along the shoreline from the Dauphin River to Halfway Point, summer 2012. This tree may have originated in Buffalo Creek.

Figure F-4. Example of fallen trees and old, rafted debris along the shoreline from Halfway Point to Willow Point, summer 2012.

Section 4: Mantagao Bay

Like most of the shoreline in Sturgeon Bay, this section was marked with abundant woody debris in the form of locally wind-felled trees or old, rafted debris (Figure F-5). There was no evidence of any recently deposited debris, and none of the old, anthropogenic debris that was relatively common closer to the Dauphin River mouth.

Section 5: Eastern Shoreline of Sturgeon Bay

Old downed trees and rafted debris characterized the eastern shoreline of Sturgeon Bay (Figure F-6); however, there was no evidence of recently deposited debris. Small amounts of old, anthropogenic debris were washed ashore just north of Mantagao Bay.

Figure F-5. Example of fallen trees and old, rafted debris along the shoreline of Mantagao Bay, summer 2012.

Figure F-6. Example of fallen trees and old, rafted debris along the eastern shoreline of Sturgeon Bay, summer 2012.