Stantec

Memo

To:	Andrew Baryla Hatch	From:	David Morgan Stantec-Winnipeg
File:	Groundwater Balance Hatch Document Number: E358159-1000-220-030-0002-Rev 0	Date:	August 18, 2021

Reference: Groundwater Balance in Region of Lake Manitoba/Lake St. Martin Outlet Channels

This memorandum has been developed to support the information request (IR) process for the environmental assessment of the Lake Manitoba Lake St. Martin Outlet Channels Project (the Project).

OVERVIEW

Water balance modelling is typically undertaken in response to structural changes that may affect hydrologic processes. For example, land development projects that pave large areas of land (i.e., changing groundwater recharge potential) typically includes a water balance analysis to determine associated changes to groundwater infiltration and surface water runoff. Both the Lake Manitoba Outlet Channel (LMOC) and Lake St. Martin Outlet Channel (LSMOC) are located in areas where groundwater pressure head within the carbonate aquifer is higher than the ground surface. These channels will become groundwater discharge areas when the Project is developed.

Currently, most groundwater discharge from the bedrock aquifer in the Project area outflows into the major nearby lakes (i.e., Lake Manitoba, Lake St. Martin, Lake Winnipeg). Groundwater seepage into wetlands or creeks is only a fraction of the discharge that is going to the major lakes.

During construction and post-construction, depressurization of the carbonate aquifer will require drawing water from the bedrock aquifer and discharging it to water bodies and water courses at the surface at/near the Project site. Since the captured groundwater flow would have otherwise seeped upwards into local surface water features (Lake Manitoba, Lake St. Martin or Lake Winnipeg), the local cycle of water flow will predominantly remain unchanged with the Project. Regionally, groundwater recharge will remain unchanged. This opinion is supported with a conventional water balance analysis, provided herein, to quantitatively evaluate potential changes in the groundwater balance.

SCOPE OF WORK

1. Define the study area based on groundwater basins and sub-basins in LMOC and LSMOC.
2. Estimate the recharge to the groundwater, based on the identified basins/sub-basins.
3. Determine the regional groundwater flow direction.
4. Estimate the discharge from the groundwater aquifer to the main surface water features (Lake Manitoba, Lake St. Martin, and Lake Winnipeg), LMOC and LSMOC, and depressurization systems during construction.
5. Provide tabulated water balance results for baseline, construction, and post construction.

Groundwater balance models were developed for the study area (Map 1) for the baseline, construction, and operation phases of the Project. The water balance models include recharge rates from sub-basins and discharge rates to surface water features, Project channels, and depressurization wells. The water balance analysis is a coarse estimate of groundwater movement and does not consider the localized changes in groundwater-surface water interactions within the sub-basins.

METHODOLOGY

STUDY AREA IDENTIFICATION OF SUB-BASINS

Groundwater basins were selected to define the study area and develop an understanding of the quantity of groundwater flowing through the Project area, including the major local water bodies (Fairford River, Lake St. Martin and the Dauphin River), and how groundwater flow may be affected by the Project. The groundwater basins were initially defined based on surface watersheds and then refined based on hydrogeological knowledge and judgment based on Stantec's understanding of groundwater flow. Six sub-basins encompassing the Project were identified between Lake Manitoba and Lake Winnipeg as shown on Map 1. The sub-basins considered for the Project water balance analysis represent only a small portion of the overall Lake Manitoba and Lake Winnipeg watersheds.

ESTIMATE OF RECHARGE

The total annual precipitation in the vicinity of the study area was estimated at 524 mm/year (Stantec 2021a). A numerical model for the LMOC project area was used to develop an estimate of recharge across the entire study area. To estimate the average recharge for each of the sub-basins in the study area (see Map 1), the average annual recharge rate (1.30 mm/year) for the study area was calculated using information from the LMOC numerical model used in the preliminary design (Table 1). This average recharge rate was adopted and applied to each sub-basin as summarized in Table 2. In reality, recharge will occur in various recharge zones within each sub-basin at higher rates in specific areas. The recharge rate will vary within each sub-basin, with recharge rates depending upon factors such as the distance between fractured bedrock and the surface, the hydraulic conductivity of the bedrock, and nature of the overlying material. To develop a high-level understanding of the groundwater movement in the study area the simplified approach of assuming a uniform recharge rate across the study area was used.

Table 1 Annual Average Groundwater Recharge Rate in the Region Around the LMOC

	Model Domain[1]	Upland Recharge Zones	Total
Total Rainfall (mm/yr)	524	524	524
Recharge (m^3/d)	3011	1037	4,147
Total area km^2	878	286	1,164
Average recharge in the study area (m/d)	3.54E-06	3.63E-06	3.56E-06
(mm/yr)	1.29	1.32	1.30
Notes: [1] - Numerical Model used in Preliminary Design of LMOC			

Table 2 Sub-basin Recharge Rates

Sub-basin Name	Area (km^2)	Area (m^2)	Annual Baseline Recharge Rate (m^3/d)	Spring, Summer and Fall Baseline Recharge Rate (m^3/d)
Birch/Watchorn Creek	775	7.75E+08	2,761	4,418
Buffalo Creek	474	4.74E+08	1,689	2,702
Dauphin River	392	3.92E+08	1,397	2,235
Lake St. Martin (east)	560	5.60E+08	1,995	3,192
Lake St. Martin (west)	750	7.50E+08	2,672	4,275
Lake Manitoba	272	2.72E+08	969	1,551
Lake Winnipeg	549	5.49E+08	1,956	3,130
Total Recharge			13,439	21,503

A total recharge rate of 13,439 m^3/d is estimated for the baseline (annual average) condition. This baseline recharge rate will be applied to the water balance analysis for the operation phase.

Recharge does not occur consistently throughout the year and most of the recharge will occur from spring snowmelt and rainfall in the spring, summer and fall (April through October), for which the average recharge rate is estimated to be 1.6 times the annual average rate. As construction will generally occur in spring, summer, and fall, recharge from spring to fall (Table 2) will be used to represent baseline construction phase conditions.

ESTIMATE OF GROUNDWATER MOVEMENT, DISCHARGE LOCATIONS AND FLOW RATES

Groundwater Movement and Discharge Locations

A high-level hydrogeological conceptual model, discussing local and regional groundwater flow paths, was provided within the EIS (MI 2020a). As shown in Map 1, groundwater flows from upland areas east of the proposed LMOC and south-east of LSMOC towards the Project, Lake Manitoba, Lake St. Martin and Lake Winnipeg.

The main surface water features (Lake Manitoba, Lake St. Martin and Lake Winnipeg) are the main groundwater discharge locations in the area. Table 3 summarizes the allocated recharge sub-basins (shown on Map 1) by baseline discharge location.

- The groundwater discharge from the Birch creek / Watchorn creek sub-basin can move both south and north through the Birch and Watchorn valleys and was apportioned to the Lake Manitoba (63%) and Lake St. Martin (37%) discharge locations.
- Groundwater west of Faulkner (the Lake Manitoba Sub-basin) flows west towards Lake Manitoba.
- The Lake St. Martin (east) and Lake St. Martin (west) sub-basin discharge into Lake St. Martin.

- The Buffalo Creek, Dauphin River and Lake Winnipeg groundwater sub-basins all discharge into Lake Winnipeg.

The water balance analysis is a coarse estimate of groundwater movement and does not consider the localized changes in groundwater-surface water interactions within the sub-basins.

Table 3 Baseline Recharge Areas Allocated to Discharge Locations

Recharge Sub-basin	Discharge Location
Birch Creek /Watchorn Creek	63% to Lake Manitoba, 37% to Lake St. Martin
Lake Manitoba	Lake Manitoba
Lake St. Martin (east)	Lake St. Martin
Lake St. Martin (west)	Lake St. Martin
Buffalo Creek	Lake Winnipeg
Dauphin River	Lake Winnipeg
Lake Winnipeg	Lake Winnipeg

Average annual and summer groundwater discharges (Table 4) were estimated for the baseline (no project) condition based on the recharge at each sub-basin. As indicated previously, the summer recharge/discharge will be used in the water balance analysis to represent construction phase conditions and the average annual recharge/discharge will be used to represent the operation phase conditions.

Table 4 Average Annual and Summer Discharge at Each Discharge Location

Discharge Location	Average Annual Baseline (m^3/d)	Summer[1] Baseline (m^3/d)
Lake Manitoba	2,709	4,334
Lake St. Martin	5,689	9,102
Lake Winnipeg	5,041	8,066
Total Discharge (m^3/d)	**13,439**	**21,503**
Notes - [1] Spring, Summer and Fall		

Estimated Groundwater Use in the Study Area

There are a number of wells serving domestic and livestock water consumption the study area (MI 2020a). The estimated population and groundwater use in the study area is shown in Table 5. An estimated per capita water use estimate of 200 liters per day was applied to the “on reserve” population for First Nations in the study area (MI 2020a) as well as the non-indigenous population in the RM of Grahamdale. The Lake

St. Martin, Little Saskatchewan and Pinaymootang First Nations would consume groundwater from the Lake St. Martin West sub-basin, thereby reducing groundwater discharge into Lake St. Martin. The total consumption from those populations is approximately 750 m³/d (as shown in Table 5), constituting about a 13% reduction of the groundwater discharge to Lake St. Martin from the Lake St. Martin (west) sub-basin. The Dauphin River First Nation estimated water consumption (50 m³/d) would be a small fraction of any discharge to Lake Winnipeg. Other First Nations in the area: Fisher River Cree Nation, Kinonjeoshtegon First Nation, Lake Manitoba First Nation, and Pequis First Nation are outside the groundwater sub-basins in the study area and their "on reserve" groundwater use would not be directly affected by the Project nor would their use affect the water groundwater budget in the study area.

The non-indigenous population in the RM of Grahamdale is located in the area around the LMOC in the Birch/Watchorn Creek or the Lake Manitoba sub-basins. Their domestic and livestock water consumption would reduce the groundwater discharge to Lake St. Martin by about a 1% fraction. Any change to the Lake Manitoba groundwater discharge from consumption of groundwaters would be very small. As changes in groundwater use in the study area are not anticipated as a result of the Project, and the net consumption in areas affected by the Project would be very small, these are not further considered in the water balance analyses.

Table 5 Estimated Groundwater Use by Population Sub-group

Population Sub-group	Population	Estimated Groundwater Usage (m³/d)
Dauphin First Nation (on reserve)	251	50
Lake St. Martin First Nation (on reserve)	1,706	341
Little Saskatchewan First Nation (on reserve)	719	144
Pinaymootang First Nation (on reserve)	1,338	268
Non-indigenous population in Grahamdale within Study Area ground-watershed	500	100
Totals	**4,514**	**903**

Estimated Construction Phase Groundwater Discharge (Depressurization Flows) to Channels

During the construction and operation phases of the Project, the LMOC, LSMOC, and depressurization wells will provide groundwater discharge locations additional to those presented in Table 3. The depressurization flow rates during construction are based on the preliminary design groundwater flow estimates at both project sites (LMOC and LSMOC). The groundwater depressurization design and approximate discharge values for both project sites are summarized in Table 6 and Table 7.

For the LMOC project, the additional direct groundwater discharge to the constructed parts of the channel (where the channel excavation is expected to intercept the bedrock) was estimated as passive discharge (Table 6). For the LSMOC project, due to a lack of detailed hydrogeological information, representative pumping rates were based on engineering judgement using reported water level changes. The discharge rates within LMOC and LSMOC will be added to the construction phase water balance analysis and compared to the summer baseline.

Reference: Groundwater Balance in Region of Lake Manitoba/Lake St. Martin Outlet Channels

Table 6 LMOC Construction Depressurization Flows

Depressurization Section Approximate Station	Number of wells	Pumping Rate Range/ Capacity (USgpm)	Water Level Drop (m)	Discharge Rate (USgpm)
Water Control Structure (229+75-228+55)	26	up to 120	14	269
13+75 to 35+00	16		6	10
34+75 to 68+00	14		6	4
67+75 to 100+00	16		6	32
99+75 to 130+00	28		6	24
130+00 to146+00	20		12	59
142+75 to176+60	20		9	22
176+35 to 198+00	36		10	84
197+75 to 2210+00			10	
228+55 to 252+70	20		14	90
Bridge1 (34+75 to 35+25)	covered with dewatering covered by station dewatering above from 13+75 to 130+00			
Bridge2 (132+75 to 133+25)	covered with dewatering covered by station dewatering above from 13+75 to 130+00			
Bridge3 (197+55 to 198+25)	6	0-120	9	9
Total avg discharge (USgpm)				603
Average Passive Discharge (m^3/s)				0.004
Total avg discharge (m^3/s)				**0.042**
Total avg discharge (m^3/d)				**3,590**

Table 7 LSMOC Construction Depressurization Flows

Depressurization at Drop Structure (DS) (Approximate Station)	Number of Wells	Pumping Rate Range/ Capacity (USgpm)	Water Level Drop (m)	Discharge Rate (USgpm)
Water Control Structure (2+00)	12	25	5	300
DS1 (12+500)		30-80	4	40
DS2 (13+000)			5	40
DS3 (15+000)			5	40
DS4 (17+500)			5	40
DS5 (18+500)			4	30
DS6 (20+500)			3	30
DS7 (21+000)			4	30
DS8 (22+500)			1	30
Total discharge (USgpm)				580
Total discharge (m^3/s)				**0.037**
Total discharge (m^3/d)				**3,162**
Pumping rate and Water level drop data are provided by KGS (2021)				

Estimated Operation Phase Groundwater Discharge to Channels

Once construction of the Project is complete, some of the depressurization wells will have been removed/ decommissioned while others would be retained or added to provide ongoing depressurization for stability of the Project and its structures. The Post-construction (operation phase) groundwater discharge rates for the completed LMOC and LSMOC projects were estimated for inclusion in the operation phase water balance analysis as summarized below. The total depressurization flow rates used in the water balance were rounded to 2,000 m^3/d for both sites for simplification.

A passive depressurization system at the LMOC consisting of non-pumping relief wells and reverse drains (Stantec 2021a) will reduce the potentiometric pressure along the channel during the operation phase. The groundwater discharge to the channel from the passive system for the water balance analysis is summarized in Table 8.

Table 8 LMOC Operation Phase Depressurization Flows

Depressurization Section (Approximate Station)	Number of Wells	Pumping Rate Range/ Capacity (USgpm)	Groundwater Level Reduction (m)	Discharge Rate (USgpm)
Water Control Structure (229+75 to 228+55)	No wells -A Reverse Drain is used to relieve pressure	NA- passive design no rate	8	110
012+40 to 130+00	4		2	95
130+00 to 157+50	12		6	95
180+00 to 213+90	9		6	63
Total avg discharge (USgpm)				364
Total avg discharge (m^3/s)				**0.023**
Total avg discharge (m^3/d)				**1,979**

The planned operation phase depressurization at the LSMOC is summarized in Table 9. As in the construction phase, pumping rates were selected based on required groundwater level changes (drawdown).

Table 9 LSMOC Operation Phase Depressurization Flows

Depressurization at Drop Structure (DS) (Approximate Station)	Number of Wells	Pumping Rate Range/ Capacity (USgpm)	Groundwater Level Reduction (m)	Discharge Rate (USgpm)
Water Control Structure (2+00)	12	9	2	108
DS1 (12+500)		35-65	1.8	35
DS2 (13+000)			4	35
DS3 (15+000)			7	50
DS4 (17+500)			7	50
DS5 (18+500)			2	35
DS6 (20+500)			1	35
DS7 (21+000)			2.5	35
DS8 (22+500)			0	0
Total discharge (USgpm)				383
Total discharge (m^3/s)				**0.024**
Total discharge (m^3/d)				**2,091**
Pumping rate and Water level drop data are provided by KGS (2021)				

ESTIMATE CHANGES IN GROUNDWATER FLOW AND DISCHARGE RATES

The groundwater discharge into Lake Manitoba, Lake St. Martin and Lake Winnipeg was estimated based on the baseline groundwater flow direction, the location of the recharge sub-basins, and the planned temporary (construction phase) and permanent (operation phase) depressurization systems. Table 10 summarizes the expected discharge location for each of the recharge sub-basins during construction. The total flow is anticipated to remain the same in the analysed system but will be re-allocated from one discharge point to another within the system.

Table 10 Construction Phase Allocated Recharge Areas and Discharge Locations

Groundwater Recharge Sub-basin	Surface Discharge Location
Birch/Watchorn Creek	Lake Manitoba, Lake St. Martin, LMOC
Buffalo Creek	Lake Winnipeg, LSMOC
Dauphin River	Lake Winnipeg
Lake St. Martin (east)	Lake St. Martin, LSMOC
Lake St. Martin (west)	Lake St. Martin, LMOC
Lake Manitoba	Lake Manitoba
Lake Winnipeg	Lake Winnipeg, LSMOC

RESULTS

As mentioned in the methodology, a percentage of groundwater flow will be redirected from the Birch Creek / Watchorn Creek and Lake St. Martin (west) sub-basins to the LMOC and from the Buffalo Creek, Lake St. Martin (east), and Lake Winnipeg sub-basins to the LSMOC (Map 2). Table 11 shows changes in the discharge rates for each of the groundwater discharge locations due to Project operation. Approximately thirty percent (30%) of the overall annual average discharge contributions to Lake Manitoba, Lake St. Martin, and Lake Winnipeg is planned to be redirected back to the lakes during operation via the Project depressurization system and channels. The total discharge (including the channels discharge) will be the same as during baseline conditions, equal to the average annual baseline discharge.

Table 11 Changes in Average Groundwater Discharge Rate During Operation

Discharge Location	Groundwater Discharge		Change in Groundwater Discharge (m^3/d)
	Baseline (Annual Average) (m^3/d)	Operation (Post-construction) (m^3/d)	
Lake Manitoba	2,709	1,739	(970)
Lake St. Martin	5,689	4,659	(1,030)
Lake Winnipeg	5,041	3,041	(2,000)
LMOC	-	2,000	2,000
LSMOC	-	2,000	2,000
Total Discharge (m^3/d)	**13,439**	**13,439**	-

During the construction phase, a portion of the summer groundwater discharge flow will be drawn from the area by the Project construction depressurization system. The planned LMOC depressurization discharge is approximately 13% higher than the planned LSMOC depressurization discharge rate. Table 12 summarizes the changes in the groundwater discharge rates for each of the considered discharge locations due to Project construction. Thirty-one percent (31%) of the overall summer baseline groundwater discharge contributions to Lake Manitoba, Lake St. Martin, and Lake Winnipeg is planned to be redirected back to the lakes via the Project depressurization system during construction. Higher recharge during the summer will result in higher discharge as well (compared to the baseline).

Table 12 Changes in Groundwater Discharge Rate During Summer Construction

Discharge Location	Groundwater Discharge		Change in Groundwater Discharge (m^3/d)
	Baseline (Summer) (m^3/d)	Construction (Summer) (m^3/d)	
Lake Manitoba	4,334	2,597	(1,737)
Lake St. Martin	9,102	7,252	(1,850)
Lake Winnipeg	8,066	4,904	(3,162)
LMOC- dewatering		3,587	3,587
LSMOC- dewatering		3,162	3,162
Total Discharge (m^3/d)	**21,503**	**21,503**	-

DISCUSSION

The overall groundwater recharge rates in the project area will not be affected by the project, therefore the overall water balance will not change. There will, however, be a partial redirection of groundwater discharged to the major lakes (Lake Manitoba, Lake S. Martin, and Lake Winnipeg) to be conveyed to the lakes via the Project rather than the current groundwater discharge areas.

GROUNDWATER CONSUMPTION IN THE PROJECT AREA

Groundwater consumption in the Project area is expected to essentially remain the same post project. The First Nation wells in the study area are not expected to be influenced by the changes in Project groundwater flow and elevation. In the area of the LMOC, residents may be affected by the reduced groundwater pressure. Mitigation is proposed (new wells and/or pumps) to allow consumption to occur at the same rate as prior to the project development. Changes in groundwater consumption due to lands being acquired for the project and residents relocating out of the study area are assumed to be very small.

COMPARISON OF GROUNDWATER SEEPAGE TO SURFACE WATER FLOWS

The amount of groundwater seepage into Lake St. Martin is estimated at 5,700 (annual average) to 9,100 m^3/d (summer) or 0.07 to 0.10 m^3/s. This is a negligible fraction of the average surface water flow rate through Lake St. Martin of 55 m^3/s.

The rate of groundwater recharge from the Birch creek and Watchorn creek sub-basins ranges from 2,761 m^3/d to 4,418 m^3/d or 0.03 to 0.05 m^3/s. Under existing baseline conditions, the hydraulic head contours indicate that the groundwater discharge from this sub-basin is directed to Lake Manitoba (63%) or Lake St. Martin (37%). The average annual surface water flow in Birch Creek and Watchorn Creek is estimated to total 0.76 m^3/s (Stantec 2021b). If a fraction (say 10%) of the recharge that is heading out to the major lakes were to seep upwards into the Birch or Watchorn Creeks, it would still be only a very small part (<1%) of the overall water balance of those creek systems and would be difficult to practically detect. As there are thick (10 m to 15 m) clay/till deposits underlying the Birch and Watchorn Creek surface watersheds (including the small wetlands), groundwater seepage to surface in these areas is considered to be minimal. It is expected that current upward groundwater seepage follows the path of least resistance and predominantly outflows into Lake Manitoba or Lake St. Martin.

The discharge into the Project channels (LMOC and LSMOC) that may occur during construction or operation is also very small relative to the size of these channels. The groundwater discharge into the channels ranges from 2,000 m^3/d to 3,600 m^3/d (0.023 m^3/s to 0.045 m^3/s). These flows would be difficult to detect in the channels that have capacities of 212 to 326 m^3/s (7,500 cfs and 11,500 cfs).

CHANGE IN GROUNDWATER DISCHARGE TO LAKE ST. MARTIN

After completion of construction, a portion of the groundwater that was discharging into Lake St. Martin will be shifted to the LMOC. The estimated discharge rate into Lake St. Martin will decrease approximately 18% from 5,689 to 4,659 m^3/d on an annual basis. During construction, dewatering rates may need to be higher, as construction will take place in summer, so groundwater discharge into Lake St. Martin during construction may decrease by approximately 20% from 9,102 to 7,252 m^3/d in summer.

Changes in Groundwater Discharge to Lake Manitoba and Lake Winnipeg

Only a small portion of the Lake Manitoba and Lake Winnipeg recharge basins were considered for this groundwater balance study. These basins cover much larger areas (Lake Manitoba has a shoreline length of 915 km and Lake Winnipeg has a shoreline length of 1,858 km) and they therefore provide much larger recharge basins than the groundwater sub-basins that were included in the study area encompassing the Project. Therefore, the actual changes in discharge rates across Lake Manitoba and Lake Winnipeg will not be detectable.

CHANGES IN SEEPAGE WITHIN SUB-BASINS

As discussed earlier, the water balance analysis is a coarse estimate of groundwater movement and does not consider the localized changes in groundwater-surface water interactions within the sub-basins. Seepage into wetlands or creeks would be a fraction of the discharge that is going to the major lakes and would be difficult to measure or even model, quantitatively. Seepage also occurs along side slopes in the area as described qualitatively in Figure 15 in the groundwater Environmental Management plan (MI 2020b). Changes in seepage in these areas would be difficult to detect with standard hydrologic or hydrogeology monitoring, however, those changes may cause changes in local vegetation. This indirect effect on vegetation from changes in water levels or seepage was discussed in the EIS (Section 8.2.4.5 Change in Wetland Function, MI 2020a). Remote sensing tools could possibly be used in the future to detect changes in vegetation that may provide an indication of changes in groundwater seepage.

CONCLUSIONS

A groundwater balance analysis was conducted to support evaluation of short term (construction phase) and long term (operation phase) effects of Project-related groundwater flow changes on water resources within the Project area. A simple water budget model was developed for the baseline (pre-project) condition to estimate the groundwater recharge and discharge in the area studied. Based on surface watershed boundaries and groundwater flow direction, groundwater sub-basins, recharge and discharge areas were identified. The baseline recharge and discharge rates were compared to construction and operation groundwater recharge and discharge rates that were determined based on the Project preliminary design (Stantec 2021a, KGS 2021). The following conclusions resulted from the comparative analysis:

- The quantities of groundwater currently discharged into surface water are very small compared to surface water flows.
- Changes in surface water flows due to changes in groundwater discharge due to the Project would be too small to practically measure or detect with hydrological monitoring (i.e. stream flow monitoring). Changes in seepage may be inferred by monitoring changes in groundwater levels or potentially changes in vegetation.
- Regionally, groundwater recharge will remain unchanged (the same areas will continue to provide groundwater recharge before and after the project is constructed/operated). Since the captured groundwater flow would have discharged from the bedrock aquifer to local surface water features (Lake Manitoba, Lake St. Martin or Lake Winnipeg), the local cycle of water flow will predominantly remain unchanged with the Project. A portion of the groundwater that is currently discharging into the major lakes will be diverted by the depressurization systems to discharge back into the lakes via the Project.

REFERENCES

KGS Group Consulting Engineers. 2021. Lake St. Martin Outlet Channel Groundwater Water Levels Assessment - Draft Rev A, June 23, 2021.

Manitoba Infrastructure (MI), 2020a Lake Manitoba And Lake St. Martin Outlet Channels Project Environmental Impact Statement March 20, 2020.

Manitoba Infrastructure (MI) 2020b. Lake Manitoba- Lake St. Martin Outlet Channels Project -Groundwater Management Plan November 9, 2020.

Stantec Consulting Ltd. 2021a. (draft) Preliminary Engineering Groundwater Management Plan - Lake Manitoba Outlet Channel. Prepared by Stantec Consulting Ltd. January 2021.

Stantec Consulting Ltd. 2021b (draft) Preliminary Engineering Report for Local Surface Water Management - Lake Manitoba Outlet Channel Jan 4, 2021 (draft).

Stantec Consulting Ltd.

PROVINCE OF MANITOBA
D. R. MORGAN
Ag 19, 2021
REGISTERED PROFESSIONAL ENGINEER

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Certificate of Authorization
Stantec Consulting Ltd.
No. 1301

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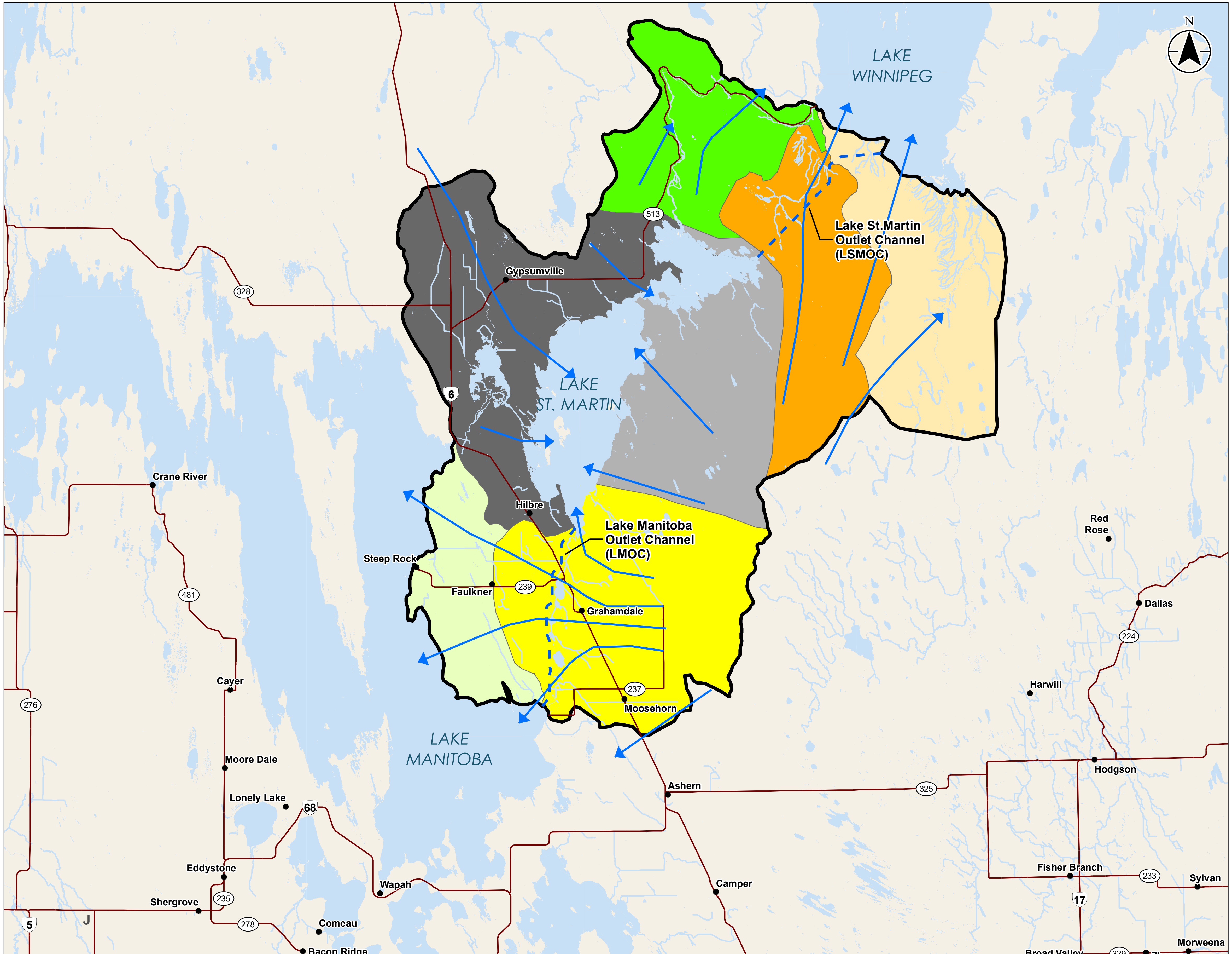
Attachment: Map 1 and 2



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Project Infrastructure

Proposed Outlet Channels

Groundwater Flow

Groundwater Flow Direction

Study Area

Sub-basins

Birch Creek / Watchorn Creek

Buffalo Creek

Dauphin River

Lake St. Martin (east)

Lake St. Martin (west)

Lake Manitoba

Lake Winnipeg

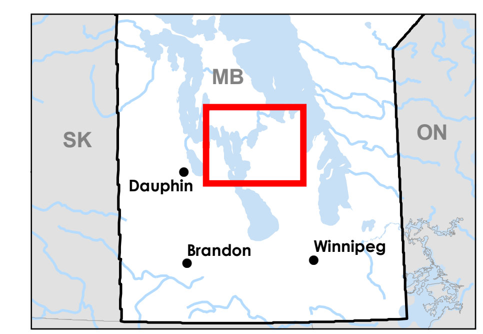
Landbase

Community

Highway

Watercourse

Waterbody



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Notes

1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base features provided by the Government of Manitoba and the Government of Canada.

Project Location 111475107

Lake Manitoba and
Lake St. Martin Outlets

Prepared by ACampigotto on 2021-04-15
Technical Review by DMorgan on 2021-04-15

Client/Project

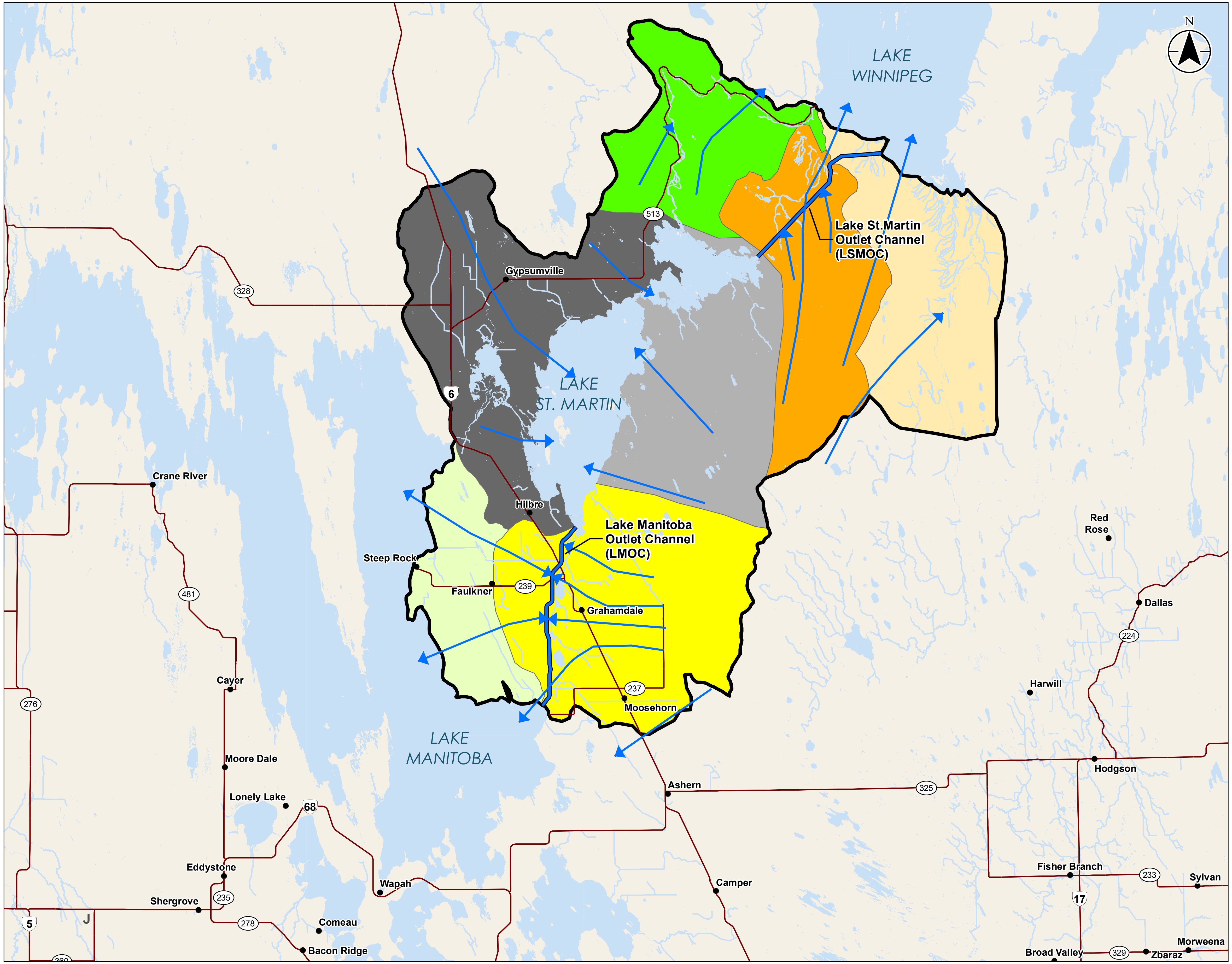
MANITOBA INFRASTRUCTURE
Lake Manitoba Outlet Channel

Map No.

1

Title

Groundwater Balance - Recharge Basins (Existing Conditions)



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Project Infrastructure

Proposed Outlet Channels

Groundwater Flow

Groundwater Flow Direction

Study Area

Sub-basins

Birch Creek / Watchorn Creek

Buffalo Creek

Dauphin River

Lake St. Martin (east)

Lake St. Martin (west)

Lake Manitoba

Lake Winnipeg

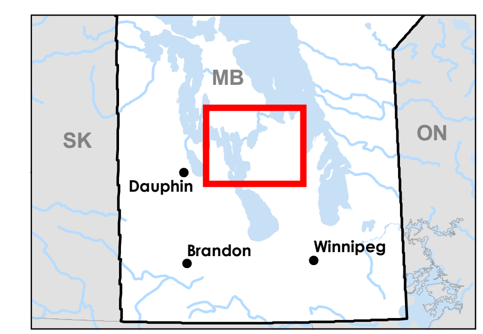
Landbase

Community

Highway

Watercourse

Waterbody



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Notes

1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base features provided by the Government of Manitoba and the Government of Canada.

Project Location 111475107

Lake Manitoba and
Lake St. Martin Outlets

Prepared by ACampigotto on 2021-04-15
Technical Review by DMorgan on 2021-04-15

Client/Project

MANITOBA INFRASTRUCTURE
Lake Manitoba Outlet Channel

Map No.

2

Title

**Groundwater Balance -
Recharge Basins (with outlet channels)**