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Lake Manitoba & Lake St. Martin Outlet Channels & Access Road: Summary of Baseline Desktop and Field Investigations

Submitted to:

Manitoba Infrastructure

Water Management and Structures

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1 INTRODUCTION

Manitoba Infrastructure (MI) is currently developing options to address ongoing flood issues in the Assiniboine River and Lake Manitoba watershed basins. As part of this endeavour, MI initiated the Assiniboine River & Lake Manitoba Basins Flood Mitigation Study. This study, which was completed in 2011, included several components. In particular, the "*Assiniboine River & Lake Manitoba Basins Flood Mitigation Study Lake Manitoba & Lake St. Martin Outlet Channels Conceptual Design - Stage 1 - Deliverable No: LMB-01*" (KGS Group 2014) and the "*Assiniboine River & Lake Manitoba Basins - Flood Mitigation Study LMB & LSM Outlet Channels Conceptual Design - Stage 2*" (KGS Group 2016) were key to identifying future flood protection initiatives for the Assiniboine River and Lake Manitoba watershed basins.

The Stage 1 and Stage 2 Conceptual Designs prepared by KGS and MI included the three following components:

- further development of the Lake St. Martin Outlet Channel (LSMOC), which involves development of a channel in the area referred to as Reach 2 and completion of the channel referred to as Reach 3;
- construction and operation of a new channel from Lake Manitoba (LM) to Lake St. Martin (LSM) to increase flow capacity and expedite movement of flood waters between these waterbodies; and
- construction and operation of an All Season Road (ASR) in the area of the Lake St. Martin Outlet Channels to facilitate year-round vehicle, crew and equipment access to the Lake St. Martin Outlet Channels.

These three main components formed the overall MI Lake Manitoba and Lake St. Martin Access Road and Outlet Channels Project (the Project) at the time of this writing. MI later engaged M. Forster Enterprises (MFE) and a team of professional consultants to conduct desktop and field investigations at varying spatial scales near the Project to provide information on the existing environmental conditions for each of the three Project components listed above. The intent of these investigations was to describe the baseline conditions in vicinity of the Project to support a future Environmental Impact Assessment (EIA). While the overall Project will require approval and licensing under the federal Canadian Environmental Assessment Act (CEAA) and the Manitoba Environment Act, the realignment and construction of an ASR for construction access will require regulatory approval and licensing from the Province of Manitoba.

Desktop and field investigations were initiated in September 2015 to collect and document information on the existing environmental conditions in the proposed Project area in support of the future Environmental Impact Assessment (EIA). At the time of this writing, MI had evaluated a number of different conceptual route options for the LMOC and selected two preferred route options for the LMOC, referred to as the LMOC Route C and LMOC Route D. As such, the examination of existing environmental conditions for the LMOC was completed for the LMOC Route C, which would be located south of the Fairford River and roughly parallel the southern border of the Pinaymootang First Nation (FN); and the LMOC Route D, which would run from an inlet on Watchorn Bay in LM to the outlet of Birch Creek on LSM (KGS Group 2016).

During meetings and discussions with MI in April 2016, MI indicated that the Reach 2 alignment and dike options described for the original LSMOC component of the assignment were being revisited. A total of four channel alignment and/or dike options were proposed to be investigated instead of the original one Reach 2 dike option. These additional alignments were referred to as Option 1, Option 2, Option 3 and Option 4. As such, the areas proposed for the four alignments were added to the 2016 desktop and field investigations for the LSMOC component of the Project. Other than the proposed lengths and locations, there were no other data available for the additional conceptual options at the time of this writing.

2 ABORIGINAL TRADITIONAL KNOWLEDGE

It is recognized that there are many plant species, wildlife species, fish species and areas of cultural significance to many First Nations peoples, and that these plants, wildlife, fish and areas of significance will vary by the practices of each First Nation, and their gathering locations. It is recognized that First Nations people have a special relationship with the earth and all living things in it. This relationship is based on a profound spiritual connection to the environment that guided indigenous peoples to practice reverence, humility and reciprocity. First Nations people have relied on many species of plants, wildlife and fish for subsistence needs and cultural values that extend back thousands of years. In regard to the collection and use of Aboriginal Traditional Knowledge (ATK) for the baseline investigations, MI and First Nations consultations were ongoing at the time of this writing, and ATK for plants, wildlife, fish and areas of cultural significance in the Project Study Area had yet to be compiled.

3 STUDY AREA AND SPATIAL BOUNDARIES

The Project study area is located in central Manitoba in the region referred to as the ‘Interlake’ as it lies between LM and Lake Winnipeg. Given that the information collected for the baseline studies would be used in the environmental assessment for the overall Project, the study design for the baseline studies included the establishment of appropriate study area spatial boundaries.

For the purposes of environmental assessment, the spatial boundaries for a project are typically described for three spatial scales: a Project Footprint (PF), a Local Study Area (LSA) and a Regional Study Area (RSA). The PF is the physical space or directly affected area on which the Project components or activities are located; the LSA is the area beyond the Project footprint in which Project effects are measurable; and the RSA is the area beyond the LSA within which most indirect and cumulative effects would occur (CEAA 2015).

As noted above, the overall Project was presented by MI as having three components and included: 1) construction and operation of the LMOC; 2) further development of the LSMOC; and 3) construction and operation of an ASR in the area of the LSMOC. The ASR and LSMOC components are linked as the ASR needs to be in place before the LSMOC works can be undertaken, and sections of the ASR and LSMOC options are contiguous or in close proximity on the landscape. The overall Project will require both federal and provincial approval and licensing, whereas the construction and operation of the ASR will only require provincial regulatory approval and licensing. In addition, MI requires the ASR to be in place to provide access for construction and operation of the LSMOC options. As such, MI required the baseline information for the ASR in advance of the baseline information for the LSMOC options, to allow MI to secure approval and licensing from the Province of Manitoba for the ASR component of the Project.

This need for the ASR baseline information prior to the LSMOC and LMOC baseline information was met by preparing three separate reports for MI: one report for the ASR, one report for the LMOC, and one report for the LSMOC. This approach was used to resolve the timing needs for the Project, but because some sections of the ASR and LSMOC occupy the same area on the landscape, and the LMOC is in proximity to the LSMOC and ASR, it also resulted in a spatial overlap when the LSA and RSA boundaries were determined for each of the three components. Figure 1 illustrates the PF, LSA and RSA for the three Project components, and shows the overlap that occurred. Figure 2 provides an illustration of the location of the proposed lengths and locations for the conceptual Options 1 to 4. As noted above, other than the proposed lengths and locations, there were no other data available for the additional conceptual options at the time of this writing. The rationale and determination for the study area boundaries are further described below. Note that the spatial boundaries selected for the EIA can be modified as desired from the spatial boundaries selected for the baseline investigations; however, the data provided for the three Project components were collected using the spatial boundaries indicated below.

3.1 Project Footprint

The PF for each of the project components was designated as the area encompassed by the length and width of the Right of Way (RoW) for each of the proposed channel routes/options, i.e., LMOC Route C, LMOC Route D, LSMOC Reach 1, LSMOC Reach 3, and LSMOC Options 1 to 4. For the LMOC route options, the PF also included the areas in LM and LSM that could potentially be affected by the use of cofferdams during construction, and by the installation of a permanent groyne in LM. For the ASR, the PF was designated as the total length of the ASR times the total width of the proposed RoW for the ASR.

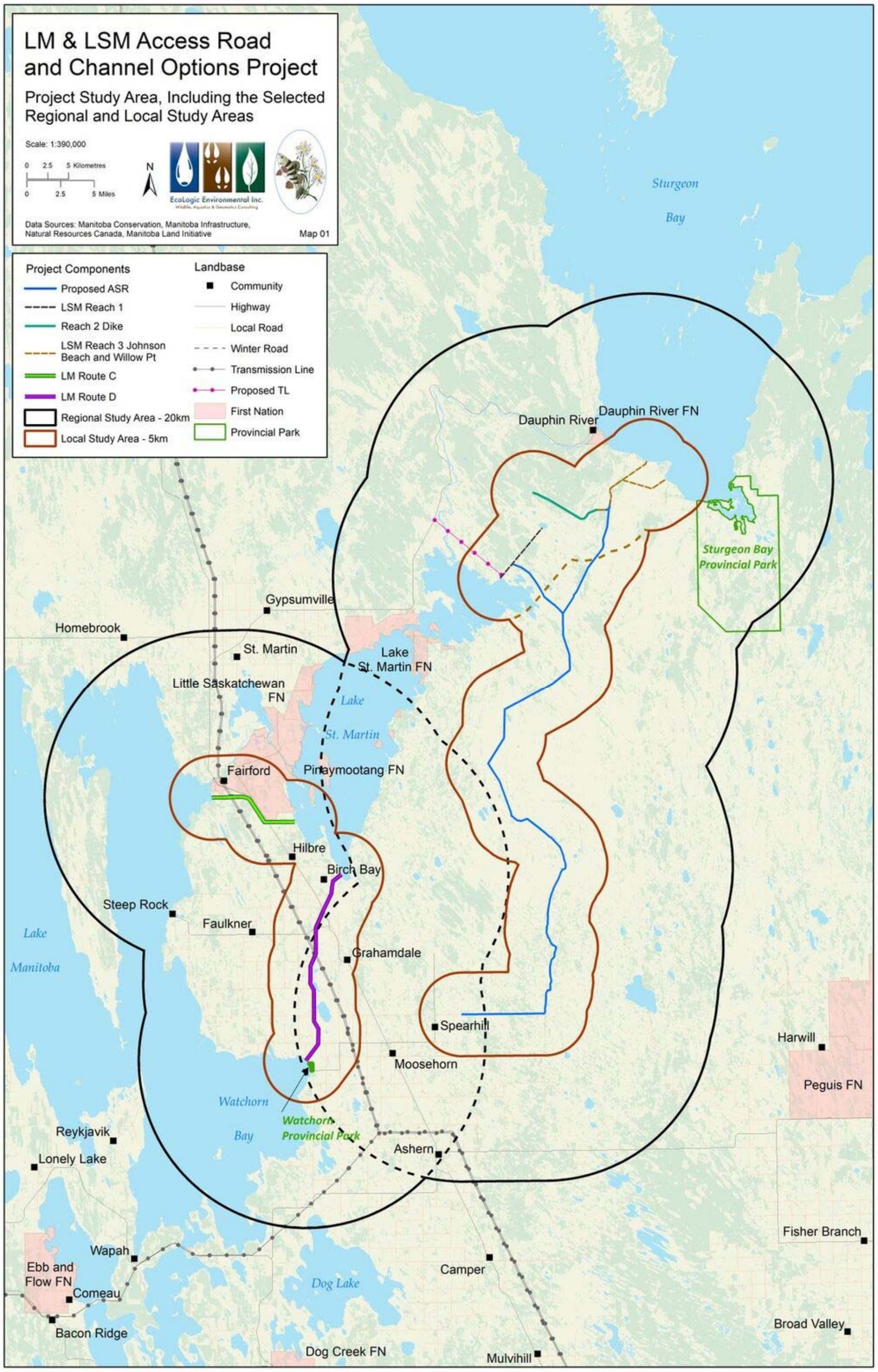

Figure 1: Project Study Area, including the selected Regional and Local Study Areas

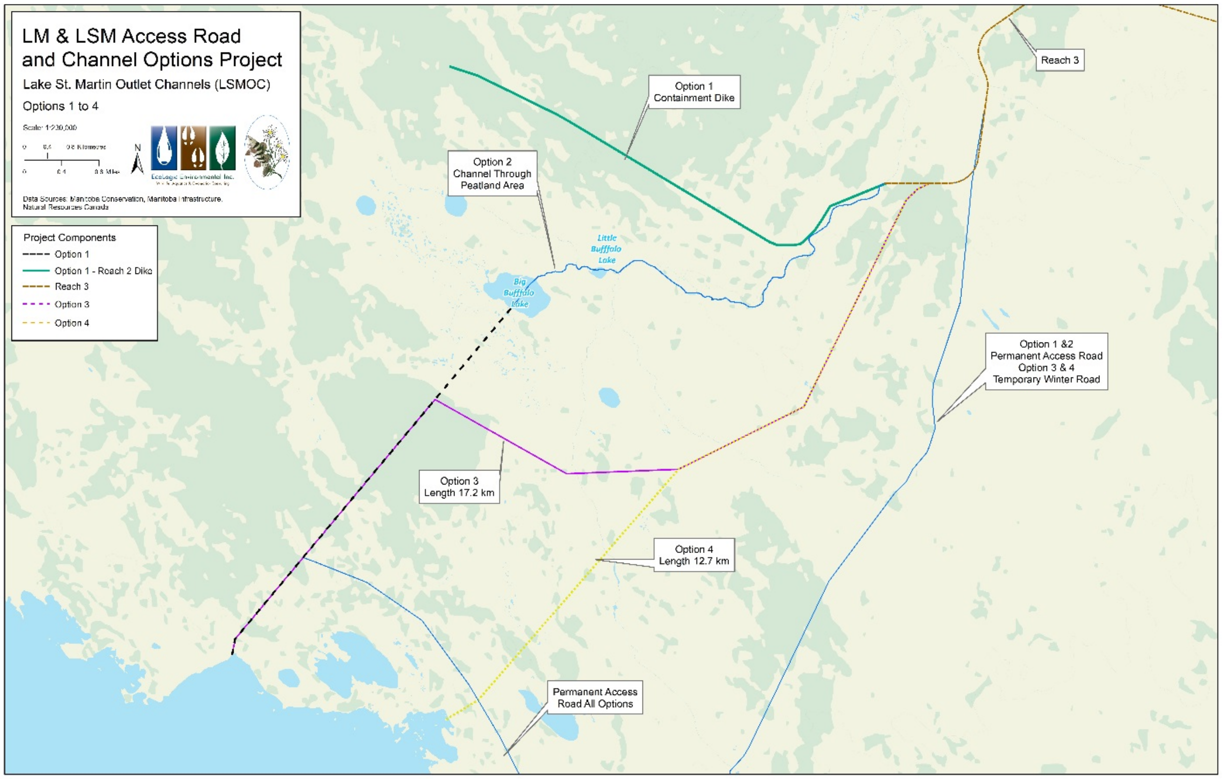

Figure 2: Illustration of Lengths and Locations of the Conceptual Options 1 to 4

3.2 Local Study Area

The LSA for the project components was designated as the total length of each of the proposed channel routes/options/ASR with a width of 5 km from either side of the centreline of the proposed route/options/ASR for all environmental components except vegetation. This 5 km width on either side of the proposed routes/options/ASR was selected based on:

- Published guidance documents and environmental assessment criteria for air quality, greenhouse gas (GHG) emissions, noise, vibration and human health (e.g., Health Canada 2011);
- The need to include waterbodies and watercourses where aquatic organisms and/or their habitat may be affected by the works associated with the construction and operation of the routes/options/ASR (e.g., by changes in flow patterns);
- Published literature on the potential local disturbance effects of roads on moose (*Alces alces*) (Laurian et al. 2008; Silverberg et al. 2003; Wasser et al. 2011; Yost and Wright 2001);
- The need to encompass wildlife movements, including Species At Risk (SAR), within the area of the proposed routes/options/ASR;

- The need to provide an understanding of the existing socio-economic features of the area surrounding the proposed routes/options/ASR; and
- The need to provide quantitative and qualitative information on the Heritage Resources within and surrounding the area of the proposed routes/options/ASR as required under existing legislation and in accordance with environmental assessment requirements.

For vegetation, the LSA was designated as the total length of the each of the proposed channel routes/options/ASR with a width of 1 km from either side of the centreline of the proposed channel routes/options/ASR to reflect the mostly sessile nature of plants, but also include areas of potential seed dispersal, new growth or colonization.

3.3 Regional Study Area

The RSA was designated as the total length of each of the proposed channel routes/options/ASR with a width of 20 km from either side of the centreline of the proposed channel routes/options/ASR for all environmental components except vegetation. This 20 km width on either side of the proposed channel routes/options/ASR was selected based on the guidelines, criteria and legislation described above for the LSA, and to capture the area of a typical moose home range, which has been cited as having a size of 40 km^2 (Hundertmark 1997).

For vegetation, the RSA was designated as the total length of each of the proposed channel routes/options/ASR with a width of 5 km from either side of the centreline of the proposed channel routes/options/ASR to allow for the assessment of vegetation at a community level, if required.

As noted above, the use of these spatial boundaries for the RSA and proximity of the Project components resulted in some overlap with the areas potentially affected by the proposed LMOC, and the existing and planned LSMOC and ASR. As a result of this overlap, the information presented for the RSA in each of the three report assignments (LMOC report; LSMOC report; ASR report) was similar for many of the environmental components, e.g., climate, air quality, GHGs, noise and vibration, and socio-economic setting.

4 BIOPHYSICAL ENVIRONMENT

The following information provides a summary of the findings on the existing biophysical conditions within the study areas established for the baseline desktop and field investigations for the Project.

4.1 Climate

Climate can be defined as the generally prevailing weather conditions of a region throughout the year, and is typically described by variables such as air pressure, cloud cover, humidity, precipitation, hours of sunshine, temperature, wind speed and wind direction. Environment and Climate Change Canada (ECCC) has collected climate normals data for several areas within Canada from 1961 to 1990, 1971 to 2000 and 1981 to 2010. The ECCC weather station closest to the RSA with the most recent climate normals data, i.e., from 1981 to 2010, is located in Lundar, Manitoba at Latitude 50°45' N and Longitude 97°56' W at an elevation of 266.7 m.

The 30 year climate normals report an average annual temperature of 1.9 degrees Celsius (°C), with a maximum of 18.3°C in July, and a minimum of -18.1°C in January (Government of Canada 2016a). Mean annual precipitation is 480.2 millimetres (mm), of which 385.5 mm falls as rain with the remainder 94.7 mm as snow (approximately 20 percent [%]). Precipitation falls primarily as snow during the winter months, with the greatest snowfalls occurring in November, December and January. Precipitation occurs mainly as rain during the spring, summer and fall seasons, with overall levels of precipitation peaking in June, July and August.

The large lakes within and around the RSA have an influence on the climate and weather. The basin size and position of LM, Lake Winnipegosis and Lake Winnipeg result in the creation of lake and land breeze circulations that can cause highly variable winds in the area (Environment and Climate Change Canada [ECCC] 2016a). The presence of the three large, shallow lakes creates the effects of land and lake breezes and evaporative cooling, which can have a direct influence on temperatures experienced on and off shore (ECCC 2016a).

Wind roses for the north basin of LM show that the prevailing wind directions on all parts of the north basin are southeasterly, southerly, westerly and northwesterly from July through August, and that the prevailing wind directions on all parts of the north basin are southeasterly, southerly, westerly, northwesterly and northerly from September through November (ECCC 2016a). Wind roses over the Narrows of Lake Winnipeg from June through August show that the prevailing wind directions on all parts of the Narrows are northwesterly, northerly, southeasterly and southerly during this period, and that the prevailing wind directions on all parts of the Narrows are southerly, westerly, northwesterly and northerly from September through November (ECCC 2016a).

4.2 Climate Change

The effects of climate change in Manitoba have been reported to include warmer temperatures, changes in rainfall and water availability, declining snow and ice cover, and extreme weather events that can lead to increased risk of flooding and erosion in spring, and increased risk of droughts in summer (Government of Manitoba 2012a). These climate change effects could lead to declines in agricultural and ecological productivity, and warmer temperatures may cause permafrost thawing and erosion, which will put northern roads, railways and other community infrastructure at risk and result in a shorter winter road season (Government of Manitoba 2012a).

To address climate change issues, the government of Manitoba enacted *The Climate Change and Emissions Reductions Act* in 2008, which set a target of reducing greenhouse gas (GHG) emissions to six per cent below 1990 levels by 2012, and required the province to report on whether emissions in 2010 were less than they were in 2000 (Government of Manitoba 2012a). Manitoba also released *Beyond Kyoto* in 2008, an action plan on climate change that outlined over 60 actions to reduce GHG emissions and adapt to the impacts of climate change across multiple sectors including energy, transportation, agriculture, municipalities, businesses and government operations. The Government of Manitoba is responding to the effects of climate change using three main areas of focus:

- reducing Manitoba's GHG emissions
- adapting to the anticipated impacts of climate change
- collaborating and sharing best practices with other jurisdictions

Other means of offsetting the potential effects of climate change include the maintenance, creation or expansion of 'carbon sinks'. Carbon sinks are processes that remove greenhouse gases from the atmosphere and store them long-term in another form, for example the storage of CO_2 (carbon dioxide) in perennial vegetation such as shelterbelts and woodlots, and in soils as organic matter (Government of Manitoba 2016a). Hundreds of billions of tonnes of carbon are also sequestered in wetlands as peat or soil in the expanses of swamps, marshes, fens and bogs that cover many areas of Manitoba (Manitoba Water Caucus 2016), including sections of the Project study area.

4.3 Greenhouse Gas Emissions

Climate change has been linked to GHG emissions that contribute to atmospheric increases in levels of CO_2 and other gases (e.g., methane [CH_4], nitrous oxide [N_2O]) that increase global temperatures, change climate and precipitation patterns, and increase the frequency of extreme weather events (ECCC 2016b). Environment and Climate Change Canada (ECCC) currently tracks six GHG substances as part of Canada's efforts to identify, quantify and reduce sources of GHGs. The six substances are CO_2, CH_4, N_2O, sulphur hexafluoride (SH_6), perfluorocarbons and hydrofluorocarbons (ECCC 2016b). Each GHG has a different global warming potential (GWP) and persists for a different length of time in the atmosphere; as such, GHG emissions from different types of gaseous compounds are converted into CO_2 equivalents to be compared and tracked over time (Climate Change Connection 2016).

Manitoba was the 7th largest emitter of GHGs in 1990 and 2005, and the 8th largest emitter of GHGs in 2014, in comparison to all other provinces and territories (ECCC 2016c).

ECCC also monitors GHGs under the Greenhouse Gas Emissions Reporting Program (GHGRP), which is Canada's legislated, publicly accessible inventory of facility-reported GHG data and information. The most current data set available at the time of this writing was the summary for the year 2014 (ECCC 2016d). In 2014, there were 12 facilities in Manitoba reporting under the GHGRP. These facilities are located about 200 to 500 km from the Project area, with the exception of the Graymont limestone and gypsum processing plant, which is located within the RSA on Provincial Trunk Highway (PTH) 239 between the towns of Steep Rock and Faulkner. This facility reported the 4th highest level of overall GHG emissions in Manitoba in 2014 (ECCC 2016d).

Other sources of GHGs in the RSA are likely from agricultural and recreational activities; vehicles travelling PTH 6, which is the main highway in the area and an important route to Thompson, Manitoba; and vehicle use on the other municipal roads and trails throughout the area. Pollutants emitted from motor vehicles include NOx (nitric oxide and nitrogen dioxide), CO (carbon monoxide), volatile organic compounds, and to a lesser extent SO_2 (sulphur dioxide) and particulate matter. These compounds are monitored under provincial and federal air quality guidelines and legislation, which are discussed below in the air quality section.

Infrastructure within the LSA for the proposed LMOC Route C and LMOC Route D includes:

- sections of paved highway, gravel roads and dirt trails;
- a portion of the Manitoba Hydro BiPole II transmission lines;
- rural residential areas, farm properties and vacation properties;
- the Fairford dam and fishway;
- wastewater treatment lagoons;
- small businesses and services such as convenience stores and gas stations;
- the Roviera resort and campground at Fairford;
- Watchorn Provincial Park; and
- quarries located on the west side of PTH 6 at Hilbre and south of PTH 6 along the Pinaymootang FN border.

Communities within the LSA include Fairford, Hilbre, Birch Bay, Grahamdale and a portion of the Pinaymootang FN.

It is expected that there are minor GHG emissions released related to the operation of services and residences in the LSA; however, the human population and amount of overall development and commercial activity in the area is of low density versus more populated urban areas. Land use conversion from vegetation to the wetted channel and associated structures of the LMOC could contribute to GHG emissions for the Project due to loss of carbon sequestration. However, this land use conversion will only occur in limited sections of the PF area, and additional areas of vegetation, including wetland areas, are present throughout the PF, LSA and RSA.

Within the LSA for the proposed LSMOC and ASR, infrastructure is limited to the existing municipal road, forestry road, winter roads, the LSMOC Reach 1 and LSMOC Reach 3. The town of Spearhill and a portion of the Dauphin River FN are the only human settlements within the LSA. Human activities within the LSA are limited to access by truck, All Terrain Vehicle (ATV) or snowmobile for hunting, fishing or other recreational use. Based on the low population and limited use of the area, the existing environment for GHG emissions in the LSA was considered to be low.

Land use conversion from vegetation to the wetted channel and associated structures for the LSMOCs and from vegetation to the permanent gravelled road surface for the ASR could contribute to GHG emissions for the Project due to loss of carbon sequestration. However, this land use conversion will only occur in limited sections of the PF area, and additional areas of vegetation, including wetland areas, are present throughout the PF, LSA and RSA.

4.4 Air Quality

In Manitoba, air quality issues are mostly local in nature and are primarily related to odour and other pollutants such as wind-blown dust released from specific local sources or activities. Emissions from the metal smelters in Flin Flon and Thompson and smoke from forest fires tend to be the most significant sources of air pollution in northern Manitoba (Government of

Manitoba 2009). Southern Manitoba has also experienced poor air quality on occasion due to smoke from forest fires or crop residue burning. Air quality within the RSA is affected by the commercial, agricultural, recreational, rural, transportation and urban activities that occur in the region, as well as from naturally occurring forest fires.

The Province of Manitoba and Environment Canada operate air quality monitoring stations in the cities of Brandon, Flin Flon, Thompson, and Winnipeg, Manitoba. The air quality monitoring stations closest to the Project area are located in the City of Winnipeg at 65 Ellen Street and at 299 Scotia Street. Air quality parameters that are monitored include: carbon monoxide (CO); particulate matter less than or equal to (≤) 10 microns (PM_{10t}); particulate matter ≤ 2.5 microns ($PM_{2.5}$), nitric oxide (NO); nitrogen dioxide (NO_2); nitrogen oxides (NO_x); ground level ozone (O_3); sulphur dioxide (SO_2); wind direction; and wind speed (Government of Manitoba 2016b).

The Manitoba Ambient Air Quality Criteria (Government of Manitoba 2016c) provides the maximum tolerable, maximum acceptable and maximum desirable concentrations of air pollutants required to protect and preserve air quality for human health. Comparison of the air quality parameters at the City of Winnipeg monitoring stations for various dates in 2016 to the Manitoba Ambient Air Quality Criteria indicated that the measured parameters do not exceed the maximum acceptable level and meet the “maximum desirable” concentrations for parameters that have this value defined.

Environment and Climate Change Canada has also developed the “Air Quality Health Index” (AQHI), an index that is based on the relative risk to human health that can be caused by a combination of common air pollutants (ECCC 2016e). These pollutants include ground-level O_3, $PM_{2.5}$ and NO_2.

The AQHI data summarized for Winnipeg for the period from 1987 to 2008 indicates good air quality for the majority of the time, with one episode of very poor air quality that occurred during 2002 that was likely due to smoke from burning crop residue in surrounding agricultural land (Government of Manitoba 2009).

The RSA is located approximately 200 km northwest of the City of Winnipeg and has a much lower density of population and development than the City of Winnipeg and surrounding areas. As such, it is expected that the ambient air quality within the RSA is of similar or higher quality than the ambient air quality for the City of Winnipeg. The RSA for the project is in a more forested landscape than the City of Winnipeg, and therefore may experience greater frequency of smoke from forest fires. The RSA includes and is adjacent to agricultural areas, which may also result in air quality effects due to the burning of crop residues.

As previously noted, the human population and amount of overall development and commercial activity in the LMOC LSA is of low density versus more populated urban areas. Existing effects on air quality in the LMOC LSA include emissions and dust due to traffic on PTH 6 and other local municipal, gravel and dirt roads and trails, including ATV and snowmobile activity; naturally occurring or human induced forest fires; emissions and dust from quarrying and quarried rock processing activities; odours, emissions and dust from farming activities; emissions from boating and other water-based activities; emissions from home heating, maintenance and other residential activities; and emissions from intermittent air traffic.

Within the LSA for the proposed LSMOC and ASR, the level of human activities and development is very low, with air quality effects limited to intermittent use of the municipal, forestry and winter roads by trucks, ATVs or snowmobiles, and naturally occurring or human induced forest fires.

4.5 Noise and Vibration

Existing noise and vibration levels in the RSA are expected to be typical of an area that consists mainly of forest, wetland and grassland areas with a transportation corridor and small urban and rural centers, cottage areas, and the presence of commercial, recreational and transportation activities. Existing sources of noise and vibration in the RSA include use of light and heavy vehicles and equipment; quarrying activities; processing activities at the Graymont plant; farming activities; recreational vehicles and activities (e.g., fishing, boating, hunting, snowmobiling, use of ATVs); occasional air traffic; wind and wave action along shoreline areas; and bird migration, nesting and breeding activities.

The Canadian National (CN) rail line that runs adjacent to PTH 6 and the spurs to Spearhill and Steeprock have been abandoned since 1997 (Transport Canada 2016) and are no longer a source of noise in the RSA. Planned upgrades to sections of PTH 6 have the potential to contribute to noise and vibrations in the RSA. The upgrades to PTH 6 are part of a five-year plan by the Manitoba Government and include paving of 19.5 km of asphalt from 1.6 km south of Moosehorn to the Steep Rock Junction at PTH 239 in the RSA (Government of Manitoba 2013).

Within the LSA for the LMOC Route C and LMOC Route D, sources of noise and vibration include road use, construction and maintenance activities by light and heavy vehicles and equipment; quarrying activities; farming activities; recreational vehicles and activities (e.g., fishing, boating, hunting, snowmobiling, use of ATVs); occasional air traffic; wind and wave action along shoreline areas; livestock; and bird migration, nesting and breeding activities. The PF and LSA for the LSMOC and ASR are located away from many of the sources of noise and vibration in the RSA, which is expected to result in an existing environment of low ambient noise and vibration in the PF and LSA for the LSMOC and ASR.

Traffic noise objectives have not been established in Manitoba for provincial highways; however, highway traffic noise is indirectly controlled by Transport Canada under the Motor Vehicle Safety Regulations (C.R.C., c. 1038) Schedule V.1 – Noise Emissions (Standard 1106), which defines maximum permissible sound levels (PSL) for individual categories of vehicles (Government of Canada 2016b).

Based on studies conducted on common noise levels and typical human reactions, noise levels in the vicinity of a highway can be in the range of 50 to 70 decibels (dB), although actual noise levels would be dependent on the volume of traffic, speed of the traffic and distance from the roadway. Road construction equipment noise ranges between about 76 dB and 89 dB at 15 m from the equipment. Noise control guidelines for land use planning are provided through Manitoba's *Guidelines for Sound Pollution* for daytime and nighttime acceptable and desirable noise levels in residential areas (MCWS 1992). For residential areas, the maximum desirable level is 55 dB during the day and 45 dB at night. For road construction, the industrial maximum desirable level would be used, which is 70 dB day or night.

D. J. Martin (1977) conducted a study on ground vibrations due to construction noise generated by different types of equipment on different types of soils and surfaces. The study found that vibration levels at 10 m from equipment such as an earth-moving plant and sheet-piling rig were above the threshold of human perception and could cause disturbance to people. However, the levels were much lower than the levels that could likely cause architectural damage to buildings. The results showed that the major sources of vibration in road construction were the tracked earthmoving plant, compaction plant and intermittent impacting plant. Rubber-tired equipment did not generate ground surface vibration levels high enough to be detected by human subjects. At distances greater than 10 m, ground attenuation effects may reduce the vibration levels to values below human sensitivity.

Vibration assessments typically measure vibration in terms of the Peak Particle Velocity (PPV), which is the maximum speed at which the ground particle moves due to the vibration, and is expressed as either millimeters or inches per second (Explosives and Rockwork Technologies Ltd. 2002). The PPV threshold for the perception of ground vibration is about 0.51 mm/s (0.02 in/s) for most people (The World of Explosives 2016). Ground vibration limits may be expressed as a single value; however, it is more likely that the limits will vary based on frequency as the limits are typically designed for the protection of property and structures.

The construction and operation of the proposed LMOC, LSMOC and ASR may require the need for quarried rock and excavation in bedrock areas. The noise and vibration from a production blast has been estimated as 128 dBa at 500 m, with a PPV of 1.3 mm/s at 500 m and an air blast (i.e., the wave of highly compressed air spreading outward from an explosion) of 119.4 dBa at 500 m (Explosives and Rockwork Technologies Ltd. 2002). As such, there will be instances during construction where noise and vibration levels may temporarily increase for short periods of time within the PF and sections of the LSA that are in proximity to the PF. Based on data on the attenuation of noise and vibration over distance, this increased noise and vibration level is not expected to extend to the entire LSA or to the RSA. Noise and vibration levels may also increase temporarily and locally during the operational phase of the proposed LMOC due to vehicle or equipment use in the PF.

4.6 Terrain and Topography

The RSA traverses two Ecoregions, the Mid-Boreal Lowlands (148) and the Interlake Plain (155); and four Ecodistricts: Sturgeon Bay (676), Waterhen (718), Gypsumville (720), and Ashern (723) (Smith et al 1998). The LMOC Route C LSA is located within the Gypsumville (720) and Ashern (723) Ecodistricts, and the LMOC Route D LSA is located mainly within the Ashern (723) Ecodistrict. The LSA for the LSMOC and ASR is located mainly within the Sturgeon Bay (676) and Ashern (723) Ecodistricts.

The Gypsumville (720) Ecodistrict is located in a small area surrounding LSM between Lake Winnipeg and LM and has a mean elevation of about 251 metres above sea level (masl) (Smith et al. 1998). The physiography of the region is mostly level to ridge till plain, partly covered with thin, glaciolacustrine clay deposits. Vegetation is dominated by forest stand mixtures of trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and white spruce (*Picea* *glauca*), while Jack pine (*Pinus banksiana*) prevails on drier sites (Smith et al. 1998). The principal sources of water in the Ecodistrict are groundwater, and surface water from LSM. Topography within the Ecodistrict includes slopes of zero to 2% that are 50 m to 150 m long, with an overall gentle slope towards the northeast of approximately 0.7 m/km from LSM (Smith et al 1998).

The Ashern (723) Ecodistrict is located between LM to the west and Lake Winnipeg to the east and has a mean elevation of about 274 masl (Smith et al. 1998). The Ecodistrict slopes very gently toward Lake Winnipeg and westward toward LM (Smith et al. 1998). The physiography is the outcome of Glacial Lake Agassiz's retreat; wave action and iceberg scouring resulted in ridges of coarse-textured small rock (cobble and gravel) and finer-textured depressions (Smith et al. 1998). Forest stand vegetation is dominated by trembling aspen in the ridge areas, but often associated with balsam poplar and white spruce whose distribution is much affected by forest fires (Smith et al. 1998). Willow (*Salix* spp.), sedge (*Carex* spp.), and meadow grass (*Poa* spp.) occur in the poorly-drained depressions.

Groundwater, the principal source of water in the Ecodistrict, is from shallow sand and gravel aquifers associated with the glacial till deposits (Smith et al. 1998). Smith et al (1998) describes the topography in the Ecodistrict as a northwest-southeast trending, ridge and swale topographic pattern, with grooved ridges ranging from about 400 m to 800 m wide and slopes that are usually less than 5% and range in length from 50 m to over 200 m. The land surface in the Ecodistrict slopes gently eastward toward Lake Winnipeg and westward toward LM at approximately 0.6 m/km, with local relief between ridges and swales of approximately 0.5 m to 3.0 m (Smith et al 1998).

The Sturgeon Bay (676) Ecodistrict encompasses most of the North Basin of Lake Winnipeg (Smith et al., 1998). The ecodistrict slopes gently northeastward toward Lake Winnipeg (Smith et al. 1998). The physiography is the outcome of Glacial Lake Agassiz's retreat; wave action and iceberg scouring resulted in ridges of coarse-textured small rock (cobble and gravel) and finer-textured depressions (Smith et al. 1998). Black spruce *(Picea mariana*) dominates forest stands due to extensive bogs/fens (peatlands) and poorly-drained mineral soils (transitional areas) (Smith et al. 1998). Associated vegetation varies from mosses (e.g., *Sphagnum* spp.), ericaceous shrubs (e.g. Labrador Tea [*Rhododendron groenlandicum*]), swamp birch (*Betula pumila*), sedge, willow, and tamarack (*Larix laricina*) depending if characterized as a peatland or as a transitional area. Groundwater, the principal source of water in the ecodistrict, is from shallow sand and gravel aquifers associated with the glacial till deposits (Smith et al. 1998).

For the proposed LMOC Route C, elevation was found to rise from about 249 masl at LM to about 256 masl at approximately 3.5 km inland, and remains above 252 masl until the area around PTH 6, after which the ground surface falls quickly to about 246 masl to LSM (KGS Group 2016). For the proposed LMOC Route D, the elevation ranges upstream of PTH 6 from about 248 masl to about 252 masl near PTH 6, from where the ground surface then falls quickly to about 245.5 masl to LSM (KGS Group 2016).

The elevation in the LSA for the proposed LSMOC and ASR is about 218 masl in the area of the proposed LSMOC Reach 3 Johnson Beach/Willow Point outlet, rising to an elevation of about 295 masl along the ridge that encompasses a section of the forestry road, and lowering to about 282 masl at the end of the municipal road.

4.7 Geology and Soils

The geology of the RSA is composed of layers of Devonian, Silurian and Ordovician carbonates and sandstone formed during the Paleozoic era that overly or onlap with Precambrian granites or gneisses (Leybourne et al. 2007). The LSM area is a region of great geological interest as it was struck by a meteor during the Jurassic, Triassic or Permian period (Lapenskie and Bamburak 2015; Leybourne et al. 2007; McCabe 1971). The LSM meteorite impacted dolomitic Ordovician to Devonian carbonates, basal sandstones and underlying Precambrian rock formations (Lapenskie and Bamburak 2015; Leybourne et al. 2007; McCabe 1971).

The LSM impact structure was described by McCabe (1971) as a crypto-explosion crater consisting of a crater or hole 22.4 km in diameter and more than 350 m deep, with a central core 3.2 km to 4.8 km in diameter, consisting of highly shock-metamorphosed Precambrian gneiss that was uplifted by at least 213 m, and is exposed in the centre of the crater. At the crater rim, lower Paleozoic and Precambrian rocks have been uplifted by about 213 m or more and are exposed in outcrop near The Narrows of LSM; beyond the crater rim is a structurally uplifted belt extending for about 22.4 km (McCabe 1971). The geological history of the area also resulted in large deposits of limestone, dolomite and gypsum, many of which have been mined for use as foundations and building structures, aggregate materials, cement, wallboard and Plaster of Paris (Government of Manitoba 2016d).

Over time, areas within the limestone, dolomite and gypsum deposits become dissolved, forming what is referred to as karst topography, which produces a variety of features such as underground drainage systems, sinkholes and caves (Bilecki 2003). These sinkholes and caves can provide wildlife habitat for a variety of species as dens, hibernacula and resting areas (Bilecki 2003). The Paleozoic boundaries mainly encompass the Interlake Plain (155), Mid-Boreal Lowlands (148), and a small portion of the Lake Manitoba Plain (162) Ecoregions, as defined by Smith et al. (1998), and the RSA is located just south of the localized permafrost zone (Lockery 1984). The surficial geology can be described as very calcareous, stony (cobble or gravel), water-worked glacial till that is deep to shallow (20-30 m) over limestone bedrock (Smith et al. 1998).

Soils within the RSA are heavily influenced by the geology of the area. Chernozemic dark grey surface horizons result, as well as soils composed of luvisol, brunisol and organic matter (Mills 1984). The soils in the Gypsumville (720) Ecodistrict are typically imperfectly-drained, dark grey chernozems developed on strongly calcareous, loamy to clay glacial till; poorly-drained gleysol and black chernozem soils occur on shallower areas (Smith et al. 1998). The Ashern (723) Ecodistrict is comprised of dominant soils in the higher ridges that are imperfectly-drained, dark chernozems developed on strongly calcareous, loamy to clay loam glacial till, while the low areas are dominated by poorly-drained gleysols to shallow, slightly decomposed organic soils (Smith et al. 1998). The soils associated with the Sturgeon Bay (676) Ecodistrict are very poorly-drained shallow to deep moderately-decomposed mesisols dominate soils, but local areas of very poorly-drained sphagnum fibrosols and imperfectly-drained brunisols on glacial till ridges also occur (Smith et al. 1998).

Geotechnical investigations conducted in 2015 showed that the stratigraphy along the proposed LMOC Route C generally consisted of a thin layer of topsoil overlying till materials including silt and clay till, silt till, clay till, and then bedrock; and that the stratigraphy along the proposed LMOC Route D generally consisted of a thin layer of topsoil overlying till materials including clay till, silty clay till, silt till, or sandy clay till with layers of sand, and then bedrock (KGS Group 2016). Along the proposed LMOC Route C, limestone bedrock was encountered in all boreholes at approximate depths ranging from 1.4 m to 6.1 m (KGS Group 2016). Along the proposed LMOC Route D, limestone bedrock was encountered in one borehole located about 2.6 km inland from LM at an approximate depth of 20.7 m, and extended to the end of the borehole at an approximate depth of 22.3 m; all other boreholes investigated in 2015 along the Route D alignment were terminated prior to reaching bedrock (KGS Group 2016).

In 2011, KGS Group drilled soil data cores in specified areas surrounding LSMOC Reach 1 and LSMOC Reach 3 (KGS Group 2013a). Results from the drilling identified that the surface soils were typically 0.75 to 0.90 m of organic peat underlain by silty clay till layers. Some gravel and clay was encountered followed by limestone granite bedrock at approximately 9.75 m (KGS Group 2013a). Additional soil surveys were completed in 2015 by KGS Group on the existing access road along the alignment of the existing winter roads to LSMOC Reach 1 and LSMOC Reach 3 (KGS Group 2016). Soils were found to be composed of a peat layer underlain by silty clay and silt till over boulders or dense silt till. The layers ranged from 0 to about 1.5 m of peat, 0.5 m to 1.5 m of silty clay, 1.5 m to 3.0 m of silt till, with boulders or dense silt till found at depths of about 3.8 m to 5.2 m (KGS Group 2016).

4.8 Vegetation

The desktop and field investigations for the vegetation studies included:

- classification of the vegetative cover classes in the Project study area using the Earth Observation for Sustainable Development of Forests (EOSD) Land Cover Classification (LCC) spatial database;
- wetland classification using the "*Classification of Natural Ponds and Lakes in the Glaciated Prairie Region*" (Stewart and Kantrud 1971) for the LMOC study area, and the Ducks Unlimited Canada's "*Enhanced Wetland Classification"* (Ducks Unlimited Canada 2014) for the LSMOC and ASR study area;
- identification of plant species of conservation concern, plant species of significance to First Nations, and invasive plant species; and
- ground and aerial surveys to collect and document the existing vegetation communities and plant species found within the Project study area.

4.8.1 LMOC

Four prominent land cover types were identified within the 5 km RSA for the proposed LMOC: modified grassland, tilled cropland, marsh wetlands and aspen dominant hardwood stands. Land use in the area is predominantly agricultural, consisting mainly of grazing and hay pastures with some cultivated croplands.

No species at risk or species of conservation concern were observed along the proposed LMOC Route C or LMOC Route D alignments during the 2016 field surveys. However, the shoreline habitats of LM at the LMOC Route C and LMOC Route D inlets were characteristic of the rocky shorelines at Steeprock, where previous observations of long-fruited parsley (*Lomatium macrocarpum*) and hairy-fruited parsley (*Lomatium foeniculaceum*) have been recorded. A small shrubby sphagnum bog along the proposed LMOC Route D alignment also provides habitat suitable for rare orchid species that have known occurrences within the RSA (i.e. ram's-head lady's-slipper [*Cypripedium arietinum*]), though none were observed.

Seneca root (*Polygala senega*) and pasture sage (*Artemisia frigida*) were two plant species identified during the 2016 field surveys that may be of significance to First Nations. Seneca root was widespread and abundant within the hayfields and grazed pastures along the proposed LMOC Route C alignment, and was found mainly adjacent to wet meadows and along forest edges. Pasture sage was only found at a few locations within open grasslands habitat and within the heavily grazed pastures near the proposed outlet at LSM. Seneca root was only found in one area along the proposed LMOC Route D alignment within a smooth brome hayfield adjacent to a wet meadow zone of a large permanent wetland complex.

Twenty-three and 19 invasive species were identified along the proposed LMOC Route C and LMOC Route D, respectively. No principal invasives or category 1 invasive species were observed along either of the alignment options. Scentless chamomile (*Tripleurospermum perforate*) and ox-eyed daisy (*Leucanthemum vulgare*) are considered Tier 2 noxious weeds under the Manitoba *Noxious Weed Act* (NWA) and category 2 listed species by the Invasive Species Council of Manitoba (ISCM) and were identified within several hayfields and pastures. Other moderate and minor invasive species were observed along both channel alignments along roadsides and within tame hayfields and grazing pastures where livestock activity and human disturbance is frequent. The frequency and abundance of invasive species varied with the degree of disturbance.

4.8.2 LSMOC and ASR

The 5 km vegetation RSA for the proposed LSMOC and ASR lies within a large depression area that is widely covered by an expansive graminoid dominant rich fen characterized by floating sedge and buckbean (*Menyanthes trifoliate*) mats with patches of common reed grass (*Phragmites australis*), bog birch (*Betula glandulosa*) and willows. Scattered throughout the large fen network are 'islands' of treed and shrubby sphagnum bogs dominated by Labrador tea (*Rhododendron groenlandicum*), pitcher plant (*Sarracenia purpurea*), bog laurel (*Kalmia polifolia*), bog cranberry (*Vaccinium oxycoccos*), and three-leaved false Solomon's seal (*Maianthemum trifolium*).

Some scattered upland mixedwood and coniferous forests were present on sandy moraine ridges. The majority of the existing Access Road follows the upland moraine ridge, which ranges from moist aspen and white spruce dominating mixedwood forests with a heavy willow and hazel (*Corylus* spp.) shrub layer, to dry, open jackpine stands with creeping juniper (*Juniperus horizontalis*) and herbaceous dominant understory.

The existing Reach 1 channel between LSM and Big Buffalo Lake is comprised of upland mixedwood forest with some areas of black spruce and tamarack sphagnum bogs, and a large expansive floating fen surrounding Big Buffalo Lake.

The area along the proposed Reach 2 dike option north of Big Buffalo Lake is composed of a black spruce dominant transitional upland forest-treed bog habitat with pockets of true shrubby and treed sphagnum bogs throughout. The majority of the area where the proposed Options 2, 3 and 4 of Reach 2 are located is one large graminoid rich fen connected to Big Buffalo Lake with small pockets of treed and shrubby sphagnum bogs.

The existing Reach 3 channel heads north from Buffalo Creek and passes through predominantly black spruce and tamarack sphagnum bog habitats. The area along the Johnson Beach option is primarily comprised of expansive black spruce/tamarack treed sphagnum bogs, whereas the habitat along the Willow Point alignment was composed largely of shrubby and open sphagnum bog habitat with few trees. As both alignment options reach Lake Winnipeg, the sphagnum bog habitats give way to hardwood riparian communities, coastal marshlands and sedge meadows.

One species of conservation concern listed by the MBCDC, the dragon's mouth orchid (*Arethusa bulbosa*), was identified during the vegetation surveys (Photograph 1).

Photograph 1: Dragon's mouth orchid (*Arethusa bulbosa*) observed within shrubby bog habitat at LSMOC plot 13. Photographed on June 10, 2016 by S. Gray Environmental Services Inc.

This orchid has a status of S2 under the MBCDC, i.e., a plant species that is rare throughout its range or in the province (6 to 20 occurrences) that may be vulnerable to extirpation. This species was found within a treed black spruce bog along the Reach 1 channel, just south of Big Buffalo

Lake and at several locations along the Willow Point option of the Reach 3 channel within open sphagnum bogs. The habitats in which the dragon's mouth orchids were found are common habitat types throughout the RSA. Although not encountered during the 2016 field surveys, there is a potential to encounter green adder's mouth orchid (*Malaxis unifolia*), ram's-head lady's-slipper, and/or other species of conservation concern that have similar habitat preferences.

Seneca root was observed during the field surveys and was identified as a species of significance to First Nations (NHLS 2016). This species was mainly found along the existing access road within dry upland jackpine dominant forest and along the edge of open pastures. There were 12 invasive species identified during the field surveys. These species were found predominantly along the disturbed banks of the existing emergency channel of Reach 1 and Reach 3, and along the shorelines of LSM and Lake Winnipeg, where human and animal traffic are more prevalent. One species identified as a Tier 2 noxious weed under the NWA and a category 2 species by the ISCM, scentless chamomile, was observed in a fairly isolated location along the municipal road and within the tame pasture to the north of the municipal road.

4.9 Wildlife and Wildlife Habitat

The desktop and field investigations for wildlife and wildlife habitat included:

- examination and classification of the wildlife habitat types in the Project study area using the Earth Observation for Sustainable Development of Forests (EOSD) Land Cover Classification (LCC) spatial database and the Forest Resource Inventory (FRI);
- selection of key wildlife species of interest in the RSA using the process for VEC selection defined by CEAA, information collected during the desktop studies, and previous knowledge of the area;
- habitat modelling and habitat evaluation for selected key species to document and quantify existing habitat for these species within the Project study area;
- field studies conducted in the fall of 2015, winter of 2015-16, spring 2016, summer 2016 and fall 2016:
    - an aerial survey of the Project area was conducted in October 2015;
    - winter 2015-16 surveys included an aerial moose, elk, and white-tailed deer survey, and an aerial multispecies survey;
    - spring 2016 surveys included an aerial shoreline survey, a Piping Plover survey, an avian Point Count survey, bird nest (egg) searches, a raptor nest and heron rookery survey, an amphibian Point Count survey and a reptile hibernacula survey; and
    - investigations for Ecologically Sensitive Site (ESS) such as mammal dens, mineral licks, snake and/or bat hibernacula, rookeries, and nests were conducted in the winter, spring, summer and fall.

Data were gathered from various agencies and sources to provide historical context to mammal, avian, reptile and amphibian presence and distribution within the RSA. Habitat modelling was conducted for moose, elk, white-tailed deer, American beaver, American marten, and 20 key bird species identified as Species At Risk or species of special interest due to their provincial conservation status, federal migratory bird status and/or socio-economic value. The fire history for the area was collated and reviewed to examine changes in vegetation on the landscape over time due to fire activity, which can influence the quality and availability of browse and other habitat conditions for moose and other wildlife. The desktop studies also included a linear density analysis for moose to establish the existing presence, size and type of linear features on the landscape that may affect moose and their habitat, and examine the changes in linear density on the landscape that may occur with the construction and operation of the Project.

4.9.1 Habitat Classification

The habitat classification using the LCC showed wetland shrub, water, wetland herb and grasslands as the most commonly occurring habitat covertypes within the RSA. Other habitat covertypes within the RSA include areas of open and dense coniferous forest, open and dense broadleaf forest, dense mixedwood forest, herb, wetland treed, and perennial crops and pasture. There were very little (<1%) low shrub, tall shrub, annual crops, developed or exposed land covertypes located within the RSA.

In the LMOC LSA, the dominant habitat covertype is grasslands, with some areas of dense broadleaf forest and wetland herb. With the exception of a small area of theLSMOC ASR LSA, the herb, annual crops, grassland and perennial crops and pasture habitat covertypes are all found within the LMOC LSA. The habitat covertypes not found within the LMOC LSA include open and dense coniferous forest, dense mixedwood forest, low shrub, tall shrub and wetland treed.

In the LSMOC and ASR LSA, the dominant habitat covertype is wetland shrub, with some areas of wetland herb and dense coniferous forest, as well as dense mixedwood forest and wetland treed. The habitat covertypes not found within the LSMOC and ASR LSA include herb, grassland, annual crops, perennial crops and pasture, open broadleaf forest, exposed land, developed, tall shrub or low shrub.

4.9.2 Key Wildlife Species of Interest

The federal environmental assessment process typically includes the need for the identification of Valued Ecosystem Components (VECs) in the study area of interest to focus the environmental assessment on key species or key components of the environment. The Canadian Environmental Assessment Agency (CEAA) defines a Valued Ecosystem Component as “the environmental element of an ecosystem that is identified as having scientific, social, cultural, economic, historical, archaeological or aesthetic importance” (CEAA 2012).

The selection of VECs is used to identify key species in the study area of interest that can represent a trophic level or guild of species (e.g., selection of a key ungulate species that is also important for human consumption), rather than conducting an assessment of all individual species in an area. Key species are selected based on their biological and socio-economic role in the ecosystem, their ability to represent the habitat and/or life history requirements of similar species, and often include Species At Risk or species of conservation concern to ensure that protected and rare species are accounted for in an environmental assessment.

Key wildlife species of interest in the Project RSA were identified to focus the analysis of potential habitat changes and/or other effects of the Project activities, and provide context for the future EIA. Key species were selected using the process for VEC selection defined by CEAA, information collected during the desktop studies, and previous knowledge of the area. **Table 1** provides a list and rationale for the key wildlife groups and common names for the species in the Project RSA that were selected for analysis.

Table 1: Summary of Key Species Selection and Rationale

Group	Key Species	Rationale
Ungulates	Moose	Demonstrate large home ranges (~40 km²) Important prey species for large carnivores e.g. wolves Hunted by rights based and licensed hunters
	Elk	Demonstrate large home ranges (50-400 km²) Important prey species for large carnivores e.g. wolves Hunted by rights based and licensed hunters
Furbearers	American marten	Commonly trapped furbearer Important species for predatory/prey dynamics Representative of mature forest habitat
	American beaver	Ecosystem engineer Representative aquatic furbearer
Bats	Little brown bat (Little brown myotis) Northern long-eared bat (Northern myotis)	Listed as "endangered" under SARA and MESEA Critical habitat for these species already identified in the Interlake region Geology within the RSA is conducive to support these species – representative of karst habitat
Migratory Birds	Forest Bird Species (including Barn Swallow, Bank Swallow, Bobolink, Canada Warbler, Common Nighthawk, Eastern Whip-Poor-Will, Eastern Wood-Pewee, Golden-winged Warbler, Olive-sided Flycatcher, Peregrine Falcon, Red-headed Woodpecker, Short-eared Owl)	Some species listed as "endangered", "threatened" or "special concern" under COSEWIC, SARA and/or MESEA Key species selected as representative of forest habitat types

Table 1: Summary of Key Species Selection and Rationale

Group	Key Species	Rationale
	Water Bird Species (including American White Pelican, Black-crowned Night Heron, Caspian Tern, Horned Grebe, Least Bittern, Piping Plover, Trumpeter Swan, Yellow Rail, ducks and geese)	Some species listed as “endangered”, "threatened" or "special concern" under COSEWIC, SARA and/or MESEA Some species hunted by rights-based and licensed hunters
Reptiles and Amphibians	Northern leopard frog, red-sided garter snake	Northern leopard frog Listed under SARA and MESEA Red-sided garter snake species most commonly found snake within RSA
Ecologically Sensitive Sites	Bat and snake hibernacula, terrestrial mammal dens (e.g. bears, wolves), rookeries, large stick nests, mineral licks	Critical wintering habitat Critical breeding habitat Species fidelity to dens and nests Culturally significant sites

4.9.3 Habitat Modelling and Analysis

Habitat modelling and analysis was conducted for moose (*Alces alces*), elk (Manitoba subspecies *Cervus elaphus manitobensis*), white-tailed deer (*Odocoileus virginianus*), American beaver (*Castor canadensis*), American marten (*Martes americana*), and the 20 bird species selected as key species of interest (**Table 1**). Potential habitat was modelled using the LCC, with some exceptions. The FRI was used in cases where a bird species had a strong preference for water and/or wetland habitats. The FRI, although dated to 1980, was determined to be a better base layer for modelling for these species given the finer scale of the FRI and therefore enhanced detailed information on riparian vegetation species such as cattails (*Typha* spp.).

The habitat modelling and analysis was conducted to examine the available existing habitat for the key wildlife species of interest, and the potential habitat for each of the key species of interest that may be affected by the Project activities. The analysis showed that, for all key wildlife species that were modelled, there would be a <1% potential alteration and/or loss of existing habitat at the RSA scale, with the exception of the horned grebe (*Podiceps auritus*), where the modelling and analysis showed a potential alteration and/or loss of 1.37% of existing habitat in the RSA.

For the LSMOC and ASR LSA, the analysis also showed that, for all key wildlife species that were modelled, there would be a <1% potential alteration and/or loss of existing habitat.

For the LMOC LSA, the potential alteration and/or loss of existing habitat was <1% for all of the mammal species except beaver, where the modelling and analysis showed a potential alteration and/or loss of 1.26% of existing habitat in the LSA for the proposed LMOC Route C. For the key bird species that were modelled, the potential alteration and/or loss of existing habitat in the LMOC

LSA ranged between <1% to <3%, with the exception of the bank swallow (*Riparia riparia*), black-crowned night heron (*Nycticorax nycticorax*), bobolink (*Dolichonyx oryzivorus*), golden-winged warbler (*Vermivora chrysoptera*), horned grebe, least bittern (*Ixobrychus exilis*) and yellow rail (*Coturnicops noveboracensis*).

For these six bird species, the potential alteration and/or loss of existing habitat was greatest in the LSA for the proposed LMOC Route D, with a potential alteration and/or loss of 5.88% of habitat for bank swallow; 7.08% of habitat for black-crowned night heron; 3.22% of habitat for bobolink; 5.70% of habitat for golden-winged warbler; 17.65% of habitat for horned grebe; 6.99% of habitat for least bittern; and 5.31% of habitat for yellow rail. The majority of these potential habitat alterations and/or losses for these six bird species are related to the alteration and/or loss of marsh, grassy marshes or wet meadow habitat types in the LSA for the proposed LMOC Route D.

4.9.4 Moose

A total of 14 moose were observed to be present in the Project RSA during the winter 2016 aerial survey. There were no signs of moose or moose activity identified during the spring 2016 ground-based track and sign surveys conducted within the RoWs for the proposed LMOC, and there were only two moose tracks observed in the LSMOC and ASR RoWs, with both tracks observed along the Reach 3 RoW.

Habitat modelling for moose showed the presence of summer habitat throughout the RSA and LSAs, and that the majority of winter habitat is found mainly to the north and east of the proposed LMOC Route C, with a higher density of winter habitat in the area of the existing LSMOC Reach 1 and proposed Reach 2 RoWs.

Based on the 90-year fire history data, the RSA burns infrequently and, in addition to fire suppression efforts in recent years, the low frequency of fires may have had an impact on available moose habitat within these areas. However, the RSA includes a number of areas of summer and winter habitat for moose, and habitat was not considered to be limiting for moose in the RSA. There are a number of existing paved, gravel and dirt roads and trails located throughout the RSA and LSAs, as well as snowmobile trails. The presence of these roadways and trails suggests that current access for hunting and recreation is widely available in the RSA and LSAs.

Salmo et al. (2004) identified a target threshold for linear disturbance for moose on a landscape scale at a density of 0.4 km/km^2 (i.e., linear disturbance features divided by the total area of interest) and a critical threshold density of 0.9 km/km^2. The current linear density for moose was found to be 0.22 km/km^2 within the Project RSA, 0.86 km/km^2 within the LMOC LSA, and 0.10 km/km^2 within the LSMOC and ASR LSA. Given that the Project RSA is based on the typical size of a moose home range of 40 km^2, the change in linear density for moose due to the Project is best examined at the RSA scale. The linear density analysis showed that, regardless of which route or options are selected, the increases in linear density in the RSA remain below the published Salmo et al. (2004) thresholds for moose.

4.9.5 Elk

A total of 16 elk were observed to be present in the Project RSA during the 2016 winter aerial survey, with the majority of the observations recorded along the east side of the proposed LMOC Route D LSA. One observation of elk scat on the proposed LMOC Route C was the only sign of elk or elk activity identified during the spring 2016 ground-based track and sign surveys conducted within the RoWs for the proposed LMOC, LSMOC and ASR. Habitat modelling for elk showed the presence of habitat throughout the RSA, with the majority of potential elk habitat found in the western and southern sections of the RSA and throughout the LSA for the proposed LMOC.

As noted above for moose, there are a number of existing paved, gravel and dirt roads and trails located throughout the RSA and LSAs, as well as snowmobile trails. The presence of these roadways and trails suggests that current access for hunting and recreation is widely available in the RSA and LSAs.

4.9.6 White-Tailed Deer

Although white-tailed deer (WTD) were not identified as a key wildlife species for the Project, understanding the current location and distribution of WTD within the RSA prior to construction is important for the understanding of any potential effects of the Project on WTD movement, and interactions among WTD and other ungulate species.

WTD are the host for the parasitic *Parelaphostrongylus tenuis* (*P.tenuis*) meningeal worm, also known as “brain worm”, which is a common parasitic nematode of the central nervous system that can be transmitted from WTD to other ungulate species such as moose and elk (Wasel et al. 2003). *P.tenuis* within WTD characteristically completes its life cycle without causing any significant adverse health effects (Kopcha et al. 2012). However, *P.tenuis* occurrence in other ungulates such as moose, elk and caribou (*Rangifer tarandus*), causes serious physical deterioration and eventual death.

A total of 628 WTD and 3495 tracks were observed in the Project RSA during the 2016 winter aerial survey. During the spring 2016 ground surveys, there were several signs of WTD activity and their presence identified along the proposed LMOC Route C, proposed LMOC Route D and the LM shoreline. A number of deer tracks, a deer trail, a deer rub and two deer were identified within the proposed LMOC Route D RoW, and two deer were observed within the RoW for the proposed LMOC Route C. One deer was also observed at the LM shoreline south of the proposed inlet for the LMOC Route D. Within the LSMOC and ASR LSA, a total of three deer, deer tracks, deer scat, and deer bones and a skull were observed in the areas of the municipal road, forestry road, Reach 1, Reach 3 and the LSM shoreline. The deer bones and skull were found at the bottom of a sinkhole in an area of rock outcrops where potential animal dens and bat and/or snake hibernacula were discovered.

4.9.7 Furbearers

The 2016 winter aerial multispecies survey identified the presence and/or tracks of beaver, marten, otter (*Lontra canadensis*), hare (*Lepus americanus*), lynx (*Lynx canadensis*) and coyote (*Canis latrans*) in the RSA. Maps showing the core use areas (i.e., spatial distribution) for beaver, marten, otter, hare, lynx, and coyote in the RSA were created from the winter 2016 aerial multispecies survey data.

Three wolves (*Canis lupus*) were also observed in the RSA during the 2016 winter aerial multispecies survey, in the vicinity of the end of the forestry road in the LSA for the LSMOC and ASR. Three wolves were also observed during the winter 2016 aerial surveys about 2 km north of the northern section of the forestry road, and one wolf was sighted by the aquatics field crew on April 29, 2016 on the forestry road, about 9 km south of where the three wolves were sighted during the winter 2016 aerial survey (M. Lowdon, pers.comm., 2016). During the aerial survey conducted in October 2015, a large adult black bear was observed in the LSMOC and ASR LSA.

Beaver activity in the LMOC LSA was limited to an area in the northwest section of the proposed LMOC Route C LSA. Marten tracks were identified in abundance throughout the RSA, but there was no marten activity identified within the LMOC LSA. Otter activity was identified in LM near the Fairford River and in the area of the proposed inlet for LMOC Route C, and in LSM in the area of the proposed outlet for LMOC Route D.

Hare activity within the LMOC LSA was limited to an area east of the proposed outlet for LMOC Route D and no lynx activity was identified within the LMOC LSA. There were a number of coyote observations and tracks identified in the area of the proposed inlet for LMOC Route D, along the length of the LSA for the proposed LMOC Route D, and in LSM in the areas near the proposed outlets for LMOC Route C and LMOC Route D.

Within the LSMOC and ASR LSA, beaver activity was identified in abundance throughout the LSA. Marten tracks were also identified in abundance throughout the LSA, except for the most southern portion of the LSA along the municipal road. Otter activity was identified most prominently in the northern portion of the LSA, and hare activity was identified in abundance throughout the LSA. Three lynx were observed during the 2016 winter aerial multispecies survey, with lynx activity identified where hare activity was identified, which covered a majority of the LSA. Coyote observations and tracks were also identified in both the southern and northern portions of the LSA. As noted above, a black bear was observed in the LMSEOC and ASR LSA during the fall 2015 aerial survey, and there were two sightings of wolves (three wolves during winter 2016 aerial surveys and one wolf during spring 2016 ground surveys) in the vicinity of the forestry road in the LSMOC and ASR LSA.

Furbearer track and sign surveys were conducted on foot in the Project area in June 2016. Within the area of the proposed LMOC Route C, coyote tracks were observed but there were no other signs of furbearer or predator activity. Within the area of the proposed LMOC Route D, a coyote, coyote tracks, a coyote vocalization and a muskrat (*Ondatra zibethicus*) and muskrat lodge were noted, as well as the observation of a bear rub, a black bear (*Ursus americanus*), and wolf (*Canis lupus*) scat. A beaver lodge was observed on the LM shoreline north of the proposed LMOC Route C inlet, and a beaver lodge was observed on the LM shoreline north of the proposed LMOC Route D inlet.

Within the LSA for the LSMOC and ASR, the furbearer track and sign surveys conducted on foot in June 2016 found several signs of furbearer activity and presence, as well as several signs of predators. Furbearer observations included: beaver dams, houses, lodges, rubs, shore dens and tracks; coyote, deer, red fox (*Vulpes vulpes*), and raccoon (*Procyon lotor*) tracks; a muskrat den and lodge; raccoon and otter scat, and an otter shore den. The majority of the furbearer activity was observed in the area of Reach 3, as well as in the area of Reach 1 and the LSM shoreline. Predator observations included a number of wolf and bear tracks, located on the Reach 3 channel and in the area of Reach 3 and Reach 1, and one observation of bear activity at the LSM shoreline.

4.9.8 Bats

There are six species of bats known to be present in Manitoba, including the big brown bat (*Eptesicus fuscus*), eastern-red bat *(Lasiurus borealis),* hoary bat (*Lasiurus cinereus*), little brown bat (or little brown myotis) (*Myotis lucifugus*), northern long-eared bat (or northern myotis) (*Myotis septentionalis)*, and silver-haired bat (*Lasionycteris noctivagans*). The eastern-red bat, hoary bat and silver-haired bat migrate in early fall to various southern wintering areas, while the big brown bat, little brown bat and northern long-eared bat remain in Manitoba and overwinter using caves, abandoned mines, wells, and other suitable areas as hibernacula.

Migratory and hibernating bat species typically 'swarm' in late summer and early fall (e.g., August to September) as part of mating and socializing activities, with the migratory species then moving on to their southern wintering areas, and the hibernating species moving into their hibernacula, as the fall weather approaches and temperatures and daylight hours decrease in late September and October.

Hibernating bat species are susceptible to white nose syndrome, a fungal disease that has spread and decimated many bat populations over the last decade. Due to the significant and fatal effects of this disease on their populations, the little brown bat and northern long-eared bat are listed as Endangered on Schedule 1 of SARA and the MESEA (SARA 2016; MBSD 2016a).

SARA currently has a proposed Recovery Strategy for the little brown bat and northern long-eared bat, with three Critical Habitat areas (i.e., hibernacula have been identified) for these species located in the Interlake area of Manitoba (EC 2015). One of the Critical Habitat areas is located about 10 km to 20 km east of the Project RSA, west of Fisher Bay and north of the Peguis FN, and two Critical Habitat areas are located around the communities of Gypsumville and St. Martin northwest of LSM (EC 2015). A portion of the Gypsumville and St. Martin Critical Habitat areas are within the RSA for the LSMOC and ASR. As such, the desktop and field investigations included the collation and review of life history and habitat information for the little brown bat and northern long-eared bat, and field surveys for potential hibernacula.

During winter 2016 aerial surveys, potential areas containing bat (and snake) hibernacula and large mammal dens were observed in the RSA. These sites were documented during the winter 2016 aerial survey and further investigated on foot during the spring 2016 and summer 2016 field work.

The spring 2016 and summer 2016 ground surveys identified potential areas of previously and/or currently active bat hibernacula within the LSA of the existing LSMOC access road. To determine the presence/absence and species of bats within the LSA, an Acoustic Recording Unit (ARU) was deployed within the LSA and along the existing LSMOC access road in 2016 during the months of August, September, and October. During the time the ARU was deployed, there were four bat species that were identified: big brown bat, hoary bat, little brown bat and silver-haired bat. The acoustic data collected from September 26, 2016 to October 17, 2016 included a small number of recordings that also indicated the potential presence of the northern long-eared bat.

To determine if there were any areas within the LSA for the LSMOC and proposed ASR being used by bats for hibernation, further investigations were conducted in March and April of 2017. These investigations included a FLIR aerial study to locate potential heat signatures or 'hotspots' on the landscape that could indicate the presence of hibernacula, followed by pedestrian searches of the hotspot areas. There were 12 hotspot locations identified during the FLIR aerial survey that were investigated by pedestrian surveys. The pedestrian investigations determined that the hotspot locations identified during the winter aerial FLIR survey were false positives. Further ground-based investigation was also conducted of the potential hibernaculum that was identified during the 2016 baseline field studies; this investigation showed that the area was not being actively used by bats. As such, the bat Species at Risk field studies conducted during March and April of 2017 did not identify the presence of active bat hibernacula within the LSMOC and proposed ASR LSA (EcoLogic 2017).

4.9.9 Birds

Key bird species of interest in the Project RSA were identified through review of information from the Manitoba Breeding Bird Atlas (MBBA 2015), Manitoba Conservation Data Centre (MBCDC 2015a, b), Manitoba Sustainable Development (MBSD 2016a~~b~~), Important Bird Areas of Canada (IBA 2015) and the federal Species At Risk Act (SARA 2016).

The LSM islands are a designated Canada Important Bird Area (IBA) that support a number of colonial waterbird species such as terns, cormorants, and pelicans, as well as other species such as herons, ducks, geese and bald eagles (IBA 2015). These islands and bird species were observed during the 2016 aerial surveys, including a significant great blue heron (*Ardea herodias*) rookery on an island in LSM (Photograph 2).

Photograph 2: Great blue heron rookery on an island in Lake St. Martin. Photographed June 9, 2016 by EcoLogic Environmental Inc.

As noted above, habitat modelling and evaluation were conducted to examine the available existing habitat for the 20 key bird species of interest, and the potential habitat for each of the key species of interest that may be affected by the Project activities. The habitat evaluation was also used to identify key habitat areas to be investigated for the field surveys.

Bird presence and activity in the Project RSA was examined through a combination of aerial nest and rookery surveys, shoreline aerial and pedestrian surveys, pedestrian nest search surveys, and point count surveys. Field surveys were conducted in the early morning, during the daylight hours, at dusk, and in the evening to capture the range of periods when different bird species may be active or vocalizing.

There was a total of 85 bird species identified during the incidental and pedestrian nest search surveys for the LMOC RoW areas and a total of 55 bird species identified during the incidental and point count surveys for the LMOC RoW areas. For the LSMOC and ASR RoW areas, a total of 63 bird species were identified during the incidental, pedestrian and aerial surveys, and a total of 34 bird species were identified during the incidental and point count surveys. There was a higher number of bird SAR and/or species of conservation concern observed along the LMOC Route D RoW in comparison to the LMOC Route C RoW.

Table 2 provides a summary of the status of the 20 bird species of interest noted in Table 1 under current federal and provincial legislation; confirmation of presence of the bird species in the Project area; and the location where the species was observed and/or heard.

Table 2: Confirmed Presence and Conservation Status of the Twenty Key Bird Species of Interest in the Project Area

Common Name	MBESEA Status	COSEWIC Status	SARA Schedule	SARA Status	Confirmed Presence During Field Studies	Observed Location
Forest and Land Birds						
Bank Swallow	N/A	Threatened	N/A	N/A	Yes	LMOC Route D RoW; municipal road near Spearhill in LSMOC & ASR LSA
Barn Swallow	N/A	Threatened	N/A	N/A	Yes	LMOC Route C RoW; LMOC Route D RoW
Bobolink	N/A	Threatened	N/A	N/A	Yes	LMOC Route D RoW
Canada Warbler	Threatened	Threatened	Schedule 1	Threatened	No	Not observed/heard
Common Nighthawk	Threatened	Threatened	Schedule 1	Threatened	Yes	LMOC Route D RoW; adjacent to the Forestry Road in the LSMOC & ASR LSA
Eastern Whip-poor-will	Threatened	Threatened	Schedule 1	Threatened	No	Not observed/heard
Eastern Wood Pewee	N/A	Special Concern	N/A	N/A	No	Not observed/heard
Golden-winged Warbler	Threatened	Threatened	Schedule 1	Threatened	No	Not observed/heard
Olive-sided Flycatcher	Threatened	Threatened	Schedule 1	Threatened	No	Not observed/heard
Peregrine Falcon	Endangered	Special Concern	Schedule 1	Special Concern	No	Not observed/heard
Red Headed Woodpecker	Threatened	Threatened	Schedule 1	Threatened	Yes	LMOC Route D RoW
Short Eared Owl	Threatened	Special Concern	Schedule 1	Special Concern	Yes	Open field within LMOC Route D LSA
Shoreline and Water Birds						
American White Pelican	N/A	N/A	N/A	Not At Risk	Yes	LMOC Route D RoW

Table 2: Confirmed Presence and Conservation Status of the Twenty Key Bird Species of Interest in the Project Area

Common Name	MBESEA Status	COSEWIC Status	SARA Schedule	SARA Status	Confirmed Presence During Field Studies	Observed Location
Black-Crowned Night Heron	N/A	N/A	N/A	Not Listed	No	Not observed/heard
Caspian Tern	N/A	N/A	N/A	Not At Risk	Yes	LM shoreline in LMOC LSA
Horned Grebe	N/A	Special Concern	N/A	N/A	No	Not observed/heard
Least Bittern	Endangered	Threatened	Schedule 1	Threatened	Yes	LSM shoreline near Reach 1 in LSMOC LSA
Piping Plover	Endangered	Endangered	Schedule 1	Endangered	No	Not observed/heard
Trumpeter Swan	Endangered	Not At Risk	N/A	N/A	Yes	Along the Forestry Road in the LSMOC & ASR PF/LSA
Yellow Rail	N/A	Special Concern	Schedule 1	Special Concern	No	Not observed/heard

Eight of the 20 modelled species were confirmed to be present within the LMOC LSA, including species listed as Endangered or Threatened on Schedule 1 of SARA and/or MESEA. Within the LSMOC and ASR LSA, four of the modelled species were identified to be present, including species listed as Endangered or Threatened on Schedule 1 of SARA and/or MESEA.

Trumpeter swans were observed to be present in the LSMOC and ASR LSA during the field studies. The trumpeter swan is still officially listed as extirpated in Manitoba, but the number of trumpeter swan sightings in Manitoba have been increasing annually in recent years (MBBA 2015). The trumpeter swan is not listed under SARA, but is listed as Endangered under MESEA. The trumpeter swans now breeding in Manitoba are considered to likely be the offspring of birds from captive release programs in the northern USA and Ontario (MBBA 2015).

The aerial and pedestrian surveys included searches for raptor nests and heron rookeries. Two bald eagle nests, two hawk nests, and a number of nesting snags, stick nests, songbird nests, snags and cavities of various sizes were observed along both of the proposed LMOC routes, and along the LM shoreline. As noted above, a significant heron rookery was observed on one of the LSM islands south of the Narrows within the LMOC RSA, but outside of the LMOC LSA.

In the LSA for the LSMOC and ASR, there were a total of six bald eagle nests and two nesting snags identified, with a number of other nests, nesting snags, nesting rocks and nesting colonies for terns, cormorants, and pelicans located on the islands within LSM outside of the LSA, but within the RSA.

4.9.10 Reptiles and Amphibians

Reptile and amphibian presence and activity in the overall Project RSA was examined through incidental observations, point count surveys and hibernacula investigations, as well as during all pedestrian early morning, daytime, dusk, and evening field work activities. Within the LMOC LSA, there were observations and vocalizations of three amphibian species: boreal chorus frog (*Pseudacris maculata*), northern leopard frog (*Rana pipiens*) and wood frog (*Rana sylvatica*); and observation of one reptile species, the red-sided garter snake (*Thamnophis sirtalis parietalis*). The northern leopard frog is currently listed as a species of Special Concern on Schedule 1 of SARA.

Within the LSMOC and ASR LSA, there were observations and vocalizations of three amphibian species: boreal chorus frog, grey tree frog (*Hyla versicolor*) and wood frog; and observation of one reptile species, the red-sided garter snake. During winter 2016 aerial surveys, there were areas of limestone depressions and sinkholes identified that were investigated on foot during the spring, summer and fall of 2016. Two of these areas were identified as potential snake hibernacula, and the red-sided garter snake noted above was observed near one of the potential snake hibernaculum.

4.9.11 Ecologically Sensitive Sites

The aerial and ground field surveys conducted in 2015 and 2016 included searches for Ecologically Sensitive Sites (ESS) such as mammal dens, large stick nests, mineral licks, rookeries and potential bat and/or snake hibernacula.

As noted above in the discussion on furbearers, bats, birds, reptiles and amphibians in the Project study area, the ESS observed in the RSA included a number of large stick nests, mammal dens, potential bat and/or snake hibernacula and the large heron rookery on one of the islands in LSM.

There were no ESS observed in the LMOC LSA during the 2015 and 2016 aerial and ground surveys. Within the LSA for the LSMOC and ASR, the ESS included three eagle nests and a goose nest, which were all located on the LSM shoreline.

4.10 Groundwater

The RSA is located within the Manitoba Lowland physiographic region, which is described as an area of gentle relief lying to the east of the Manitoba Escarpment (Betcher et al. 1995). This area is underlain by gently southwestwardly dipping Paleozoic and Mesozoic sediments consisting mainly of carbonate rocks with some clastic and argillaceous units, with bedrock overlain by glacial tills and proglacial lacustrine sediments (Betcher et al. 1995).

The surficial deposits within the RSA consist mainly of glacial till and sand and gravel deposits, with fairly extensive sand and gravel deposits at the surface being common in the area (Rutulis 1973). The availability and quality of groundwater is dependent upon the presence of shallow aquifers, which are generally sand or sand and gravel lenses (Rutulis 1973). The depth to these aquifers may range from less than 6 m where the sand and gravel deposits are at ground surface, to more than 60 m in low-lying areas where thick clay beds cover the aquifer (Rutulis 1973).

Water quality in the sand and gravel aquifers ranges from fair to excellent (Betcher et al. 1995; Rutulis, 1973). Areas where the sand and gravel deposits are at or close to the ground surface, and that are probable or existing groundwater sources, are susceptible to contamination from surface activities (Rutulis 1973).

KGS Group conducted groundwater studies in the Project area in 2011 and 2015 (KGS Group 2016) and again in 2016 as part of additional studies on groundwater and surface water in the LMOC LSA (KGS Group, in prep.) Results from the studies showed that flowing artesian well conditions are somewhat common in the study area, in particular along Birch Creek, and in the vicinity of LSM (KGS Group 2016). Flowing artesian well conditions also occur in the Dauphin River area and were consistent with the 2011 and 2015 field investigation results where artesian flow conditions were encountered up to 1 m above ground surface (KGS Group 2016).

KGS Group (2016) reported that the regional groundwater flow is easterly towards Lake Winnipeg, as well as westerly toward LM and LSM (and Lake Winnipegosis). Discharge from the aquifer occurs as seepage and flow into streams, marshes, and lakes found throughout the Interlake, with piezometric pressures in the aquifer between about 250 masl to 260 masl in the Birch Creek (LMOC Route D) area, and between about 240 masl to 250 masl in the Fairford River area (KGS Group 2016). KGS Group (2016) also reported that sparse data available in the northeast, near Dauphin River, showed regional piezometric levels in the order of 220 masl to 230 masl.

Well yields are highly variable in the region, which is a direct result of the fractured rock conditions, with water yields dependent on the number of fractures intersected by a well and the aperture size, extent, and interconnection to other fractures (KGS Group 2016). East of LM, the water quality is generally fresh, with Total Dissolved Solids (TDS) <1,000 mg/L, and water quality generally of the Mg-Ca-HCO3 type, with TDS in the order of 400 mg/L to 650 mg/L (KGS Group 2016). KGS Group (2016) noted that this water quality is reflective of the effects of the meteor impact (described above in Geology and Soils) and aquifer recharge zone noted within the Interlake area. Due to more complex geology and evaporate mineralogy in the Gypsumville area, water quality varies and is locally poorer with TDS concentrations up to 4,550 mg/L (Betcher 1987).

The groundwater studies conducted by KGS Group (2016) included:

- monitoring of water levels via measurement of piezometric pressures in test pits and boreholes installed along LMOC Route C and LMOC Route D;
- review of the Provincial well record database (GWDrill) to determine existing well locations;
- assessment of the potential for basal heave or groundwater blowouts during excavation;
- examination of aquifer drawdown during channel construction and operation;
- assessment of Groundwater Under the Direct Influence of Surface Water (GUDI);
- review of potential changes to LSM surface water quality; and
- for LMOC Route D, analysis of the potential drainage of surface water bodies near the channel alignment.

4.10.1 LMOC Route C

Results of the 2015 studies showed groundwater depths that ranged from 1.21 m to 2.70 m along the proposed LMOC Route C (KGS Group 2016). There were no artesian conditions encountered during the 2015 drilling program along LMOC Route C.

Based on the preliminary review of the area, it was determined that there are up to 145 possible residential locations within 3 km of the proposed LMOC Route C, with 135 of these wells located on the Pinaymootang First Nation (FN) (KGS Group 2016).

The assessment of the potential for basal heave or groundwater blowouts during excavation found that, due to the existing geological and groundwater conditions of the area, blowout/basal heave conditions may occur within the channel excavation during the construction phase of the Project and to a lesser degree in the operational phase of the Project (KGS Group 2016). The risk of basal blowout for the proposed LMOC Route C was cited by KGS Group (2016) as a significant concern for the Project that will need to be addressed as part of the detailed design.

The examination of aquifer drawdown found that drawdown of aquifer groundwater piezometric pressures would be anticipated during construction, as well as during channel operation, given the shallow depth to groundwater and deep excavation into bedrock (up to 13 m) along the proposed Route C (KGS Group 2016). The analysis showed a potential maximum of 2 m to 3 m of drawdown at 1 km from the channel during construction, equating to as much as 5 m to 6 m of drawdown in the immediate vicinity of the channel excavation. This potential drawdown effect could have an effect on the available capacity of the local supply wells.

The GUDI assessment showed that the extent of excavation into the bedrock aquifer required for the proposed LMOC Route C will result in a direct connection between surface water and groundwater. This direct connection greatly increases the vulnerability of the aquifer to contamination by surface water, which can lead to contamination of local groundwater resources. The direct connection of surface water to the bedrock aquifer is a strongly negative aspect of the Route C alignment, and could potentially affect the groundwater resources and domestic wells located in the Pinaymootang FN.

The review of potential changes to LSM surface water quality found that discharge of groundwater to the channel is expected given the channel excavation depth, aquifer piezometric pressure conditions, interconnection to the carbonate aquifer, and construction and operational channel conditions (KGS Group 2016). The groundwater quality is considered to be relatively fresh (TDS = 390 to 550 mg/L, Chloride = 2 to 19 mg/L), but may have lower levels of dissolved oxygen than the surface waters. The groundwater system currently naturally discharges to LM and LSM; therefore, the volume of groundwater discharge to the surface water bodies is not expected to be greatly increased. There will also be varying amounts of surface water baseflow in the channel during operation, which will provide some degree of dilution of groundwater prior to discharge to LSM (KGS Group 2016).

4.10.2 LMOC Route D

Results of the 2015 studies showed groundwater depths that ranged from 2.51 m below the ground surface elevation to 5.42 m above ground surface elevation along the proposed LMOC Route D (KGS Group 2016). Artesian conditions were encountered at four of the borehole locations along the proposed LMOC Route D.

Based on the preliminary review of the area, it was determined that there are up to 70 possible residential locations within 3 km of the proposed LMOC Route D (KGS Group 2016).

Based on the current channel design and available geotechnical investigations for LMOC Route D, the channel invert is above the bedrock, and is excavated within the tills, for the entire length of the channel. As such, the assessment of the potential for basal heave or groundwater blowouts during excavation found that blowout / basal heave conditions may occur within the channel excavation during the construction phase of the project, if the bedrock aquifer groundwater piezometric pressures exceed the confining overburden mass that remains between the channel excavation invert and bedrock surface elevation during excavation (KGS Group 2016). During channel operation, blowout or basal heave / seepage would be expected if these bedrock aquifer pressures exceed the operating channel surface water profile, and where not confined by sufficient overburden thicknesses (KGS Group 2016).

The examination of aquifer drawdown found that drawdown of aquifer groundwater piezometric pressures would be anticipated during channel construction and operation, given the flowing artesian bedrock piezometric pressure conditions, and potential direct connection to the bedrock aquifer via seepage through fractured till due to a possible groundwater blowout (KGS Group 2016). The analysis showed a potential maximum of 2.5 m to 4.2 m of drawdown at a 1 km distance from the channel during construction, and as much as 6 m to 8 m in the immediate vicinity of the channel excavation. This potential drawdown effect could have an effect on the available capacity of the local supply wells.

The GUDI assessment showed that there will be a varying depth of till beneath the invert of the channel and above the bedrock aquifer along Route D, although a connection between the bedrock aquifer and the channel is expected either due to blowout, or with possible installation of depressurization sumps within the channel excavation (KGS Group 2016). The potential for GUDI exists in the long-term even with a permanent depressurization system, due to the complexities of fracture flow within bedrock, and the possibility of an adjacent well user pumping heavily from a directly interconnected and transmissive fracture or bedding plane parting within the bedrock, which could result in the draw of surface water from the channel, directly into the 3rd party well (KGS Group 2016). A connection between the bedrock aquifer and the channel increases the vulnerability of the aquifer to contamination by surface water, which can lead to contamination of local groundwater resources, and could potentially affect the domestic wells located within 3 km of the proposed LMOC Route D channel.

As seen for LMOC Route C, the review of potential changes to LSM surface water quality found that discharge of groundwater to the channel is expected given the channel excavation depth, aquifer piezometric pressure conditions, interconnection to the carbonate aquifer, and construction and operational channel conditions (KGS Group 2016). The groundwater quality is considered to be relatively fresh (TDS = 390 to 550 mg/L, Chloride = 2 to 19 mg/L), but may have lower levels of dissolved oxygen than the surface waters. The groundwater system currently naturally discharges to LM and LSM; therefore, the volume of groundwater discharge to the surface water bodies is not expected to be greatly increased. There will also be varying amounts of surface water baseflow in the channel during operation, which will provide some degree of dilution of groundwater prior to discharge to LSM (KGS Group 2016).

In regard to the drainage of surface water bodies near the channel alignment, there are several wetland areas, ponds, sloughs, and lakes (e.g., Reed Lake, Clear Lake, Goodison Lake) located within the LSA for LMOC Route D that may have connection to the groundwater aquifer, depending on the total depth of the water body, underlying soil stratigraphy, and depth to bedrock surface (KGS Group 2016). Based on the data collected in 2011 and 2015 for the measured bedrock aquifer piezometric pressures, bedrock elevations, and till thickness, there is a low possibility for groundwater baseflow contribution to the wetlands; however, there is potential for interconnections where there may be a relatively thin till confining layer, and/or a pervious intertill granular zone that allows for some seepage to the surface water system, e.g., a “spring” feed to the base of the wetland areas (KGS Group 2016). Therefore, the existing upward gradient to discharge could be periodically reversed if there is a reduction in groundwater pressures, such as during construction when there may be more significant groundwater piezometric pressure drawdowns, or the groundwater baseflow to the wetlands could be reduced (KGS Group 2016).

KGS Group (2016) noted that the contribution of groundwater to surface water areas adjacent to the proposed LMOC Route D was unknown at the time of writing and further understanding of the hydrogeology of this area is needed. For example, layered fine-grained sediments formed within the basins of the ponds, sloughs and lakes, as well as potentially thick, competent till acting as an aquiclude between the wetlands and bedrock, would be significant limiting factors to wetland drainage.

4.10.3 LSMOC Reach 1

The stratigraphy along Reach 1 generally consisted of 0.5 m to 3 m of peat overlying silt till. Bedrock was identified at the Reach 1 inlet at an elevation of about 221 masl. The nearest data from the Provincial Groundwater Availability Map Series indicated bedrock at an elevation of about 224 masl. The depth to groundwater at three sites sampled at the Reach 1 inlet was 0.57 m to 3.08 m below the ground surface elevation of 247.74 masl.

KGS (2016) noted that, based on the overburden depth, piezometric pressures, and channel design, the potential for blowout of basal soils along the Reach 1 alignment is low. Based on the overburden thickness and bedrock aquifer piezometric pressures, there is minimal connectivity expected between the channel surface water and the groundwater aquifer. There were no residential wells identified in close proximity to the channel; therefore, there are no concerns related to aquifer drawdown or GUDI associated with the construction or operation of Reach 1.

The proposed Reach 1 channel design includes the use of till for the channel sideslopes for stability and to mitigate the drainage of the perched water table present within the overlying peat into the channel excavation; as such, it is not anticipated that the channel will result in drainage of local wetlands. The till is estimated to have a maximum hydraulic conductivity in the range of

1 x 10^{-6} m/s. Provided that the till berms along the channel are continuous, the till should provide a barrier to any significant groundwater inflow to the channel, including from the perched aquifer zones (KGS Group 2016).

4.10.4 LSMOC Reach 2

The stratigraphy along Reach 2 generally consisted of about 0.4 m to 1.3 m of peat overlying 1.7 m to 2.1 m of clay, underlain by silt till. There was no bedrock identified along Reach 2 and only limited seepage from the silt till layer was observed during test-pitting. The proposed design for Reach 2 includes stripping of peat for the construction of containment berms up to 4 m in height, with minimal channel excavation (KGS Group 2016). There were no concerns identified in regard to potential effects to groundwater during construction, or longer-term aquifer vulnerability as a result of the proposed Reach 2 construction and operations.

4.10.5 LSMOC Reach 2 Alternatives - Options 1 to 4

During meetings and discussions with MI in April 2016, MI indicated that the Reach 2 alignment and dike options described for the original assignment were being revisited. Three other channel alignment and/or dike options were being investigated, in addition to the Reach 2 dike option. The extension and widening of the existing Reach 1 and construction of the Reach 2 dike was referred to as Option 1, and the additional alignments were referred to as Option 2, Option 3 and Option 4. Other than the proposed lengths and locations, there were no other data available for the additional conceptual options at the time of this writing.

The three new options were added to examine other routes that could be used to manage flows from LSM to Lake Winnipeg, and included the construction of a new channel to the east of the existing Reach 1 channel, which would tie into Reach 3 near Big Buffalo Creek. As such, the areas associated with Options 2 to 4 were included into the baseline desktop and field investigations conducted in 2016. It is assumed that further geotechnical investigations will be conducted in 2017 to determine the groundwater conditions for the selected channel alignment.

4.10.6 LSMOC Reach 3

The stratigraphy along the Reach 3 alignment generally consisted of peat overlaying silty clay and silt till, with till generally found at depths ranging from 1.37 m to 5.49 m below grade. In the area of the Reach 3 inlet near Buffalo Creek, artesian groundwater conditions in bedrock were observed; the bedrock was found at a ground elevation of 234.16 masl, and the groundwater elevation was 1.95 m above grade (KGS Group 2016). At a second testhole located just south of the artesian condition, the groundwater elevation was 1.25 m below the ground elevation of 235.34 masl in silt till. Further along the alignment, groundwater was found at depths between 1.36 m to 2.09 m below grade in bedrock and till, with the exception of one testhole where the groundwater elevation was 0.55 m above grade in bedrock, i.e., an artesian condition in bedrock (KGS Group 2016).

For the Willow Point alignment, groundwater depths ranged from 0.11 m to 3.08 m in mainly silt till with some clay till, at ground elevations that ranged from 221.13 masl to 228.5 masl (KGS Group 2016).

During the construction phase of the Project, blowout / basal heave conditions may occur within excavated areas, if the bedrock aquifer groundwater piezometric pressures exceed the confining overburden mass that remains between the channel excavation invert and bedrock surface elevation during excavation (KGS Group 2016). During the operation of the channel, blowout or basal heave / seepage would be expected if these bedrock aquifer pressures exceed the operating channel surface water profile, where it is not confined by sufficient overburden thicknesses. As such, a depressurization program or other construction-based method of accommodating the high aquifer piezometric pressures and associated basal heave / blowout conditions would be required during the construction and operational phases of the Project (KGS Group 2016).

A temporary channel blowout could result in the discharge of confined groundwater into the channel, which could lower the aquifer groundwater level in the vicinity of the channel. There is the potential for the groundwater discharge to affect surface water quality, although groundwater discharge to Lake Winnipeg already occurs naturally (KGS Group 2016). During operation of the channel, flood water levels in the channel could exceed the underlying groundwater levels, and lead to potential infiltration to the local aquifer.

There were no residential wells identified in close proximity to the Reach 3 channel alignment. As such, no concerns related to aquifer drawdown or GUDI are associated with the Reach 3 construction or operation (KGS Group 2016). Based on the Reach 3 channel design, including the utilization of till for the channel side slopes and to mitigate the drainage of the perched water table present within the overlying peat into the channel excavation, it is not anticipated that the channel will result in drainage of local wetlands. The till is estimated to have a maximum hydraulic conductivity in the range of 1×10^{-6} m/s and should provide a barrier to any significant groundwater inflow to the channel (KGS Group 2016).

4.10.7 ASR

The 2015 geotechnical investigations conducted by KGS Group (2016) included surveys for riprap and granular borrow in areas of the existing forestry road, e.g., the area referred to as the Campsite Quarry. Borehole logs from sites located at the end of the forestry road showed the following:

- TH15-14 - a layer of boulder till over cobble from the ground surface to about 4.5 m below the ground surface, underlain by limestone, and a groundwater depth of 4.13 m below the ground surface;
- TH15-15 - a layer of peat over cobble and boulder till from the ground surface to about 2.5m below the ground surface, with a layer of cobble and gravel over limestone to a depth of 9.2m, and groundwater observed at 5.07 m below the ground surface.
- TH15-16 - boulders near the surface; and
- TH15-17 – a layer of sand and gravel to a depth of 3.1 m, with no groundwater observed (KGS Group 2016).

There were no other groundwater data specific to the existing Access Road PF or LSA. The majority of the area within the LSA for the proposed ASR is undeveloped and uninhabited, with the exception of seasonal trailers and other small dwellings used for hunting and recreation. As such, there were no recent or local data available for groundwater use, groundwater quality or well yields in the Access Road PF or LSA.

4.11 Surface Water

Major named watercourses and waterbodies in the RSA from west to east include Portage Bay and Watchorn Bay in LM; Fairford River; Inlet Creek; Lake Pineimuta; LSM; Reed, Clear and Goodison lakes; Birch Creek; Beardy Creek; Dauphin River; Bear Creek; Little Buffalo Lake; Big Buffalo Lake; Buffalo Creek; Sturgeon Bay in Lake Winnipeg; Mantagao Bay, Mantagao River and Mantagao Lake; and a number of named and unnamed creeks, ponds and small lakes that are located throughout the RSA.

4.11.1 Lake Manitoba, Fairford River and Lake St. Martin - Water Quantity

Based on review of the hydrographs and data presented in the Stage 2 report (KGS Group 2016), lake levels in LM for the period of record ranged from a minimum of about 247 masl (810.3 feet) in 2003 to a maximum of about 249.1 masl (817.1 feet) in 2011. The *Lake Manitoba and Lake St. Martin Regulation Review Committee* cited the long-term, average level of LM as 812.2 feet (247.6 masl) (LM & LSMRRC 2013). The Fairford River monthly mean flows for the period of record from 1912 to 2015 have ranged from a minimum of zero flow in the winter months of 1960 and 1961, to a maximum flow of 610 cubic meters per second (cms) in July 2011. In LSM, lake levels ranged from a minimum of about 242.3 masl (794.8 feet) in 1965 to a maximum of about 245.5 masl (805.5 feet) in 2011 for the same period of record (1961 to 2014) (KGS Group 2016). Lake levels above 243.8 masl (800 feet) start to flood haylands along the edge of the lake (LM & LSMRRC 2013).

4.11.2 Lake Manitoba, Fairford River and Lake St. Martin - Water Quality

The Water Quality Management Section of MBSD carries out a long term water quality monitoring network on major streams, rivers and lakes in Manitoba, including several lake and river sampling stations in the LM watershed and in LSM (MBSD 2017). There are three long-term lake monitoring stations: two stations are located on LM, at Delta Marsh and at the Narrows, and a third station is located on the Fairford River at PTH 6 (LM & LSMRRC 2013).

In addition, two other lake monitoring stations were added at Lundar and St. Ambroise in 2011, and the frequency of sampling was increased during the 2011 flood (LM & LSMRRC 2013). River monitoring is conducted at three long-term stations located on three of the major rivers of the LM watershed: the Waterhen River at PR 328, the Whitemud River at Highway 16, and the Assiniboine River. The frequency of sampling at the river monitoring stations was increased during the 2011 flood, and water quality was also sampled in LSM at three locations – the North Basin, the Narrows and the South Basin (LM & LSMRRC 2013).

In addition to water quality sampling and monitoring, MBSD investigated the potential relationship between water levels in LM and water quality, using average concentrations of total phosphorus (TP) and total nitrogen (TN) as the basis for the examination of water quality. LM average TP levels from 1992 to 2011 as measured at the Delta Marsh station ranged from about 0.045 milligrams per litre (mg/l) to about 0.13 mg/l, with the highest concentration observed in the 2011 sampling (LM & LSMRRC 2013). LM average TN levels from 1992 to 2011 as measured at the Delta Marsh station ranged from about 0.09 mg/l to about 1.8 mg/l, with the highest concentration observed in the 1999 sampling (LM & LSMRRC 2013).

The Portage Diversion is the largest source of phosphorus to LM when it is flowing; in 2011, more than 60 percent of the TP load to LM was transported by the Portage Diversion (LM & LSMRRC 2013). TP was elevated at Delta Marsh in 2011, as well as in other wet years, but an increase in average TP was not found in the water quality sampling done at the station located at the Narrows in LM (LM & LSMRRC 2013).

The Waterhen River was identified as the largest source of TN to LM; in 2011, nearly 60 percent of the TN load to LM was transported by the Waterhen River (LM & LSMRRC 2013). It was also noted that the percentage of the TN load is greater in years when the Portage Diversion does not flow, and, unlike the average TP concentrations, average TN concentrations were not affected by the 2011 flood, with no significant increases observed (LM & LSMRRC 2013).

Other indicators of water quality being sampled by MBSD include chlorophyll α, total suspended solids, conductivity, dissolved oxygen, metals and pesticides. The average chlorophyll α concentration in LM was slightly higher in 2011 than the long-term average, but within the range of historical concentrations. When it flows, the Portage Diversion is the largest source of TSS to LM, and contributed more than 85% of the lake's load in 2011; however, TSS in LM in 2011 was similar to the long-term average and within the range of historical concentrations (LM & LSMRRC 2013).

Dissolved oxygen concentrations in LM are typically sufficient for aquatic life, but have occasionally been below the guideline for supporting aquatic life, including measurements in May 2011 and in August 2011. Conductivity has been declining in LM in recent years, it appeared to be affected by the 2011 flood and can be linked to the inflow from the Portage Diversion (LM & LSMRRC 2013). Water quality monitoring over time has shown increases in phosphorus and chlorophyll and decreases in conductivity in LM, but water levels do not appear to be a major driver of water quality (LM & LSMRRC 2013). Water quality in the south basin of LM does appear to have been significantly affected by the Portage Diversion.

In 2011 to 2012, monitoring was conducted at five stations – Waterhen River, Lake Manitoba Narrows, Fairford River, Dauphin River, and Sturgeon Bay - to examine the regional water quality prior to and during the operation of the LSMOC. Monitoring showed that the LSM water quality "met the majority of water quality objectives and guidelines" (LM & LSMRRC 2013). TP, turbidity and chlorophyll α levels were found to be lower in LSM than in the south end of LM, which had the highest levels of these parameters.

Mercury levels in fish were examined in tissue samples collected from northern pike (*Esox lucius*), lake whitefish (*Coregonus clupeaformis*), white sucker (*Catostomus commersoni*) and yellow perch (*Perca flavescens*) in LSM in the fall of 2011. The tissue concentrations of mercury were found to be generally low and within the safe limits for human consumption and unrestricted commercial sale (LM & LSMRRC 2013).

A total of 58 types of pesticides were analysed at selected sites in the Fairford River, Dauphin River and Sturgeon Bay (NSC 2013a). Glyphosate was detected at all sites sampled on July 16 and July 17, 2011, and October 28 and October 29, 2011; in one sample from the Dauphin River on July 17, 2012, 2-4-D was detected at the detection limit amount of 0.50 µg/L (NSC 2013a); all other pesticides for which sufficient sample was collected to conduct the analysis were below analytical detection limits on these dates (NSC 2013a,b). Pesticides were consistently below the analytical detection limits in samples collected from the Fairford and Dauphin rivers on November 6, 2011 after Reach 1 was in operation, and glyphosate concentrations did not exceed the MWQSOGs or CCME guideline for PAL, or the MWQSOGs for drinking water, in any samples collected in fall 2011 (NSC 2013b).

These monitoring activities and studies show the complicated nature and influence of inflows and outflows to LM and LSM, and the range of variability of water quality parameters in these basins. Current water chemistry and water quality parameters in the LM and LSM watersheds have been and continue to be significantly affected by inputs from other connected waterways. Given that the FRWCS has been in operation for many decades, it is expected that the inter-basin transfer of water between LM and LSM is an historical and ongoing occurrence. As such, the transfer of nutrients and potential contaminants such as *E. coli* and microcystin from LM to LSM is likely to have already taken place. However, the increased flows and transfer of water from LM to LSM that will result from the development of the LMOC may increase the potential for changes to the existing LSM water chemistry and water quality.

4.11.3 LMOC

Information on surface water in the LSAs for the proposed LMOC Route C and LMOC Route D was collected as part of the fisheries and aquatic habitat assessments completed by AAE Tech Services Inc. (AAE) in the fall of 2015 and spring of 2016 (AAE 2016a). Investigations were focused on the waterways intersecting both channel routes, including two sampling sites on LM within the vicinity of the proposed inlet areas and two sampling sites on LSM within the vicinity of the proposed outlet areas.

The two LM channel inlet sites were located approximately 2.0 km south of the outlet into the Fairford River (LMOC Route C inlet) and within Watchorn Bay (LMOC Route D inlet), referred to as the Fairford and Watchorn Bay sites, respectively. The two LSM outlet sites were located 1 km north of Harrison Creek (LMOC Route C outlet) and at Birch Bay immediately north of Birch Creek (LMOC Route D outlet), referred to as the Harrison Bay and Birch Bay sites, respectively.

The field surveys included the collection of bathymetry data and *in situ* field water quality measurements. The Fairford study site was characterized as having a gently sloping lake bottom reaching a maximum measured depth of 2.2 m about 650 m from shore. The Watchorn Bay study site was characterized as having a very shallow sloping lake bottom reaching a maximum measured depth of 2.7 m about 750 m from shore.

The Harrison Bay study site bathymetric survey depicted a gradually sloping lake bottom throughout most of Harrison Bay, reaching a maximum measured depth of 3.2 m about 750 m from shore. Results of the bathymetric survey demonstrated a gradually sloping lake bottom throughout most of Birch Bay, reaching a maximum measured depth of 3.7 m. Slopes were steepest along the west shoreline of Birch Bay at the Route D channel site, following a relatively consistent slope to a depth of 3 m about 250 m from shore.

Water quality sampling for the proposed LMOC Route C and LMOC Route D included the collection of *in situ* measurements of temperature, dissolved oxygen, pH, conductivity, turbidity, and total suspended solids. In general, all four sites had good water quality and all water quality measures were consistently within the CCME guidelines for the protection of aquatic life (CCME 1999).

4.11.4 LSMOC

Information on surface water in the LSMOC study area was obtained from the series of reports prepared by KGS Group and North/South Consultants Inc. (NSC) for MI from 2011 to 2016. A number of field surveys and monitoring activities were conducted from 2011 to 2015 in relation to surface water, including:

- Collection of water level measurements, flow metering, cross-sectional profiles, and bathymetry data;
- Ice formation studies, sediment transport studies, and turbidity monitoring;
- Collection of water chemistry samples from the study area waterbodies and watercourses;
- Incorporation of historical water chemistry data collected for the Coordinated Aquatic Monitoring Program (CAMP), which is managed through a partnership between Manitoba Hydro and the Province of Manitoba; and
- Incorporation of water quality data collected in the study area by Manitoba Conservation and Water Stewardship (MCWS) from 1973-2014.

Monitoring for the emergency reduction of LM and LSM water levels included two main water quality monitoring programs: (1) a Regional Water Quality Monitoring Program (RWQMP) that 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 (LSMOC Monitoring) (NSC and KGS Group 2016). *In situ* water quality monitoring was done in Sturgeon Bay to gather and examine spatial information on the water quality of Sturgeon Bay, and to define the area of influence of the Dauphin River (NSC and KGS Group 2016).

Water quality monitoring studies were conducted annually, with varying rates of frequency of sampling depending on the parameter, and focussed on the collection and analyses of samples for standard field parameters, dissolved oxygen, total suspended solids, nutrients, chlorophyll α, metals and major ions; samples for the analysis of petroleum hydrocarbons were also collected during some sampling events (NSC and KGS Group 2016), as well as water samples for the examination of pesticides and fish tissue samples for the examination of mercury in fish tissue (NSC 2013b). The list of the key water quality parameters included:

- Dissolved Oxygen (DO);
- Conductivity and total dissolved solids (TDS);

- pH;
- Total suspended solids (TSS) and turbidity;
- Nitrogen;
- Phosphorus;
- Carbon;
- Chlorophyll α;
- Hardness;
- Metals and major ions with Manitoba Water Quality Standards, Objectives, and Guidelines (MWQSOGs) or Canadian Council of Ministers of the Environment (CCME) guidelines for the Protection of Aquatic Life (PAL), or MWQSOGs or Health Canada Guidelines for drinking water; and
- Petroleum hydrocarbons, e.g., benzene, ethyl-benzene, toluene, xylenes, total hydrocarbons (C6 to C50) (NSC and KGS Group 2016).

Metals and major ions on the list included: aluminum, antimony, arsenic, barium, boron, cadmium, chloride, chromium, copper, fluoride, iron, lead, manganese, mercury, methyl mercury, molybdenum, nickel, selenium, silver, sodium, sulphate, thallium, uranium and zinc (NSC and KGS Group 2016).

Detailed descriptions of the sampling methods, sampling frequency, sampling locations and results for the water quality sampling and monitoring programs conducted by NSC and KGS Group from 2011 to 2015 are provided in Volume 3 – Water Quality (NSC and KGS Group 2016).

Within the LSA for the LSMOC, the waterbodies and watercourses examined in the 2011 to 2015 surface water studies included sampling sites in LSM, Reach 1, Big Buffalo Lake, Buffalo Creek, Dauphin River, Mantagao Bay and Sturgeon Bay (NSC and KGS Group 2016). NSC and KGS Group (2016) reported that there were little to no historical water quality data available for LSM, Big Buffalo Lake, Buffalo Creek, and Sturgeon Bay. As such, data collected during the 2011 flood prior to the operation of Reach 1 were considered as the baseline for the pre-operational phase of the Project (NSC 2012).

The sampling sites in LSM showed natural variability in the measured water quality parameters over the course of the monitoring program, with fluctuations in the measured parameters seasonally and among years (NSC and KGS Group 2016). There was no linkage found between the operation of Reach 1 and water quality in LSM, with the following exception:

- During dredging in October 2011, TSS in the vicinity of the Reach 1 inlet exceeded the 30 day MWQSOG / CCME long-term guideline for PAL (i.e., average of 5 mg/L above background), and periodically exceeded the 1-day MWQSOG PAL objective/CCME short-term PAL guideline (i.e., 25 mg/L above background) (NSC and KGS Group 2016).

Based on data collected in 2011, NSC and KGS Group (2016) described the water quality of LSM as moderately nutrient rich, low to moderately turbid, slightly alkaline, very hard, and well-oxygenated.

A brief sampling program was conducted in Big Buffalo Lake in August of 2011 to support the planning of field studies and monitoring in the Project area (NSC 2012). The lake was considered to be not thermally stratified, relatively well-oxygenated and near-neutral based on *in situ* measurements collected from four sites in Big Buffalo Lake (NSC 2012).

In situ measurements of surface water quality collected at the mouth of Buffalo Creek immediately upstream of its confluence with the Dauphin River showed that water at the creek mouth was slightly more turbid, acidic, less oxygenated, and warmer than measured at Big Buffalo Lake (NSC 2013b). Based on data collected in 2011, NSC and KGS Group (2016) described the water quality of Buffalo Creek as generally well-oxygenated, nutrient moderate, clear, slightly alkaline, highly coloured and hard. The water quality of Buffalo Creek differed from Lake St. Martin, the Dauphin River or Sturgeon Bay; Buffalo Creek had lower turbidity/TSS, lower conductivity and TDS, lower chlorophyll α, higher concentrations of organic carbon, greater colour, and a higher amount of phosphorus in dissolved form than the other waterbodies in the study area (NSC 2013b).

Mean flows for the Dauphin River for the period of record from 1977 to 2015 were 103 cm with a minimum recorded flow of 1.13 cm in January, 2004 and a maximum recorded flow of 579 cm in July, 2011 (Government of Canada 2016c). Based on the historical data and data collected in 2011, NSC and KGS Group (2016) described the water quality of the Dauphin River as moderately nutrient rich, low to moderately turbid, slightly alkaline, very hard, and well-oxygenated.

The Dauphin River flows into the west side of Sturgeon Bay, and the Mantagao River and a number of small unnamed streams flow into the south-eastern corner and eastern side of Sturgeon Bay. The southern part of the bay is adjacent to the Sturgeon Bay Provincial Park. Water depths of 2.7 m to 8 m under ice thicknesses of 0.65 m to 0.90 m were recorded in Sturgeon Bay in February 2012 during the deployment of sediment traps throughout the bay (NSC 2013a). Data obtained by NSC (2012) from the Canadian Hydrographic Service indicated a maximum depth of about 10.4 m at the northern end of the bay. Based on the data collected in 2011, NSC and KGS Group (2016) described the water quality of Sturgeon Bay as moderately nutrient rich, low to moderately turbid, slightly alkaline, hard to very hard, and well-oxygenated.

4.11.5 ASR

Information on surface water in the LSA for the proposed ASR was collected as part of the fisheries and aquatic habitat assessments completed by AAE Tech Services Inc. (AAE) in the fall of 2015 and spring of 2016 (AAE 2016b). Investigations were focused on the waterways intersecting the proposed ASR that could provide habitat for fish, specifically species that support a Commercial, Recreational or Aboriginal (CRA) fishery and/or Species At Risk (SAR). As such, field studies were conducted at one section of Bear Creek and two sections of Winthers Creek that crossed the existing Access Road, and at Mantagao Lake, which is the headwaters of Winthers Creek and a known fishing location in the LSA. There were no historical hydrological or surface water chemistry data found for Bear Creek, Mantagao Lake or Winthers Creek.

All of the measured water quality parameters were within the Manitoba *Tier II Water Quality Objectives* and *Tier III Water Quality Guidelines*, with the exception of pH (MCWS 2011). The *Tier III Water Quality Guideline* for Surface Water for the Protection of Freshwater Aquatic Life for pH is 6.5 to 9.0 (MCWS 2011). The pH measurements at Crossing 1 and Crossing 2 on Winthers

Creek ranged from 6.09 to 6.31. The pH of natural waters is influenced by the geology, soils and vegetation that the water flows over, through or around. The lower pH level in Winthers Creek could be a result of lower alkalinity that occurs in the absence of carbonate sources such as limestone or dolomite; or could reflect the presence of peat or Sphagnum moss, as water in peat bogs typically have a pH range of 3.3 - 5.5, and transitional bog waters have a pH in the range of 4.5 - 6.0 (Upper Thames River Conservation Authority 2016).

4.12 Fisheries and Aquatic Habitat

4.12.1 LMOC

Fisheries and aquatic habitat assessments were completed by AAE in the LSAs for the proposed LMOC Route C and LMOC Route D in the fall of 2015 and spring of 2016 (AAE 2016a). Investigations were focused on the waterways intersecting both channel routes, including two sampling sites on LM within the vicinity of the proposed inlet areas and two sampling sites on LSM within the vicinity of the proposed outlet areas. The two LM channel inlet sites were located approximately 2 km south of the outlet into the Fairford River (LMOC Route C inlet) and within Watchorn Bay (LMOC Route D inlet), referred to as the Fairford and Watchorn Bay sites, respectively.

The two LSM outlet sites were located 1 km north of Harrison Creek (LMOC Route C outlet) and at Birch Bay immediately north of Birch Creek (LMOC Route D outlet), referred to as the Harrison Bay and Birch Bay sites, respectively. Data collection was also completed on four tributaries connected to these sites: Birch Creek (connected to Birch Bay site), Watchorn Creek (connected to Watchorn Bay site), Mercer Creek (connected to Watchorn Bay site), and Harrison Creek (connected to Harrison Bay site).

Fieldwork was completed during the fall of 2015 and spring of 2016. Data were collected to document the existing conditions for five components:

1. Desktop review of potential protected species inhabiting the area;
2. Aquatic and riparian habitat assessment;
3. *In situ* water quality measures;
4. Fish distribution and composition; and
5. Benthic invertebrate analysis.

The habitat assessment included a bathymetric survey, which consisted of an analysis of depth, substrate, and vegetation cover at each study site, and cross-sectional profiles of each tributary. Baseline water quality variables measures were collected, including temperature, dissolved oxygen (DO), pH, conductivity, turbidity, and total suspended solids (TSS).

Fish distribution and composition was assessed through boat and backpack electrofishing surveys, gill net sets, hoop netting, larval fish net tows, egg mat sampling, and kick net sampling. Fall fish sampling was performed using fewer, shorter set times to avoid disrupting the migratory patterns of lake whitefish (*Coregonus clupeaformis*), a commercially important fall-spawning species previously documented to be utilizing LM and LSM. Benthic macroinvertebrates were collected, identified and examined as an indicator of water quality and ecosystem health. Results were tabulated, compiled, and presented for each study site.

4.12.1.1 Fairford Study Site – Lake Manitoba, Route C

The Fairford study site was characterized as having a gently sloping lake bottom reaching a maximum measured depth of 2.2 m approximately 650 m from shore. Substrate was predominantly coarse, including mixtures of gravel, sand and cobble. Vegetation cover was greatest at depths between 1 m and 1.5 m, though plant height was relatively low (<0.6 m) and biovolume was found to be relatively low across the site.

A total of 226 fish representing 14 species were captured during spring and fall sampling at Fairford. Fall sampling found northern pike to be the most abundant species, with white sucker and lake whitefish also present. Spring sampling identified a large fish community including predominantly northern pike, walleye (*Sander vitreus*), white sucker and yellow perch. Fish larvae net tows yielded 63 larval fish representing two species, including walleye and white sucker. Egg mat (70 mats) and kick sampling efforts (25 m^2) yielded no eggs during either the spring or fall field season.

A total of 23 taxa from 10 orders of benthic macroinvertebrates were captured at Fairford. The most common orders were Amphipoda (scuds), Diptera (true flies), Ephemeroptera (mayflies), and Trichoptera (caddisfly).

Overall, habitat structure and water quality were characteristic of high quality aquatic habitat for fish species. Benthic invertebrate species identified further suggest very good water quality at the Fairford study site. While egg mat surveys did not identify any eggs, fish in spawning condition were identified during both the fall and spring study period, and small numbers of fish larvae sampled in the spring suggest that some spawning may take place within the Fairford site.

4.12.1.2 Watchorn Bay Study Site – Lake Manitoba, Route D

The Watchorn Bay study site was characterized as having a very shallow sloping lake bottom reaching a maximum measured depth of 2.7 m approximately 750 m from shore. Substrate was predominantly sand to depths of 1.5 m. Vegetation cover was minimal, restricted to pockets of gravel/cobble substrate at depths greater than 2 m.

A total of 218 fish representing 12 species were captured during spring and fall sampling at Watchorn Bay. Fall sampling yielded predominantly lake whitefish, while spring sampling yielded predominantly yellow perch and white sucker. Fish larvae net tows yielded 24 larval fish representing two species, including walleye and white sucker. Egg mat sampling (70 mats) yielded no eggs during either the spring or fall field season.

A total of 16 taxa from eight orders of benthic macroinvertebrates were collected in Watchorn Bay. The most common orders were Amphipoda, Diptera, Ephemeroptera and Trombidiformes (mites).

Overall, habitat structure and water quality did not represent diverse aquatic habitat for fish species. With primarily sandy substrate, Watchorn Bay is characteristic of a shallow and windswept bay. The increased wave action and sediment movement found at this site resulted in egg mats becoming completely clogged and embedded in sediment; this effect is not conducive to productive spawning habitat as eggs would similarly be battered and covered in sediment.

The creeks that drain into Watchorn Bay (Mercer Creek and Watchorn Creek), however, were determined to be valuable spawning sites, with white sucker in spawning condition migrating upstream within both systems, and the presence of licensed commercial trap nets on both creeks confirmed these creeks as productive fish migration routes. These observations would suggest that Watchorn Bay may serve as an important part of the spawning migratory route in this area, supported by the collection of lake whitefish (fall) and white sucker (spring) in spawning condition within the Watchorn Bay study site. The overall quality of habitat potentially affected by the proposed LMOC Route D channel construction was assessed as low.

4.12.1.3 Harrison Bay Study Site – Lake St. Martin, Route C

The Harrison Bay study site bathymetric survey depicted a gradually sloping lake bottom throughout most of Harrison Bay, reaching a maximum measured depth of 3.2 m approximately 750 m from shore. Substrate was predominantly a gravel-sand mixture. Vegetation cover was dense at depths greater than 1.5 m, though plant height and total biovolume was extremely low.

A total of 271 fish representing 16 species, were captured during fall and spring sampling at Harrison Bay. Fall sampling yielded predominantly lake whitefish, northern pike and yellow perch. Spring sampling identified a diverse fish community (14 species), including large numbers of white suckers. Fish larvae net tows yielded 5,844 larval fish representing two species including white sucker and walleye. Egg mat sampling (70 mats) yielded no eggs during either the spring or fall field season.

A total of 22 taxa from ten orders of benthic macroinvertebrates were collected in Harrison Bay. The most common orders were Amphipoda, Diptera, Ephemeroptera and Trombidiformes.

Riparian habitat was the most extensive and complex at the Harrison Bay site. Aquatic vegetation within the marsh was extremely dense and highly productive, draining directly into LSM at the LMOC Route C site. This habitat is characteristic of spawning habitat for fish species such as northern pike and yellow perch. Overall, aquatic habitat quality at the Harrison Bay site was very high, with both the highest total number of species observed, and the highest total catch and CPUE of spring larval fish. The presence of fish in spawning condition and fish larvae suggest that the Harrison Bay site provides important spawning habitats for the fish communities within LSM, although egg mat sampling was not able to identify specific spawning sites.

4.12.1.4 Birch Bay Study Site – Lake St. Martin, Route D

Results of the bathymetric survey demonstrated a gradually sloping lake bottom throughout most of Birch Bay, reaching a maximum measured depth of 3.7 m. Slopes were steepest along the west shoreline at the Route D channel site, following a relatively consistent slope to a depth of 3 m approximately 250 m from shore. Substrate was predominantly sand and gravel.

Vegetation cover was sparse especially in the western portion of Birch Bay at the LMOC Route D channel site, with relatively low biovolume outside the mouth of Birch Creek. Where the creek enters the lake, habitat is heavily vegetated, with long grass and cattails extending north. This narrow band of marsh habitat will likely be utilized by northern pike, yellow perch or forage fish for spawning, nursery of refuge. It is, however, less extensive than the habitat observed at Harrison Creek.

A total of 89 fish representing 8 species were captured during fall and spring sampling at Birch Bay, which was the lowest species diversity observed at the four study sites. Fall sampling yielded predominantly lake whitefish, and spring sampling yielded predominantly white sucker, northern pike, and common carp (*Cyprinus carpio*). Fish larvae net tows yielded capture of 2,855 larval fish representing two species, including white sucker and walleye. Egg mat sampling (70 mats) yielded no eggs during either the spring or fall field seasons.

A total of 22 taxa from 11 orders of benthic macroinvertebrates were collected in Birch Bay. The most common orders were Amphipoda, Diptera and Ephemeroptera.

Similar to Harrison Bay to the north, Birch Bay was found to include productive, high quality aquatic habitat with substrate and water quality characteristics conducive to fish spawning and habitation. While egg mat sampling did not identify specific spawning sites with this area, high larval fish counts and the presence of fish in spawning condition suggest this area plays an active role in fish spawning and migration. The capture of a significant number of spawning white sucker on Birch Creek, as well as the presence of a licensed commercial trap net on this creek, support the importance of Birch Bay and the Birch Creek tributary to the productivity of this fishery.

4.12.1.5 Fisheries and Aquatic Habitat Study Summary

The baseline assessment found that all four of the study sites possessed a healthy aquatic ecosystem with established fish communities. When examining the results of the benthic invertebrate study, combined with water quality measurements, in particular turbidity and TSS levels, it can be determined that the aquatic habitat within the proposed LMOC Route C area of impact (Fairford and Harrison Bay) represents relatively higher quality fish and aquatic habitat vs. the proposed LMOC Route D area of impact. This determination is reflected in the comparative CPUE of adult and larval fish, species diversity, and overall habitat characteristics between the Route C and Route D sites, most notably between the LSM sites.

Although the Fairford and Watchorn sites were comparable for fish productivity and species diversity, the Harrison site (LMOC Route C outlet) had much higher productivity and species diversity than the Birch Bay site (LMOC Route D outlet). The extensive riparian marsh habitat at the Harrison Bay site provides potential nursery and spawning habitat for fish, as evidenced by fish larvae sampling and between-site comparisons of fish communities. The collections at the Harrison Bay site resulted in over 3x the number of adult fish, over 2x the number of larval fish, and 2x the number of fish species than those at the Birch Bay site. The Fairford site (LMOC Route C inlet) is also expected to offer better fish spawning habitat with its gravel-sand substrate and higher vegetation cover, in comparison to Watchorn's (LMOC Route D inlet) windswept and sandy conditions.

4.12.2 LSMOC

Information on fisheries and aquatic habitat in the LSMOC study area was obtained from the series of reports prepared by North/South Consultants Inc. (NSC) for MI from 2011 to 2016. A number of field surveys and monitoring activities were conducted from 2011 to 2015 in relation to fisheries and aquatic habitat, including:

- Collection and analysis of habitat data via aerial surveys;
- Collection of substrate and bathymetry data via field surveys;
- Classification and quantification of aquatic habitat via field surveys;
- Examination of benthic invertebrate presence/absence via field surveys;
- Investigation of fish species presence/absence via gill net surveys;
- Investigation of fish species presence/absence via electrofishing surveys;
- Examination of spawning areas and activities using egg mats; and
- Examination of the presence/absence, abundance, distribution and movement of larval fish using neuston tows and larval drift nets.

Detailed descriptions of the sampling methods, sampling frequency, sampling locations and results for the fisheries and aquatic habitat sampling and monitoring programs conducted by NSC from 2011 to 2015 are provided in Volume 4 – Fish Habitat (NSC 2016a) and Volume 5 – Fish (NSC 2016b).

4.12.2.1 Lake St. Martin

NSC (2012) described LSM as having substrates primarily composed of soft mud, with an extensive area of gravel, sand, and compacted mud along the LSM western shore near the mouth of the Fairford River, and areas of bare bedrock in the northeast basin and the narrows. It was noted that extensive gravel bars and boulders are abundant in LSM, and these habitat types can provide suitable spawning habitat for several fish species in the area (NSC 2012). These substrate and cover features, along with areas of submerged and emergent vegetation, and a number of islands and reefs, were also observed during spring 2016 avian field surveys.

A total of 10 fish species were captured during gill-netting studies in LSM including cisco (*Coregonus artedii*), common carp, freshwater drum (*Aplodinotus grunniens*), lake whitefish, longnose sucker (*Catostomus catostomus*), northern pike, shorthead redhorse (*Moxostoma macrolepidotum*), walleye, white sucker and yellow perch (NSC 2016b). LSM was noted as an important spawning area for lake whitefish, shorthead redhorse, white sucker and yellow perch (NSC 2016b). NSC (2012) cited the fish species of commercial and domestic importance known to occur in LSM as northern pike, walleye, and lake whitefish; with common carp, goldeye (*Hiodon alosoides*), burbot (*Lota lota*), longnose sucker, white sucker, yellow perch, sauger (*Sander canadensis*), and cisco composing a smaller portion of the LSM commercial fishery.

4.12.2.2 Big Buffalo Lake

Big Buffalo Lake lies within an area of mainly herb and shrub wetlands, with some areas of floating bog and pockets of sparse coniferous forest present around the lake (NSC 2012). Lake substrates were cited as a being composed of a deep layer of loosely compacted organic sediments; aquatic vegetation (mainly *Potamogeton* spp.) was present throughout most of the lake, with less dense areas in the centre of the lake vs. the shallower areas (NSC 2012). Inflow to the lake is provided as runoff from the surrounding wetland areas, with outflow to Little Buffalo and Buffalo Creek.

A total of five fish species were captured during gill-netting studies in Big Buffalo Lake including golden shiner (*Notomigonus crysoleucas*), northern pike, white sucker and yellow perch during spring and summer surveys, and lake whitefish during fall surveys (NSC 2012; 2016a). Juveniles and adults of all four species were captured, as well as young-of-the-year (YOY) yellow perch; it was suggested that yellow perch were using the lake for significant spawning activity, and a resident population of yellow perch may have been present in the lake prior to the operation of Reach 1 (NSC 2016a). White sucker may also have been spawning in Big Buffalo Lake, and the juvenile fish present were likely using the lake for feeding (NSC 2016a). There were large numbers of YOY cyprinids observed within areas of dense aquatic vegetation that were not captured and therefore not identified to species (NSC 2016a). There were no commercial, domestic or sport fishing activities identified in Big Buffalo Lake.

4.12.2.3 Buffalo Creek

The habitat in Buffalo Creek was described in NSC (2012) as follows: the first four kilometers of the creek downstream from Buffalo Lake flows through a treeless wetland via a narrow channel (< 5 m wide) that becomes undefined in some areas; topography was very flat in this area with water depths up to 1 m, and substrates primarily composed of loosely compacted organic sediment. Downstream of this wetland area, soils are better-drained and the creek channel has a meandering pattern with a series of run/riffle/pool habitat over substrates of cobble, gravel and sand. This area of the creek contained gradient changes and beaver dams were common.

Fish species captured in the upper reach areas included included central mudminnows (*Umbra limi*), juvenile white suckers, ninespine (*Pungitius pungitius*) and/or brook stickleback (*Culaea inconstans*), logperch (*Percina caprodes*) and large numbers of YOY northern redbelly dace (*Phoxinus eos*) and/or finescale dace (*Phoxinus neogaeus*). Large numbers of crayfish and other aquatic macroinvertebrates such as snails were also observed in this area of the creek (NSC 2012).

Fish species captured in the lower reach area included logperch, longnose dace (*Rhinichthys cataractae*), juvenile northern pike, mottled (*Cottus bairdii*) and/or slimy sculpin (*Cottus cognatus*).

Drift traps set in Buffalo Creek about 200 m upstream of the confluence with the Dauphin River in spring 2012 captured larval cisco, lake whitefish, northern pike, sculpins, sticklebacks, suckers, unidentified percids (likely darters or yellow perch), unidentified cyprinids, white bass (*Morone chrysops*) and yellow perch. About 95% of the larval fish captured were suckers; cyprinids, lake whitefish and sculpins were the next most abundant larval fish species captured (NSC 2013a).

The capture of adult and larval white sucker in the Buffalo Creek watershed indicated that white suckers are spawning somewhere in Buffalo Creek during periods of Reach 1 operation (NSC 2016b). Lake whitefish spawned in the area of the mouth of Buffalo Creek and in the area of the confluence of Buffalo Creek with the Dauphin River in November 2011 during the pre-operation phase and the initial onset of operation of Reach 1, and in the same general area from fall 2011 to fall 2014, but these spawning areas occurred in areas of the Dauphin River more so than in the lower reaches of Buffalo Creek (NSC 2016b).

There were no commercial, domestic or sport fishing activities identified in Buffalo Creek; however, a local commercial fisher indicated that northern pike, white sucker and yellow perch move into the creek during spring (NSC 2012). NSC (2012) observed that suitable spawning habitat for these species, as well as for walleye, is present in the lower reach of the creek, therefore these species may spawn in these areas, but the commercial fisher did not think that walleye moved into the creek.

4.12.2.4 Dauphin River

Substrates in the Dauphin River were classified as bedrock/limestone, cobble/boulder, compacted gravel, gravel/cobble, gravel/sand and sand (NSC 2013b). Cobble/boulder and gravel/sand were cited as the most abundant substrate type, with each of these substrate types composing almost 28% of the mapped area of the river; gravel/cobble and bedrock were the next most common substrate types (NSC 2013b). Bedrock/limestone shelves were observed near the Buffalo Creek confluence, with patches of sand and cobble/boulder substrates upstream of the mouth of the creek, and mainly gravel/cobble substrate downstream of the confluence, until about 1 km upstream of Sturgeon Bay, after which the substrates downstream to Sturgeon Bay consisted largely of gravel/sand (NSC 2013b). NSC (2012) noted that a recent list of fish species known from the Dauphin River was not available, but that the river likely contains many of the same fish species that inhabit Lake Winnipeg and LSM.

A total of seven fish species were captured from the Dauphin River during fall 2011 surveys including cisco, freshwater drum, lake whitefish, northern pike, walleye, white sucker and yellow perch; lake whitefish accounted for 94% of the captured fish (NSC 2013b). In spring 2012 surveys, a total of 23 fish species were captured in the Dauphin River including brook stickleback, central mudminnow, cisco, common carp, emerald shiner (*Notropis atherinoides*), fathead minnow (*Pimephales promelas*), finescale dace, freshwater drum, Iowa darter (*Etheostoma exile*), Johnny darter (*Etheostoma nigrum*), lake whitefish, longnose sucker, ninespine stickleback, northern pike, northern redbelly dace, quillback (*Carpiodes cyprinus*), rainbow smelt (*Osmerus mordax*), river shiner (*Notropis blennius*), shorthead redhorse, spottail shiner (*Notropis hudsonius*), walleye, white sucker and yellow perch (NSC 2013a).

Several thousand lake whitefish eggs were retrieved from egg mats set in the Dauphin River in fall 2011 as part of the examination of spawning activity in the river, with the majority of the eggs found upstream of Buffalo Creek (NSC 2013b). Egg mats set in the river in spring 2012 yielded smaller numbers of eggs (< 100) that were identified as suckers (NSC 2013a).

During spring 2012 sampling, larval cisco, lake whitefish, northern pike, rainbow smelt, suckers, sculpins, yellow perch, unidentified cyprinids and unidentified percids (likely darters or yellow perch) were captured in drift traps set in the Dauphin River (NSC 2013a). Several sucker species were captured in the Dauphin River during the spring 2012 surveys; however, white sucker was the most abundant sucker species captured, and therefore it was reasoned that the sucker eggs and larvae captured were white suckers (NSC 2013a). As such, the majority of larval fish captured in spring 2012 were white suckers; other cyprinids, lake whitefish, and sculpins and were the next most abundant larval species (NSC 2013a).

Historical data indicated that the Dauphin River is important to walleye for spawning and movement (Pollard 1973 In NSC 2013a); however, congregations of walleye were not observed during the spring 2012 surveys, and walleye were only a small portion of the overall fish captured (NSC 2013a).

The Dauphin River supports commercial, domestic and sports fishing in the area; commercial and domestic fish species captured include mainly lake whitefish, walleye and cisco, as well as common carp, northern pike, sauger, and yellow perch (NSC 2012). NSC (2012) noted that the construction of the road to Anama Bay in the mid-1960s stimulated the growth of significant commercial and sport fisheries in the Dauphin River by the early 1970s.

4.12.2.5 Sturgeon Bay

NSC (2013b) reported the presence of substrates of cobble/boulder, compacted gravel, gravel/cobble, gravel/sand, sand and clay; nearshore sites were typically sand and gravel, with the exception of nearshore sites near Hay Point and north of Poplar Point, where substrates of boulder and boulder/cobble were dominant; offshore sites were composed of clay.

Detailed bathymetry at the outlet of the Dauphin River showed substrates of gravel/sand in the area of the outlet as well as about 1.5 km to 2 km offshore, with an area of sand extending from the shoreline north of the river outlet to about 0.25 km offshore, and areas of compacted gravel, gravel/cobble, and cobble/boulder among the gravel/sand areas; substrate conditions suitable to support spawning for lake whitefish, walleye and other fish species, i.e., gravels, cobbles and some boulders, were found at several locations in nearshore areas of Sturgeon Bay, including to the west and east of Willow Point (NSC 2013b).

NSC (2012) indicated a total of 19 fish species likely to be present in Sturgeon Bay based on fish species distribution information presented in Stewart and Watkinson (2008). In fall 2011, a total of nine fish species were captured including burbot, cisco, freshwater drum, lake whitefish, northern pike, shorthead redhorse, walleye, white sucker and yellow perch (NSC 2013b). Egg mats deployed in Sturgeon Bay in spring 2012 yielded < 30 eggs, which were identified as yellow perch and white bass, with one unidentified egg (NSC 2013a).

Fish species captured during spring 2012 neuston tows in Sturgeon Bay included cisco, emerald shiner, lake whitefish, ninespine stickleback, rainbow smelt, spottail shiner, white bass, yellow perch, as well as unidentified cyprinids (likely white suckers) and percids (walleye or yellow perch); the majority of the captured fish were juvenile and adult emerald shiners (NSC 2013a). Gill net sets in Sturgeon Bay in spring 2012 captured a total of 12 fish species, including cisco, freshwater drum, lake whitefish, longnose sucker, northern pike, sauger, shorthead redhorse, trout-perch, walleye, white bass, white sucker, and yellow perch (NSC 2013a).

Sturgeon Bay supports commercial, domestic and sport fishing in the area, which provides employment and income for the community of Dauphin River and other nearby communities (NSC 2012). Sport fishing is popular in the Dauphin River, Mantagao River, Sturgeon Bay, and in tributaries located to the north of the Dauphin River that flow into Sturgeon Bay (Pollard 1973 In NSC 2012), with angling for freshwater drum (also referred to as silver bass), northern pike, sauger, walleye, and yellow perch, and bow fishing for carp in the spring (Benson's Big Rock Camp and Campground 2017).

4.12.2.6 Local Knowledge

NSC (2012) noted that LSM, the Dauphin River and Sturgeon Bay support domestic, sport, and/or commercial fisheries that provide substantial employment and economic support for local communities around these lakes and rivers. Local knowledge on fishing activities in the LSMOC area was collected from a series of meetings held as part of the community consultation process undertaken by Manitoba Infrastructure and Transportation, Aboriginal Affairs and Northern Development Canada, and Manitoba Aboriginal and Northern Affairs (NSC 2013b).

Meeting attendees indicated that spawning areas for common carp, lake whitefish, northern pike, suckers and walleye occur in LSM near the Narrows and at the confluence of local creeks such as Beardy Creek and Bear Creek with LSM. The confluence of Buffalo Creek with the Dauphin River was indicated as a spawning area for common carp, northern pike and yellow perch, and the Dauphin River was cited as a migratory route for spawning lake whitefish moving between LSM and Sturgeon Bay (NSC 2013b).

Local community members also indicated that historically walleye were present in the Dauphin River throughout the winter (NSC 2013b). Meeting attendees shared that Sturgeon Bay provides spawning areas for cisco (*Coregonus artedii*), lake whitefish, sauger (*Sander canadensis*), walleye and yellow perch, and that walleye used to spawn near the confluence of the Mantagao River with Sturgeon Bay, but this area was now blocked (NSC 2013b).

4.12.3 ASR

Fisheries and aquatic habitat assessments were completed by AAE in the LSA for the proposed ASR in the fall of 2015 and spring of 2016 (AAE 2016b). The aquatic field studies for the proposed ASR focused on watercourses and waterbodies within the LSA that could provide habitat for fish, specifically species that support a CRA fishery and/or SAR. Following initial review of potential waterways, field studies were conducted at one section of Bear Creek and two sections of Winthers Creek that crossed the existing access road via culverts, and at Mantagao Lake, which is the headwaters of Winthers Creek and a known fishing location in the LSA.

Upstream habitat was similar at all three crossing sites, marked by extensive beaver activity at all three crossings and across the LSA, indicated by the presence of dams and lodges, abundant woody debris along shorelines, and beaver cut stumps. As a result, woody debris and soil had accumulated upstream of all culverts resulting in significant water retention and road washout at all three sites, with little to no flow through the crossings. Downstream habitat was more variable among sites and often differed from the upstream habitat.

Habitat connectivity was found to be limited at all three crossing sites, as well as across the entire LSA. Culvert crossings at all three sites were found to be blocked and/or damaged. The culvert at Winthers Creek Crossing #2 was grubbed and cleaned in October 2015; the culvert was observed to be blocked again the following spring, and continued beaver activity had resulted in numerous road washouts and extensive culvert blockage/damage along the extent of the access road. Blockages at Winthers Creek Crossing #2 and Bear Creek Crossing #3 resulted in extensive damage and washout of the forestry road in the spring of 2016.

There were four forage fish species captured at the three crossings: brook stickleback, central mudminnow, finescale dace, northern redbelly dace, and hybrids of the two dace species. There were no large-bodied fish or fish that support a CRA fishery captured. Beaver dams, beaver lodges and associated culvert blockages were observed along Winthers Creek and Bear Creek, which appeared to act as barriers to fish passage that completely exclude the entry of large-bodied fish into the area of the crossings.

Boat electrofishing at Mantagao Lake in summer 2016 captured 69 fish representing seven species, including CRA fish species: blacknose shiner (*Notropis heterolepis*), emerald shiner, fathead minnow, golden shiner, northern pike, walleye and yellow perch. Almost 45% of the fish captured were yellow perch, about 29% of the fish captured were blacknose shiner, and the remaining 26% of the catch was comprised of the other five fish species. Large-bodied adult fish such as northern pike, walleye and yellow perch, i.e., the CRA fish species, can not currently access the areas of Winthers Creek located within the ASR LSA due to the presence of debris and blockages in various areas of the channel caused by beaver activity.

There were no CRA fish species found within the waterways that intersect the proposed ASR, but the creeks that were examined support very productive forage fish communities that contribute to the productivity and diversity of the watershed.

4.12.4 Aquatic Invasive Species

The Invasive Species Council of Manitoba (ISCM) provides information on the Category 1 and Category 2 aquatic invasive species in Manitoba (ISCM 2016). There are a number of aquatic plants currently listed as Category 1, i.e., species that are not yet detected in Manitoba but pose a threat due to emigration and/or transport from other areas; and a number of aquatic plant, fish and invertebrate species currently listed as Category 2, i.e., already present in Manitoba and capable of spreading.

The fish species listed as Category 2 on the ISCM (2016) include common carp, mosquitofish (*Gambusia affinis* or *Gambusia holbrooki*), rainbow smelt and round goby (*Neogobius melanostomus*). Common carp were first introduced into Manitoba in 1886 in the Assiniboine River watershed and today are found in all watersheds in southern Manitoba northward to the Nelson River (Stewart and Watkinson 2008). Rainbow smelt were introduced into the Hudson Bay drainage and the first occurrence in Lake Winnipeg was noted in 1991 (Stewart and Watkinson 2008). It is now found in the Winnipeg River, Lake Winnipeg and the Nelson River downstream to Hudson Bay, and was observed in the Dauphin River in 2003 (Stewart and Watkinson 2008). Other than the listing on the ISCM, there was no other information found on the current presence and distribution of mosquitofish or round goby in Manitoba.

As noted above, common carp and rainbow smelt are already present in some of the Project area waterbodies and watercourses. Common carp were captured in LM, LSM, and the Dauphin River during aquatic studies conducted by AAE (2016a) and NSC (2016c) in the Project area, and are also a harvested species in the regional commercial fisheries. Adult and larval rainbow smelt were captured in the Dauphin River and Sturgeon Bay by NSC in spring 2012, but this species was not captured in any subsequent surveys conducted from 2013 to 2015 (NSC 2016b).

The invertebrate species listed as Category 2 on the ISCM (2016) include rusty crayfish (*Orconectes rusticus*), spiny water flea (*Bythotrephes longimanus*), and zebra mussel (*Dreissena polymorpha*). The rusty crayfish is a new invader to Manitoba that was first detected in Falcon Lake in 2007 (MBSD 2016b). The spiny water flea is a zooplankton species native to Eurasia that was introduced to North America from ballast waters of ocean-going ships in 1982 (ISCM 2016). This species has since invaded all the Laurentian Great Lakes, is present in the Lake of the Woods region, and has been identified to be present in the Winnipeg River and Lake Winnipeg in Manitoba (ISCM 2016). The zebra mussel is native to the Black and Caspian Sea region of Eurasia, and was likely introduced to Canada by cargo ships traveling to the Great Lakes in the 1980s; in October 2013, zebra mussel adults were confirmed in the southwest section of Lake Winnipeg in Manitoba (ISCM 2016). MBSD reported that as of July 2016, zebra mussels are present in the north and south basin of Lake Winnipeg, the Manitoba portion of the Red River, and Cedar Lake immediately west of Grand Rapids (MBSD 2016b).

The construction and operation of the selected LMOC, Reach 1, Reach 2 Option and Reach 3 creates an additional pathway for water transfer and the potential movement of species from LM to LSM to Lake Winnipeg; however, this pathway for water transfer and aquatic species movements has already occurred naturally in the region via the Fairford River and Dauphin River. Invasive species can also be transferred in ballast and equipment by boaters and fishers traveling from one boating or fishing area to another. Given that the pathway of introduction for most of these aquatic invasive species is emigration or transport from Lake Winnipeg, the concerns for the further introduction of aquatic invasive species in the RSA are expected to be related to preventing additional movement of aquatic invasive species to LSM, LM and other connected waterways.

4.13 Species at Risk

The examination of SAR in the RSA was accomplished by:

- Reviewing the regulatory parameters and terminology for SAR and species of conservation concern;
- Reviewing provincial and federal databases for information on Project area species;
- Identification of SAR and species of conservation concern potentially present or known to be present in the RSA;

- Habitat modelling to evaluate potential habitat in the RSA suitable for selected bird SAR and/or species of conservation concern; and
- Conducting field studies that included investigations for the identified SAR and/or species of conservation concern.

Based on the review of regulatory parameters and terminology, the SAR for the Project area were defined as:

- Species currently designated by COSEWIC for listing on Schedule 1 of the federal SARA, including species in the risk categories of extirpated, endangered, threatened and special concern;
- Provincial species currently listed as endangered or threatened under MESEA; and
- Species of conservation concern in the RSA that are currently listed as very rare (provincial status of S1), rare (provincial status of S2) or uncommon (provincial status of S3) throughout their range by the MBCDC.

4.13.1 Flora

A vegetation survey conducted by KGS Group in 2011 in the RSA found two species listed by MBCDC to be of conservation concern (S2) that were identified during the field survey (KGS Group 2013a). Three occurrences of green adder's mouth orchid (S2) were encountered within damp black spruce sphagnum bogs. Two occurrences were located approximately 1.5 km and 2 km north of the Reach 1 Outlet Channel inlet, while one was encountered near the confluence of Buffalo Creek and the Dauphin River (KGS Group 2013a). Habitat for this species was cited as common throughout the study (KGS Group 2013a).

The second species of conservation concern identified during the KGS field survey was eelgrass (*Zostera marina*) (S2), which was encountered at one location along Buffalo Creek beside a fen habitat (KGS Group 2013a). The known distribution of eelgrass in Manitoba is restricted to the Hudson Bay coastline and it is unlikely that this species is present within the RSA. It is possible that the eelgrass encountered during the KGS survey was misidentified as *Zostera marina* and is actually *Vallisneria americana*, the freshwater eelgrass, which is not a listed species.

There were no federally or provincially listed species observed during the 2016 vegetation surveys. One species listed by the MBCDC as a species of conservation concern was identified at several locations along the LSMOC, the dragon's mouth orchid (Photograph 1), which is considered rare throughout its range or in the province (6 to 20 occurrences) and may be vulnerable to extirpation. This species was found within a treed black spruce bog along the Reach 1 channel, just south of Big Buffalo Lake, and at several locations along the Willow Point option of the Reach 3 channel within open sphagnum bogs. The habitats in which the dragon's mouth orchids were found are common habitat types throughout the LSA for the LSMOC. Although not encountered during the 2016 field surveys, there is a potential to encounter green adder's mouth orchid, ram's-head lady's-slipper, and/or other species of conservation concern that have similar habitat preferences.

4.13.2 Fauna

There were two mammal, eight bird and one amphibian SAR identified during the wildlife studies. The mammal SAR identified for the overall Project RSA included the little brown bat (little brown myotis) and the northern long-eared bat (northern myotis). Both of these bat species are listed under Schedule 1 of SARA and MESEA as Endangered, and SARA currently has a proposed Recovery Strategy for the little brown bat and northern long-eared bat, with three Critical Habitat areas for these species identified in the Interlake area of Manitoba (EC 2015b; Norquay et al. 2013). The little brown bat and potentially the northern long-eared bat were identified to be present in the LSA through the investigation of caves and sinkholes identified during winter aerial surveys, and placement of an ARU in the vicinity of the identified caves/sinkholes habitats. There were two potential bat hibernacula identified located within the LSA for the LSMOC and ASR: one located approximately 2.9 km to the west of the forestry road, and one located approximately 27 km north of the municipal road. Further investigations of the area conducted during March and April of 2017 did not identify the presence of active bat hibernacula within the LSA.

Table 2 above provides a summary of the status of the bird species of interest under current federal and provincial legislation; confirmation of presence of the bird species in the Project area; and the location where the species was observed and/or heard.

In the LMOC LSA, the barn swallow was the only bird SAR confirmed to be present within the proposed LMOC Route C. The bird SAR confirmed to be present within the proposed LMOC Route D LSA included bank swallow, barn swallow, bobolink, common nighthawk, red-headed woodpecker and short-eared owl. A least bittern was observed outside of the LSA but within the RSA on the LM shoreline west of the proposed LMOC Route D and about 10 km south of Steeprock, MB.

In the LSMOC and ASR LSA, the bird SAR confirmed to be present included bank swallow, common nighthawk, least bittern and trumpeter swan.

Northern leopard frogs were observed within the proposed LMOC Route C RoW and the proposed LMOC Route D RoW. These frogs were the only reptile or amphibian SAR observed or heard during the field studies.

5 SOCIO-ECONOMIC ENVIRONMENT

5.1 Regional Communities and Population

Within the RSA there are two rural municipalities, the RM of Grahamdale and the RM of Siglunes. The 2011 census data for the RM of Grahamdale showed a population of 1364 people in the 2384.62 km^2 area of the RM, or a population density of 0.6 people/km^2 (Statistics Canada 2016), and the 2011 census data for the RM of Siglunes showed a population of 1360 people in the 837.42 km^2 area of the RM, or a population density of 1.6 people/km^2 (Statistics Canada 2016). In comparison, the population density in the City of Winnipeg in 2011 was reported as 137.7 people/km^2 (Statistics Canada 2016).

The community of Moosehorn has the largest concentrated population in the RM of Grahamdale, with other settlement centres in Camper, Faulkner, Fairford, Grahamdale, Gypsumville, Hilbre, Mulvihill, St. Martin, and Steep Rock (RM of Grahamdale 2016).

The communities in the Project area are typically small hubs providing local services to the regional population and tourists. Occupations in the area include farming, ranching, fishing and operation of the businesses found in the region, such as gas stations, hotels/motels, grocery stores, building materials stores, agricultural equipment stores, vehicle sales and repairs, credit unions, government and municipal services, restaurants, beach resorts, hunting and fishing outfitters, and campgrounds. The major economic sector in the region continues to be agriculture, which is focused mainly on ranching and feedlots for cattle (RM of Grahamdale 2016).

5.2 Aboriginal Population

There are four First Nations (FN) located within the RSA: Dauphin River, Lake St. Martin, Pinaymootang, and Little Saskatchewan. The Peguis FN has a Community Interest Zone (CIZ) that includes a portion of the RSA and LSA. There are also a number of people of Métis descent whom reside in the area. **Figure 3** shows the location of the four First Nations and the Peguis FN CIZ. At the time of this writing, MI was in the process of meetings and consultations with the regional First Nations and Metis people who have interest in the Project; as such, Aboriginal Traditional Knowledge (ATK) for the area was not available for the baseline investigation studies. MI will collect and collate the ATK as part of the EIA process.

5.3 Land Use

A large portion of the land in the RSA is designated for agricultural use. However, the land and soil characteristics, coupled with the poor drainage and surface water pooling found in several areas, results in moderate to severe limitations for agriculture in the area (RM of Grahamdale 2016). As such, the majority of agricultural activities are related to cattle production, with some areas used for pastures and forage crops where the land is suitable for these practices. The RM of West Interlake cites the major products produced in the region as agricultural products, specifically grain, hay, forage seed, livestock and Pregnant Mares Urine (PMU) (RM of West Interlake 2016).

Limestone, dolomite and gypsum quarrying and processing are also important economic land use activities that take place in the RSA and LSA; this resource use is described below in the Resource Use section. As noted in the Vegetation section above, Seneca root is gathered in the area and is an important plant used for medicinal and ceremonious purposes (NHLS 2017). The majority of Seneca root for manufacture of pharmaceutical cold and cough remedies is produced in the Interlake region (V. Petch, pers.comm., 2016).

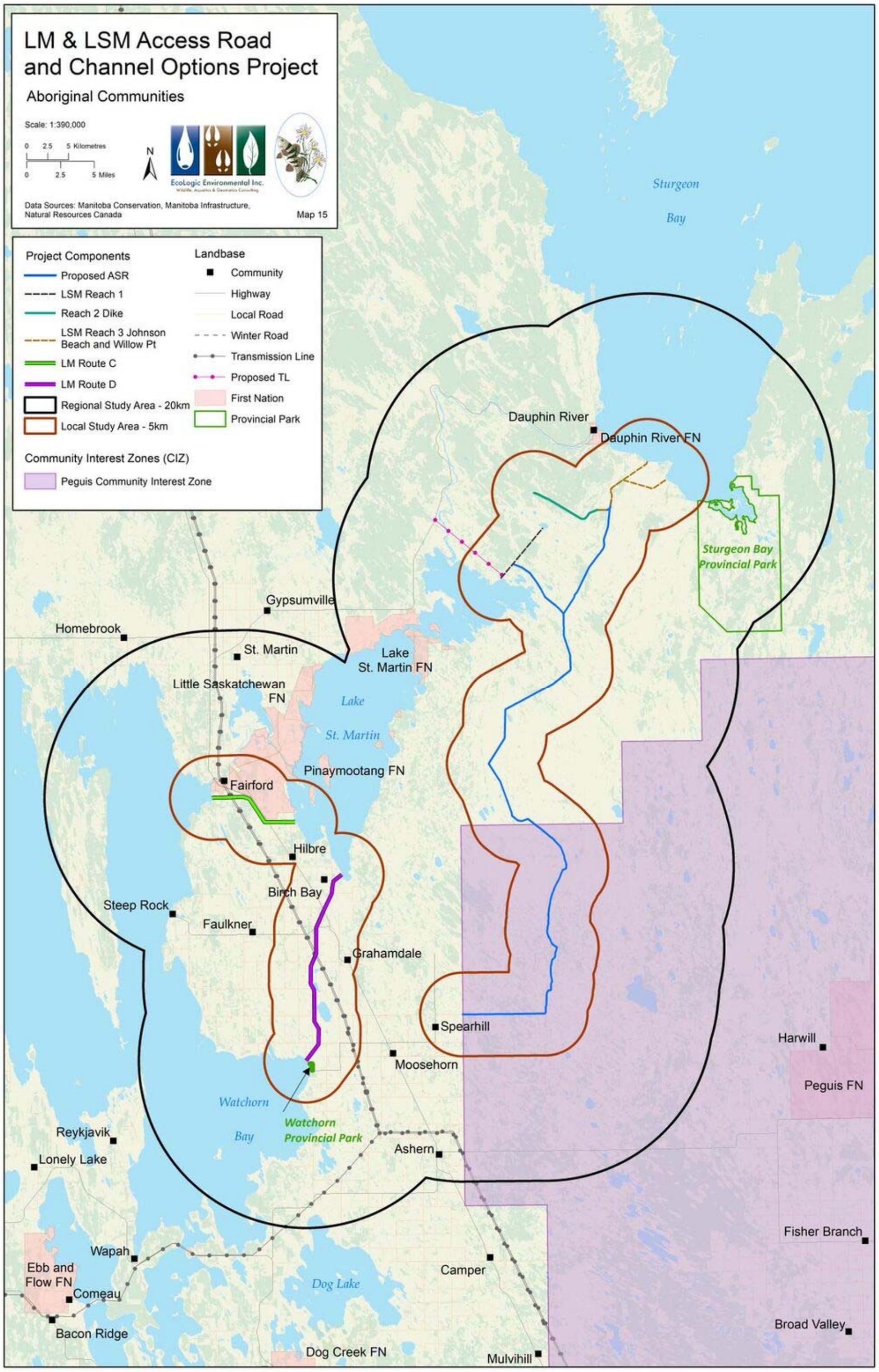

Figure 3: Aboriginal Communities and Community Interest Zones

The majority of the agricultural and industrial use in the RSA occurs within the LMOC LSA. Other land use activities in the LMOC LSA include transportation via provincial, municipal and private roadways and trails; services such as electrical transmission, waste disposal and wastewater treatment lagoons; and recreation such as hunting, trapping, fishing, snowmobiling, boating and other water-based activities.

Within the LSMOC and ASR LSA, land use activities consist mainly of hunting, trapping, fishing, snowmobiling, boating and other water-based activities, as well as some quarry activity.

5.4 Infrastructure and Services

The infrastructure and services identified to be located within the RSA included:

- *Airports* - there are three airports located within the RSA at Ashern, Anama Bay-Dauphin River and Pineimuta; the Anama Bay-Dauphin River and Pineimuta airports are no longer active; the Ashern airport was active at the time of this writing but was not being operated for nighttime flying;
- *Hydroelectric Power Transmission* - transmission lines located within the RSA include a section of the Bipole I and BiPole II 500 kV lines that pass through the RSA in a RoW adjacent to PTH 6, and sections of 230 kV lines that connect the communities; the overall Project plans also include the potential need for a new 24 kV transmission line in the LSA, shown as a 'proposed TL' that connects on the west side of Reach 1 on Figure 1 and Figure 2;
- *Pipelines* - there were no natural gas, oil, water or other pipelines identified within the RSA or LSA;
- *Railways* - the 104 km long line segment for the Warren to Steep Rock Junction route that parallels PTH 6 in the RSA was operated by the CN Railway but was abandoned in 1997; the spurs to Spearhill and Steep Rock connected to the route were also abandoned;
- *Roads and Highways* - PTH 6 is a major road artery in the region that is located in the western part of the RSA and is the principal access to the proposed Project area; PTH 6 crosses the Fairford River east of Lake Manitoba and is the connecting road for the four Provincial Roads in the RSA: PR 325 from Ashern to Hodgson; PR 237 from Watchorn Provincial Park to Spearhill; PR 239 from PTH 6 to Steeprock; and PR 513, which is a paved road from PTH 6 to Gypsumville, and a gravel surface to the community of Dauphin River on the shore of Lake Winnipeg. Portions of PTH 6, PR 236 and PR 239 are located within the LMOC LSA, as well as a number of municipal roads, private roads, access trails, dirt roads and snowmobile trails; within the LSMOC and ASR LSA, the existing road network consists of a section of municipal road, the forestry road and the winter road sections, as well as a number of access trails, dirt roads and snowmobile trails;
- *Waste Disposal* - waste disposal grounds are located in proximity to the communities of Ashern, Faulkner, Moosehorn and Pineimuta; there were no waste disposal grounds identified within the LMOC LSA or LSMOC and ASR LSA; a waste disposal ground is being constructed in the community of Dauphin River, but was not yet operational as of December 15, 2016 (K. Dorward, pers.comm., 2016);

- *Wastewater Treatment Lagoons* - there are five wastewater treatment lagoons in the RSA located in proximity to the communities of Ashern, Fairford, Faulkner, Moosehorn, and Pineimuta; there were no wastewater treatment lagoons identified within the LSA; a wastewater treatment lagoon is being constructed in the community of Dauphin River, but was not yet operational as of December 15, 2016 (K. Dorward, pers.comm., 2016).

There are no wastewater treatment plants in the RSA (K. Dorward, pers.comm., 2016).

5.5 Resource Use

5.5.1 Agriculture

A large portion of the land in the RSA is designated for agricultural use, but much of these lands have soil and moisture conditions that restrict some agricultural activities; less than 2% of the land area within the RM of Grahamdale has Agricultural Suitability in Classes 1 to 3, i.e., the Classes that are most suited to annual crop production (Agriculture and Agri-Food Canada 1999). The predominant vegetation cover in the RSA is wetland at 44%, followed by water at 22% and grassland at 10.2%. Agricultural classifications of annual crop, perennial crop and pasture in the LCC data only account for 1.44% of the lands within the RSA and 0.06% of the lands in the LSMOC and ASR LSA. Within the LMOC LSA, 4.46% of the land base within the proposed Route C is classified as annual crop and perennial crop and pasture, and 13.14% of the of the land base within the proposed Route D is classified as annual crop and perennial crop and pasture. The major economic sector in the region continues to be agriculture, which is focused mainly on ranching and feedlots for cattle (RM of Grahamdale 2016).

5.5.2 Forestry

The province of Manitoba manages and regulates forestry activities in Manitoba through the establishment of administrative boundaries such as Forest Management Units (FMUs) and Integrated Wood Supply Areas (IWSAs), which are used to delineate and manage harvestable timber areas and wood supply areas. FMUs within the RSA include units 41, 43, and 45, and IWSAs in the RSA includes IWSA #2 (MCWS 2013). The majority of the LSA for the proposed LMOC is in FMU 43, and the majority of the LSA for the proposed LSMOC is in FMU 41 and IWSA #2 (EcoLogic 2016).

5.5.3 Lodges and Outfitters

There were four lodges or outfitters identified in the RSA: Einarsson's Guide Service, near Dauphin River; Bear Track Outfitters, northeast of Gypsumville; Steep Rock Canoe and Kayak, at Steep Rock; and Wildwood Outfitters near Moosehorn. None of these lodges or outfitters are located within the LSA for the LMOC, LSMOC or ASR. During field studies in 2016, there were five hunting shacks observed in the LMOC Route C LSA around the community of Hilbre, and one hunting shack noted in the LMOC Route D LSA located west of the community of Grahamdale. There were six hunting shacks and a hunting camp observed in the LSMOC and ASR LSA in the area of the municipal road and lower section of the forestry road.

5.5.4 Industry

As noted above, the major economic sector in the region continues to be agriculture, which is focused mainly on ranching and feedlots for cattle (RM of Grahamdale 2016). Other notable industry in the RSA includes the Graymont Western Canada Inc. limestone and gypsum quarries and processing plant, which is located on PTH 239 between the towns of Steep Rock and Faulkner and provides employment for a number of local residents (Groom 2004). Limestone was historically quarried from sites near Spearhill, and the Winnipeg Supply and Fuel Company operated a limestone processing plant from 1969-1972 in Spearhill (Government of Manitoba 2016e).

5.5.5 Quarries and Mining

Limestone, dolomite and gypsum have been mined in the RSA since the early 1900s (RM of Grahamdale 2016; Government of Manitoba 2016d,e). Materials produced from these mineral resources include building foundations and building structures, aggregate materials, cement, wallboard and Plaster of Paris (Government of Manitoba 2016d).

There are many existing quarrying sites in the RSA, with the majority being quarry withdrawal activity, and the remainder are quarry lease, private quarry permit, mining claims and casual quarry permits. Seven quarries adjacent to Highway 6 are past or current producers of aggregate that were opened in the late 1960s to provide material for the construction of the highway (Groom 2004). Other quarry activity within the LMOC LSA includes a quarry withdrawal and a casual quarry permit located south of the proposed LMOC Route C and the Pinaymootang FN. Within the LSMOC and ASR LSA there were four areas of quarry withdrawals, one quarry lease and one casual quarry permit identified.

5.5.6 Recreational Trails and Campgrounds

There were five campgrounds identified within the RSA: Benson's Big Rock Camp and Campground on the north shore of Lake St. Martin near the entrance to the Dauphin River; the Roviera Resort and Campsite at Fairford; the Steep Rock Beach Park Campsite at Steep Rock; the Elm Point Campground south of Faulkner on the east shore of Lake Manitoba; and the Watchorn Bay Provincial Park Campground located west of Moosehorn. The Sturgeon Bay Provincial Park was established in 2015 and lies within the northeast section of the RSA on the western shore of Lake Winnipeg. The park is designated as a wilderness camping area and there is no road access or facilities located on park land, and there are no plans for development (MBSD 2016c). There are many recreational and snowmobile trails located throughout the RSA. There were fewer trails around the area of the winter roads, Reach 1, Reach 2 and Reach 3 than in the other areas of the RSA.

5.5.7 Boating and Water Sports

The lakes and large rivers in the RSA are enjoyed by residents and tourists to the area for a number of water related activities such as recreational boating, windsurfing, sailing, canoeing, kayaking, swimming and the use of jet skis. During the winter months, the frozen lakes provide access for snowmobiles and other vehicles. The proposed LMOC will have an inlet located in LM and an outlet to LSM, and permanent groyne structures will be constructed at the inlet area to offset the potential transport of sediment to the channel, and reduce the effects of wind and currents in the inlet areas. The proposed LSMOC includes operation of an inlet located in LSM at Reach 1 and an outlet to Lake Winnipeg via Reach 3 at Willow Point in Sturgeon Bay. These shoreline changes in the RSA could affect existing water related activities and navigation in these areas. The inlet, groyne and outlet areas will need to be marked for safety reasons in accordance with Transport Canada marine regulations, including regulations under the current Navigation Protection Program (NPP).

5.5.8 Commercial, Subsistence and Recreational Fishing

Commercial, subsistence and recreational fishing take place in the RSA in LM, LSM, Dauphin River, Mantagao River, Sturgeon Bay and some tributaries to LM, LSM and Sturgeon Bay. LM and LSM provide fisheries resources and/or income to First Nations communities, permanent and seasonal residents, tourists, farmers, and recreational and commercial fishermen within the region.

Commercial, subsistence and recreational fishing takes place in the open water and winter seasons. NSC (2012) cited the fish species of commercial and domestic importance known to occur in LSM as northern pike, walleye, and lake whitefish; with common carp, goldeye, burbot, longnose sucker, white sucker, yellow perch, sauger and cisco composing a smaller portion of the LSM commercial fishery. LSM supports a winter commercial fishery for walleye, lake whitefish, and sauger; and a year-round fishery for rough fish (carp and suckers only) (NSC 2012).Within the LMOC LSA, commercial fishing for white suckers is also practiced in Birch Creek, Mercer Creek and Watchorn Creek during the open water season (AAE 2016a).

The Dauphin River supports commercial, domestic and sports fishing in the area; commercial and domestic fish species captured include mainly lake whitefish, walleye and cisco, as well as common carp, northern pike, sauger, and yellow perch (NSC 2012). NSC (2012) noted that the construction of the road to Anama Bay in the mid-1960s stimulated the growth of significant commercial and sport fisheries in the Dauphin River by the early 1970s. Commercial fishing in Sturgeon Bay has been the most important source of income to the residents of Dauphin River, as well as providing employment to residents of other nearby communities (Pollard 1973 In NSC 2012). In Lake Winnipeg, there are two open-water fisheries (summer and fall) and a winter fishery (NSC 2012).

Local knowledge on fishing activities in the RSA was collected from a series of meetings held as part of the community consultation process undertaken by Manitoba Infrastructure and Transportation, Aboriginal Affairs and Northern Development Canada, and Manitoba Aboriginal and Northern Affairs (NSC 2013b). Meeting attendees indicated that fishing for carp, lake whitefish, walleye and yellow perch took place in several areas of LSM, including areas south of the Fairford River outlet, and areas south of the islands below the Fairford River outlet; areas south of the Narrows adjacent to the north shoreline; areas north of the Narrows; areas near the mouths of Beardy Creek and Bear Creek; and near the inlet to the Dauphin River (NSC 2013b). In Sturgeon Bay, attendees indicated that lake whitefish, walleye and yellow perch were captured in areas adjacent to the shoreline west of Willow Point, and lake whitefish and walleye were captured in areas of Mantagao Bay north of the Mantagao River (NSC 2013b).

Some areas of LM, LSM and the large rivers (Dauphin, Fairford, Mantagao) in the RSA are popular recreational fishing areas with angling for freshwater drum (also referred to as silver bass), northern pike, sauger, walleye, and yellow perch, and bow fishing for carp in the spring (Benson's Big Rock Camp and Campground 2017).

5.5.9 Hunting

The GHAs located within the RSA include GHAs 16, 20, 21 and 25. The LSA for the LMOC Route C is located within portions of GHAs 16, 20, 21 and 25, and the LSA for the LMOC Route D is located within GHAs 21 and 25. The LSMOC and ASR LSA is located within GHA 21 on the west side of Lake Winnipeg and is adjacent to GHA 20 and GHA 25 to the west, and GHA 16 to the north.

Animals hunted in the RSA include black bear, coyote, elk, moose, WTD, wolves and a number of game birds and waterfowl such as American coot (*Fulica americana*), Canada goose (*Branta canadensis*), common snipe (*Gallinago gallinago*), mallard (*Anas platyrhynchos*), ruffed grouse (*Bonasa umbellus*), sandhill crane (*Grus canadensis*), sharp-tailed grouse (*Tympanuchus phasianellus*) and spruce grouse *(Falcipennis canadensis*).

5.5.10 Trapping

Commercial trapping of furbearers is administered by MBSD through the Registered Trap Line (RTL) system (MBSD 2016d). The RSA lies within the Interlake RTL district (Trapping Area 7), and intersects a portion of the Crane River RTL on the west side of the RSA, and a portion of the Gypsumville RTL in the north-central area of the RSA. The remainder of the RSA, as well as the entire LMOC LSA, is part of Open Trap Area #3 (MBSD 2016d).

Animals trapped within the RSA include badger (*Taxidea taxus*), beaver, coyote, cross fox, fisher, lynx, marten, mink, muskrat, otter, raccoon, red fox, red squirrel, weasel (*Mustela* spp.), and wolf. MBSD tracks trapping production in the RTLs, but does not track production within an open block.

5.6 Protected Areas

Manitoba's Protected Areas Initiative is a government program developing and managing land to protect Manitoba's enduring features and biodiversity, in terrestrial, marine and freshwater environments (MBSD 2016c). Protected areas fall under several designations and levels of protection including Areas of Special Interest (ASIs), Ecological Reserves, Parks and Park Reserves, and Wildlife Management Areas (WMAs) (MBSD 2016c).

Within the area of the RSA, there are six land areas designated as ASIs: Lynx Bay ASI, Sturgeon Bay ASI, Gypsum Lake ASI, and Idylwild ASI. The Sturgeon Bay ASI is composed of three parcels.

The Reindeer Island Ecological Reserve is located north of Sturgeon Bay in Lake Winnipeg, but is not part of the RSA.

There are two Provincial Parks located within the RSA, the Sturgeon Bay Provincial Park and the Watchorn Bay Provincial Park.

There are six WMAs in the RSA: Grahamdale WMA, located northeast of Grahamdale; Hilbre WMA, located west of Hilbre; Little Birch WMA, located southeast of Ashern; Mantagao Lake WMA, located east of Spearhill; Moosehorn WMA, located southwest of Moosehorn; and Peonan Point WMA, located northwest of Steep Rock.

The protected areas within the LMOC LSA include Watchorn Provincial Park and parts of the Hilbre WMA. The LSMOC and ASR LSA includes parts of the Sturgeon Bay ASI areas, the Idylwild ASI, and the Mantagao Lake WMA.

5.7 Culture and Heritage Resources

A baseline overview of the culture history of the study area was undertaken to provide the background heritage resources information for the Project in preparation for a Heritage Resources Impact Assessment (HRIA). Attention was given to heritage resources protected under The *Manitoba Heritage Resources Act* (Government of Manitoba 1986) (The Act) as well as human remains, which are further protected by Manitoba's Policy Concerning the Reporting, Exhumation and Reburial of Found Human Remains (Government of Manitoba 1987). The Policy refers to burials and found human remains that occur outside of registered cemeteries.

Existing data for the region were reviewed prior to field studies to gain an understanding of the area and provide information to focus the field studies on sites and/or areas in need of investigation. Three main sources of information were reviewed: the archaeological and historical records and, where possible, accessible sources of Aboriginal Traditional Knowledge (ATK).

The Provincial Archaeological Site Inventory for the RSA noted six registered archaeological sites. Four of the sites were identified as historic period and included fur trade and homestead influence; the two remaining sites were identified as Middle to Late Woodland Period (ca. 2,000 to 350 years ago), based on the stone tools and Native ceramics. Five of the sites are located within or adjacent to the Pinaymootang FN lands, with four of these sites located in the LMOC Route C LSA. The sixth site is located within the Dauphin River FN lands outside of the LSMOC and ASR LSA.

A review of the Provincial designated sites and commemorative plaques indicated that there were no Provincial commemorations within the RSA. However, a private plaque was noted to have been erected commemorating Spear Hill at some time in the past. The location of the plaque requires verification since it is noted by the Heritage Resources Branch records to be on the southwest shore of Lake St. Martin; however, Spear Hill is located some 30 km to the southeast of this area.

The general archaeologic and historic records for the study area indicate human occupation over the past 8000-7000 years. Within the RSA and LSA, minimal archaeological field research has occurred only along a portion of the Fairford River, leaving the impression that the land was never used. However, the archaeological record to the immediate south in the Siglunes and The Narrows area confirms occupation by First People at least by 5000 years ago. Increased seasonal occupation is apparent by the presence of numerous Middle and Late Woodland Sites (ca. 2000-

350 BP) found around the RSA. The Woodland traditions are considered to be the ancestors of today's Cree and Anishinaabeg (Ojibwa).

The history of the general study area, as recorded in archival and other documents reviewed, is concerned mainly with the chronology of facts such as European exploration, the historic First Nations and early European settlement, and is focussed on the waterway between Lake Manitoba and Lake Winnipeg and the lands immediately adjacent. The record takes into account fur trade, historic First Nations and immigrant settlements and homesteads. It does not address potential heritage resources associated with the footprints of the proposed LMOC, LSMOC or ASR. The available oral history is found in the thesis and dissertation of Ballard (nee Traverse) (Ballard 1999) for the Lake St. Martin First Nation, which suggests traditional use of areas within the RSA and LSA. Available ATK indicated the use of plants such as cranberries (*Vaccinium* spp.), ram's head lady's slipper (*Cypripedium arietinum*) and Seneca root by local FN for medicinal purposes.

With the exception of the ridge areas described above in the Terrain and Topography section, the study area was considered to be of low potential for archaeological sites. Ground and aerial based surveys conducted in the RSA in the summer of 2016 did not indicate any areas that had potential for heritage resources. The lands nearest LMOC Routes C and D along LM have been used by cattle and are extremely disturbed. Furthermore, the lands in these areas do not meet the criteria for having high or medium potential for archaeological sites. The lands between LM and LSM are low and wet and have been modified by agriculture, ranching, transmission lines and roads. From time to time farmers may find the occasional artifact, but these finds are often out of context and therefore of little archaeological interest if provenience is not recorded.

The existing access road and winter roads are surrounded by low and swampy lands, which do not rate as having high or medium potential for archaeological sites. Ground and aerial surveys conducted in the proposed LSMOC LSA during the summer of 2016 did not reveal any further archaeological evidence or heritage resources in the area, with the exception of one site on Lake Winnipeg northeast of the proposed Reach 3 Willow Point outlet. Here, several secondary grey chert flakes and preforms were recovered. Chert is a common rock type that occurs most often in carbonate rocks as nodes or layers (Sand Atlas 2017). Chert is described as a hard and compact sedimentary rock that consists mainly of small quartz crystals (Sand Atlas 2017). It was used by ancient peoples for the manufacture of tools where flint, which is of higher quality than chert, was not available (Archaeology Wordsmith 2017). A preform is a bifacially flaked piece of stone that exhibits both percussion (i.e., being struck) and pressure flaking, usually triangular in shape, indicating it was intended to be shaped into a projectile point or knife (Archaeology Wordsmith 2017). The term preform refers to various flint (or chert) objects that may be unfinished tools or discarded unsuccessful attempts at creating a tool (Oklahoma Archaeological Survey 2017). They are a common artifact and may be plentiful at lithic workshops or locations where flint knapping was done (Oklahoma Archaeological Survey 2017).

Sites related to seasonal harvesting were expected to be identified in and around the municipal road near the former Spearhill quarry since this was noted by Warms (2001) as a Seneca root gathering place of the local First Nations; however, as noted above, there were no archaeological sites found during the summer 2016 field studies. The presence of recently constructed bear platforms and hunting cabins in the vicinity of the forestry road indicated ongoing resource harvesting by local residents. ATK data to be collected and collated by MI for the EIA can be integrated with the existing information on Culture and Heritage Resources in the RSA and LSA and provide further context for the study and future EIA process.

Heritage resources are often buried beneath the ground surface. It is important to understand that there is potential for heritage resources to be discovered during construction activities. Therefore, a Heritage Resources Protection Plan should be prepared that will provide guidance to contractors and equipment operators should artifacts or human remains be unearthed. If heritage resources are found during construction, activity at that location must stop immediately and the project archaeologist contacted. If human remains are exposed during construction, activity at that location must stop immediately and the RCMP and Historic Resource Branch contacted immediately (Manitoba's Policy Concerning the Reporting, Exhumation and Reburial of Found Human Remains 1987), and the Project archaeologist will also be informed.

5.8 Human Health and Safety

The EIA process includes the assessment of potential project activities that could be linked to potential effects on human health and safety. For the proposed Project, the potential project activities that could be linked to effects on human health and safety include:

- GHG emissions;
- Vehicle and equipment emissions;
- Vehicle and equipment noise and vibration;
- Changes to soil, vegetation, groundwater or surface water quality or quantity;
- Changes to the quality and/or contaminant uptake of trapped, captured or hunted fish and wildlife consumed by local residents and tourists;
- Changes to traffic patterns and/or access to homes, services or recreational areas;
- Alteration or loss of natural areas, recreational areas, or Protected Areas; and
- Alteration or loss of archaeological, historical or Heritage Resources.

The data collected, collated, analyzed and summarized for this report will provide information on the existing conditions in the LSA and RSA prior to construction and operation of the proposed LMOC, LSMOC and ASR.

6 CLOSURE

We trust that the above information meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

Sincerely,

Maureen Forster, MSc., EP – Fisheries and Wildlife

M. Forster Enterprises

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7.1 Personal Communications

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