Downstream Use and Impact Study

Kinistin Saulteaux Nation

Sewage Lagoon Upgrade

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SLR Project No: 208.30024.00000

May 2022

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ACRONYMS

/100 mL	per 100 millilitres
BOD5	5-day biochemical oxygen demand
BCL	BCL Engineering Ltd.
cBOD	carbonaceous biochemical oxygen demand
°C	degrees Celsius
CCME	Canadian Council of Ministers of the Environment
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
DUIS	Downstream Use and Impact Study
EDO	effluent discharge objective
km	kilometre
KSN	Kinistin Saulteaux Nation
mg/L	milligrams per litre
m^3	cubic metres
mg/L	milligram per litre
N	nitrogen
n	number of samples
uNH_3	unionized ammonia
P	phosphorous
SK	Saskatchewan
SLR	SLR Consulting (Canada) Ltd. and SLR International Corporation
s.u.	standard unit (pH)
TSS	total suspended solids
WQG	CCME water quality guideline
WQO	WSA water quality objective
WSA	Saskatchewan Water Security Agency
WSER	federal Wastewater System Effluent Regulations

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1.0 INTRODUCTION

1.1 Background

SLR Consulting (Canada) Ltd. and SLR International Corporation (SLR) were retained by BCL Engineering Ltd. (BCL) to conduct a Downstream Use and Impact Study (DUIS) on behalf of the Kinistin Saulteaux Nation (KSN) in support of their sewage lagoon upgrade project. The existing sewage lagoon system is located approximately 1.7 kilometres (km) northeast of the community core and is undersized (Drawing 1).

Prior to SLR's involvement in the project, three possible new lagoon sites had been identified based on engineering studies. SLR coordinated a community engagement process to identify culturally significant areas of the community and other community concerns to help guide the lagoon location and disposal location selection processes. A site evaluation matrix was developed to assess those potential sites and the existing site based on results of the community engagement. Evaluation criteria were tied to community values such as vegetation, wildlife, medicinal plants, hunting, fishing, education, and culturally important sites. Details were provided to KSN in a report (Kinistin Saulteaux Nation Community Engagement). Results with respect to lagoon location are summarized below.

- There is some reluctance to disturbing a new area for construction of a lagoon. Given the community's care for and respect for the environment, many community members are hesitant to disturb new land for purpose of a sewage lagoon.
- Several community members expressed concern over odours from the current lagoon, which is not surprising given its proximity to the community core.
- The potential location in the northeast corner of KSN, identified in the community engagement report as proposed site location 2, was the only location for which no direct effects were identified in the site evaluation matrix (plant gathering was identified as an activity that takes place south of proposed site location 2, but outside the buffer zone).
- Direct effects to medicinal plants, fishing, and ceremonial sites were identified for proposed site location 1 in the northwest corner of the KSN Reserve. Direct effects to fishing and archaeological sites were identified for proposed site location 3 in the southwest corner of the KSN Reserve.

1.2 Purpose

While the community engagement largely focused on the lagoon site itself, the purpose of a DUIS is to assess how a lagoon discharge may impact potential instream uses of the receiving water. Sewage lagoon systems are typically discharged either annually or biannually, with releases occurring in the spring and/or fall for durations of two to four weeks, depending on volume and considerations for impacts. Potential uses of surface water as described in the Saskatchewan Water Security Agency (WSA) *Surface Water Quality Objectives* (WQOs) include recreation and aesthetics, agriculture (irrigation and livestock watering), industrial and municipal water supplies, aquatic life, and wildlife. Numerical concertation objectives have been established for the protection of each use.

Although not subject to regulation by the WSA, First Nation lagoon effluents are still subject to federal Wastewater System Effluent Regulations (WSER) which include the following maximum effluent limits for protection of aquatic life:

- Carbonaceous biochemical oxygen demand (cBOD) not exceeding 25 milligrams per litre (mg/L);
- Total suspended solids (TSS) not exceeding 25 mg/L; and
- Unionized ammonia (uNH_3) less than 1.25 mg/L.

Additionally, there is a provincial 30 mg/L effluent limit for 5-day biochemical oxygen demand (BOD5) in the Saskatchewan *Waterworks and Sewage Works Regulation*. At a minimum, a DUIS must consider the above parameters to assess whether the WSER and provincial limits are adequately protective or whether stricter limits should apply. It is common practice to also consider other pollutants commonly associated with sewage lagoon effluent such as bacteria (to protect agricultural and recreational uses) and nutrients (to protect agricultural, recreational, aquatic life, and aesthetic uses). Given the high value the KSN community places on its natural and cultural resources, the DUIS for the sewage lagoon upgrade considered these potential pollutants as well.

1.3 Approach

This DUIS was conducted in two phases. The first phase consisted of a screening level feasibility assessment for potential lagoon discharge locations, including several locations along the Barrier River, and Spence Lake. Following the same approach as for the community engagement, an evaluation matrix for locations was developed to assess potential downstream uses with respect to aquatic life and other instream water uses as described in Section 1.2.

Based on the assessment, Spence Lake was identified as the most favorable discharge location. Spence Lake was also the closest of the assessed discharge locations to proposed lagoon site location 2, which was the only previously identified site for which no direct impacts to cultural resources were identified through the community engagement process. Though not categorically ruled out by the assessment, all locations on the Barrier River were found less favorable for discharge based on known aquatic life and fishing uses along it by the KSN community, and documented concerns for nutrient loading and algal blooms in downstream Kipabiskau Lake.

Results from the feasibility assessment were summarized in a memo and presented to KSN at the February 2, 2022 Project Management Team meeting. At the meeting, KSN and BCL confirmed plans to move forward with locating the new lagoon at proposed site 2 with discharge to Spence Lake. This report includes a summary of results from the screening level feasibility assessment (Section 2), and a focused DUIS specific to a new lagoon system at site 2 with discharge to Spence Lake (Section 3).

2.0 SCREENING LEVEL FEASIBILITY ASSESSMENT

The screening level feasibility assessment included the following steps, which are discussed in detail in the sections below:

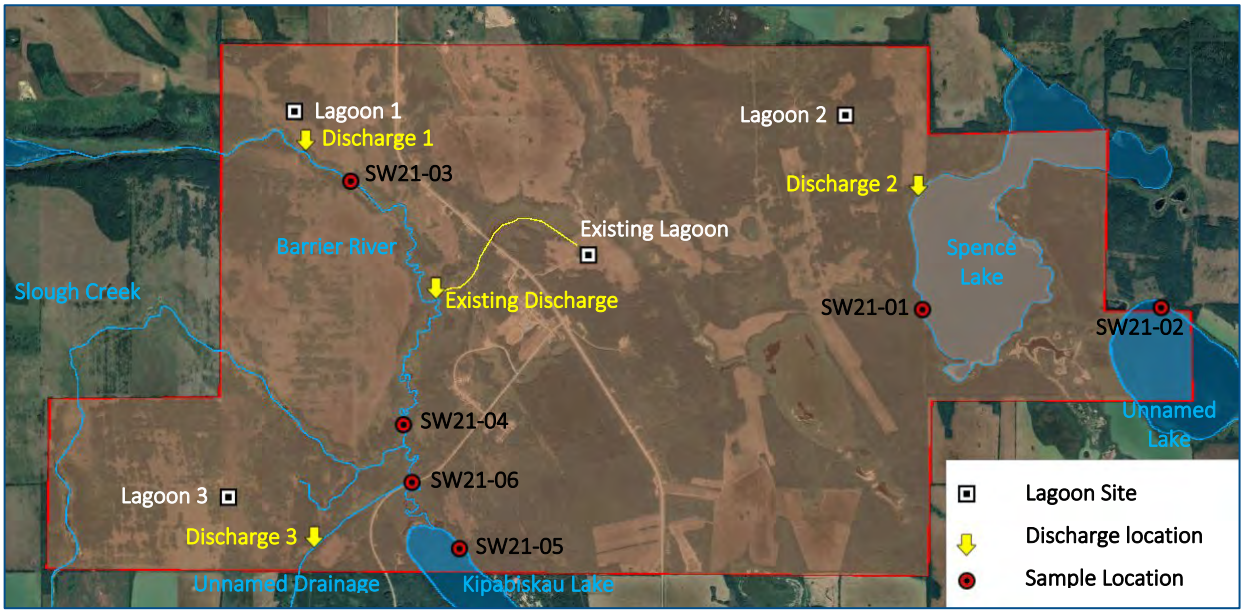
- Identify potential discharge locations for the proposed lagoon sites based on topology (Section 2.1).
- Identify known uses (recreation and aesthetics, irrigation, livestock watering, industrial and municipal water supplies, aquatic life, and wildlife) of the potential receiving waters, including those downstream (Section 2.2).

- Conduct a site visit to visually inspect the potential receiving waters and collect samples for analysis of background concentrations.
- Assess background water quality using data from the site visit and other readily available data sources and identify any existing concerns or impairments (Section 2.3).
- Estimate available dilution in the potential receiving waters (Section 2.4).
- Develop and evaluation matrix for assessing potential impacts to downstream water uses as they relate to potential pollutants in the lagoon discharge (Section 2.5).

2.1 Potential Discharge Locations

Prior to SLR's involvement, three possible new lagoon sites had been identified based on engineering studies. The proposed and existing lagoon locations are illustrated below on Figure 1. Potential discharge locations associated with the current and proposed lagoon sites are also shown, and include the Barrier River, an unnamed drainage to the Barrier River, and Spence Lake.

Figure 1 Proposed Lagoon Sites and Associated Discharge Locations



Notes:
The KSN Reservation 91 boundary is shown in red. Water bodies and water courses are identified in blue. Existing and proposed lagoon sites are identified by the white and black squares. Discharge locations assessed as part of this study are identified by the yellow arrows, and the existing discharge path is shown as the yellow line. Locations of samples collected by SLR in November 2021 (see Section 2.3) are identified by the red and black circles.

2.2 Downstream Water Uses

Potential uses as defined in the WSA *Surface Water Quality Objectives* were assessed for the potential immediate and downstream receiving waters, which include Spence Lake, Barrier River, and Kipabiskau Lake. Results are summarized below on Table 1 (on the following page). Details pertaining to each use are provided in Section 2.2.1 through Section 2.2.5.

Table 1 Receiving Water Uses

Use	Spence Lake	Barrier River	Kipabiskau Lake
Aquatic life	None identified	Fish-bearing	Fish-bearing
Mapped Wildlife	Sharp-Tailed Grouse[1]	None identified	White-tailed deer[1] Freshwater clams[2]
Recreation and aesthetics	None identified	None identified	Contact recreation
Agriculture	None identified	None identified	None identified
Water supply	None identified	None identified	None identified

Notes:

1 Delineated Terrestrial Wildlife Habitat

2 Potential rare species

2.2.1 Aquatic Life

The Saskatchewan Hunting, Angling, and Biodiversity Information online mapping application, HABISask, was used to assess whether the potential receiving waters were fish-bearing. Fisheries reports (included in Appendix A) run through the application indicate the presence of common carp, northern pike, walleye, white sucker, and yellow perch in Kipabiskau Lake and fathead minnow, nine spine stickleback, and white sucker in Kwatapie Lake. Since the Barrier River connects the two lakes, which are on opposite sides of the reserve, those species are likely to be present along the river through the KSN Reserve as well. The fish-bearing status of the Barrier River was corroborated during the community engagement by KSN community members who indicated that fishing was common on the Reserve along the entire length of the Barrier River.

No fisheries information was identified for Spence Lake or any of its tributaries (which include only small streams). Use for fishing by the KSN community was not identified in the community engagement. Though undocumented, it is likely that the lake does support some aquatic life due to its size, but in comparison to the Barrier River, aquatic life use of the lake is not likely a significant use.

2.2.2 Wildlife and Habitat

The Fisheries and Oceans Canada (DFO) Aquatic Species at Risk Map was used to identify potential federally listed critical habitat or aquatic species at risk in in the potential receiving waters. No federally listed critical aquatic habitat or rare, endangered, or at-risk aquatic species were identified in the potential receiving waters (see results in Appendix A).

HABISask was used to identify potential federally listed critical terrestrial habitat, delineated terrestrial wildlife habitat inventory lands, and protected areas in the vicinity of the proposed lagoon sites or receiving waters (see maps in Appendix A):

- No federally listed critical terrestrial habitat was identified in the vicinity of the proposed lagoon sites or receiving waters. The nearest delineated federal critical habitat area was approximately 10 km south of the reserve for red-headed woodpecker.
- Lands along the northwest corner of Spence Lake were identified as potential habitat for sharp-tailed grouse and lands along the shores of Kipabiskau Lake were identified as potential habitat for white-tailed deer.

- No game preserves, national wildlife areas, migratory bird sanctuaries, ecological reserves, wildlife habitat protection areas, wildlife refuges, or protected and conserved areas, national or provincial parks were identified in the vicinity of the proposed lagoon sites or receiving waters.
- No rare or endangered species were identified in Spence Lake or the Barrier River. Quadrangular pillclam, shortened peaclam, and Lilljeborg peaclam were identified as potentially present in Kipabiskau Lake downstream on the Barrier River from the Reserve based on documentation from 1905. These freshwater bivalve mollusks have the provincial rank of SU, which denotes that their provincial status is uncertain due to limited information. Globally and nationally their ranks are G5 and N5, respectively, denoting that they are at very low risk due to extensive range, abundant populations, and little to no concern from declines or threats.

2.2.3 Recreation and Aesthetics

Contact recreation (swimming) was not identified as a known use of Spence Lake or the Barrier River and no mapped parks or recreation area were identified along their shores using HABISask (see maps in Appendix A). In contrast, contact recreation, including swimming and water skiing, is known to occur on Kipabiskau Lake, particularly at Kipabiskau Regional Park, which surrounds much of the western half of the lake.

2.2.4 Agriculture

HABISask was used to identify land uses and land cover in the vicinity of the proposed lagoon sites and receiving waters (see maps in Appendix A). Mapped land cover is mostly pasture (seeded grassland) with scattered hardwood canopy. There is some mapped agricultural land in the southwest corner of the KSN Reserve in the vicinity of proposed lagoon site 3, and at the north side of Spence Lake near proposed lagoon site 2. No direct withdrawals for irrigation or livestock watering were identified for any of the receiving waters.

2.2.5 Water Supply

Neither Spence Lake nor Kipabiskau Lake were identified as municipal or industrial water sources. The KSN community and nearby Hamlet of Kipabiskau both use groundwater for municipal supply.

2.3 Background Water Quality

In support of the feasibility assessment and DUIS, a round of surface water sampling was performed by SLR during the community engagement site visit in November 2021 to assess background water quality. Sampling locations included three locations along the Barrier River (one upstream and two downstream of the existing discharge), Kipabiskau Lake, Spence Lake, and an unnamed lake connected hydrologically connected to Spence Lake (see water flow map in Appendix A). Samples were analyzed for parameters of concern associated with sewage lagoon effluent including pH (field measurement), uNH_3, total phosphorus (P), total nitrogen (N) total coliform, *E. coli*, and TSS. Results are presented below on Table 2 (on the following page) along with applicable surface water quality criteria including WSA WQOs and water quality guidelines (WQGs) from the Canadian Council of Ministers of Environment (CCME).

When sampled in November 2021, all potential receiving waters included in the feasibility assessment were within the strictest ambient criterion range (6.5 to 9.0) for pH. Except for the upstream-most sample from the Barrier River, all measured pH values were greater than 8. This result is not unusual for surface waters in the region but is significant because ammonia criteria for protection of aquatic life are expressed in terms of the more toxic unionized fraction, which increases with increasing pH and temperature.

Table 2 November 2021 Ambient Water Quality and Applicable Criteria

Parameter	Criteria[1]	SW21-01 Spence Lake	SW21-02 Unnamed Lake	SW21-03 Barrier River	SW21-04 Barrier River	SW21-05 Kipabiskau Lake	SW21-06 Barrier River
pH (s.u.)	6.5 to 9[2,3]	8.20	8.21	7.90	8.47	8.27	8.33
uNH_3 (mg/L as N)[4]	0.0019[2,3]	**0.032**	0.005	**0.040**	0.004	0.002	0.001
P (mg/L)	<+50%[2,5]	0.20	1.21	0.11	0.15	0.03	0.15
N (mg/L)	none	7.34	10.0	3.37	2.90	1.18	2.68
Coliform (/100 mL)	1,000[2,3]	**1,730**	866	488	88	770	120
E. coli (/100 mL)	100[2,6]	<1	<1	10	3	<1	1
TSS (mg/L)	+5 & +25[2,7]	25	778	32	36	25	14

Notes: **Bold** denotes concentrations exceeding ambient criteria.

1. Criteria shown are the strictest for any use, regardless of whether that use has been identified in the water body. pH, uNH_3, TSS, and P criteria shown above are for protection of aquatic life. *E. coli* and total coliform criteria are for agriculture (irrigation). Dissolved oxygen (DO) was also measured, but results are not shown. DO is highly seasonal (typically low in the winter due to ice cover, which prevents reaeration) and lagoon discharges would not take place in November when the sampling was conducted. WQGs and WQOs for DO are 9.5 mg/L for cold-water biota in early life stages and 6.5 mg/L for cold-water biota in other life stages.
2. CCME WQGs.
3 WSA WQOs.
4 Data shown for uNH_3 have been converted from total ammonia using the equation f = 1/(10(pka-ph)+1) where f is the fraction of ammonia in unionized form, T is the water temperature in Celsius, and pka = 0.0901821 + 2729.92/(273.2+T). The unionized fraction was estimated from the field-recorded pH and a temperature of 15°C, which is common practice in the province. 15°C is used because it corresponds to the temperature at which effluent criteria are expressed in accordance with the WSER. However, the samples were collected offseason relative to when lagoon discharges occur. Water temperatures measured during the sampling event ranged from 1 to 3°C, at which the uNH_3 concentrations would be below the criterion since the unionized fraction decreases with decreasing temperature. It is unclear from the one sampling event whether total ammonia concentrations would remain sufficiently high in open water season to result in exceedances of the ambient ammonia criteria in the spring or fall when the lagoon discharges would occur.
5 The CCME WQG for P follows a tiered framework. P concentrations must not exceed "trigger" ranges" for the water body or increase more than 50% above the background level. With the exception of SW21-05, all concentrations fell in the hypereutrophic range (P > 0.1 mg/L). The result for SW21-05 is within the meso-eutrophic range (0.02 to 0.035 mg/L).
6 The WSA *E. coli* WQO of 100 per 100 millilitres (/100 mL) is based on agricultural uses (specifically irrigation). There are additional, less strict WQOs for recreation, which are a geometric mean concentration of ≤200/100 mL and a maximum concentration of 400/100 mL.
7 For "clear flow" the TSS WQGs are a maximum increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 hours and 30 days). Sampling results from November 2021 may be biased high due to bottom sediments being disturbed when surface ice was broken to retrieve samples.

Unionized ammonia exceeded the aquatic life criterion in samples collected from Spence Lake and the upstream-most sampling location on the Barrier River. While aquatic life is not a documented use of Spence Lake, it is a known use of the Barrier River. It is notable that unionized ammonia in the Barrier River sample exceeded the criterion despite being the only sample with a pH less than 8. Results suggest that parts of the Barrier River may be more sensitive to and possibly impacted with respect to ammonia as compared to the other potential receiving waters assessed in this study.

All potential receiving waters met ambient total coliform criteria for protection of agricultural uses with the exception of Spence Lake. The sample, however, was collected from the lake shore and may not be representative of the water body as a whole. Also, no agricultural uses of Spence Lake water were identified, therefore; the total coliform criterion is not presently applicable.

All potential receiving waters met ambient *E. coli* criteria for protection of agricultural and recreational uses when sampled in November 2021. Additionally, sampling at Kipabiskau Lake is conducted annually at Kipabiskau Regional Park between July and August as part of the Saskatchewan Healthy Beach Program. Results for the last three years (2019 through 2021) were that the water was suitable for swimming (met recreational *E. coli* criteria).

Ambient criteria for P and TSS are assessed as changes relative to background rather than by comparison to numeric criteria and therefore were not assessed here. Similarly, there are no numeric or narrative criteria for total nitrogen.

2.4 Available Dilution

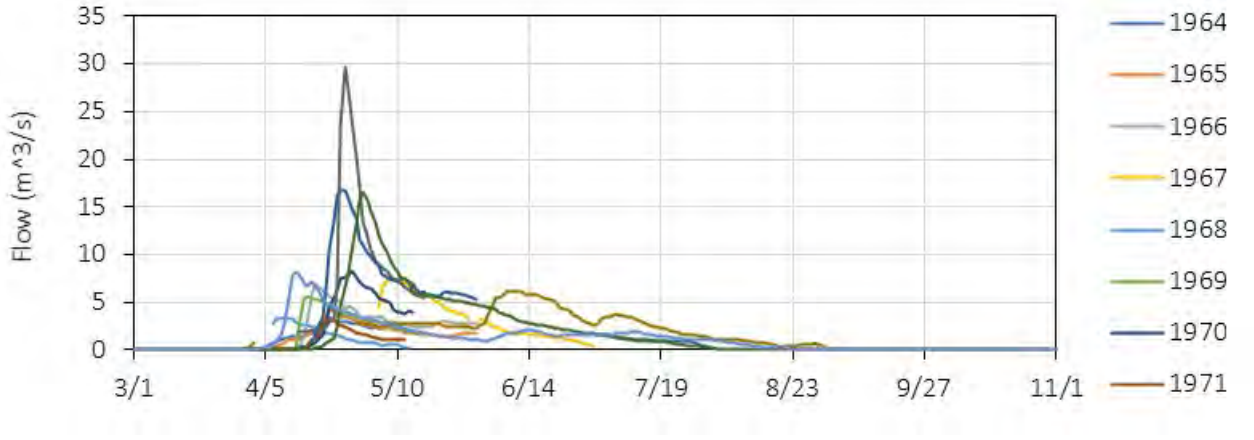
Available dilution was estimated for the Barrier River and Spence Lake to assess the relative assimilative capacity of the two water bodies. Dilutions were assessed for two potential lagoon designs, as provided by BCL. The first design corresponds to a twice per year discharge of 40,700 cubic metres (m^3), which represents 220 days of storage at the projected 20-year raw water consumption rate (minimum size as required under WSA regulation). The second design corresponds to a once per year discharge of 68,000 m^3, which represents 365 days of storage for the 20-year raw water consumption rate. Both scenarios were assessed for discharge durations ranging from two to four weeks. It is assumed that the preferred design is for 40,700 m^3 of storage and a twice per year discharge since the lagoon footprint would be smaller at the lower capacity. Both potential lagoon designs were assessed to compare relative impacts, which may inform the final design selection.

2.4.1 Barrier River

Available dilution into streams and rivers is estimated as the ratio between river flow rate and discharge flow rate. There are no active gauging stations on the Barrier River near the KSN community. The nearest available river flow data were identified for a historical gauging station (station 05LA002) on the Barrier River approximately 6 km downstream of Kipabiskau Lake. Since the Barrier River is the only significant inflow or outflow from the lake, river flow downstream of the lake is likely a good approximation of river flow upstream of the lake.

Barrier River flow data were recorded seasonally (March through October) over the period from 1964 through 1971. The data were downloaded from the Canadian Water Office website and were reviewed. Although older, the data (Graph 1 on the following page) show a strong seasonal trend with peak flows typically occurring in May or April. The trend is unlikely to have changed since the data were collected since the river is not regulated (dammed).

Graph 1 Barrier River Daily Discharge



Notes: Daily discharge data from historical gauging station 05LA002 for the period from 1964 through 1971.

The gauging station data were used to estimate average daily discharge by month. As shown below on Graph 2, average monthly discharge ranged from zero in October to approximately 4 cubic metres per second (m^3/s) in May. Variability in the peak month of May was high, with a coefficient of variation of over 70%.

Graph 2 Barrier River Average Daily Discharge by Month

Notes: Average daily discharge by month for historical gauging station 05LA002 for the period from 1964 through 1971. Number of measurements, n, shown for each month.

When designed to discharge twice per year, lagoons discharges take place in the spring and fall seasons (WSA, 2004). Due to the lack of flow in the Barrier River in September and October, a fall discharge is not recommended. A lagoon system designed for a once-per year discharge would be required, with the discharge to occur in the spring coincident with higher river flows. As shown below on Table 3 (following page), available dilutions estimated for this scenario range from 71:1 for a two-week discharge to 143:1 for a four-week discharge.

Table 3 Barrier River Available Dilution

Discharge Scenario	2-week discharge	3-week discharge	4-week discharge
Twice per year	Not recommended	Not recommended	Not recommended
Once per year, spring	71:1	107:1	143:1

Notes: Available dilution ratios for the once per year spring discharge were calculated as (discharge volume/duration): Barrier River flow rate where the discharge volume is 68,000 m^3 and the Barrier River flow rate is 4.01 m3/s, which corresponds to the estimated average flow for May.

2.4.2 Spence Lake

In lakes, available dilution is estimated as the ratio between lake volume and discharge volume. There are no bathymetric data available for Spence Lake, therefore; lake volume was estimated based on its area (approximately 250 hectares) and a conservative estimation of average depth (3 metres) based on visual observations made during the November 2021 site visit. Based on these assumptions, available dilution estimated for a once per year of 68,000 m^3 discharge is 109:1. Available dilution estimated for a twice per year discharge of 40,700 m^3 is 183:1 (Table 4).

Table 4 Spence Lake Available Dilution

Discharge Scenario	3 m depth
Twice per year	183:1
Once per year, spring	109:1

Notes: Available dilutions were estimated as (lake area x lake depth): discharge volume where the once and twice per year discharge volumes were 68,000 m^3 and 40,700 m^3, respectively, and the lake area was 250 hectares.

2.5 Summary and Recommendations

Potential impacts to downstream water uses were assessed in consideration of available dilution and relative to parameters of concern in sewage lagoon effluent. Results for each parameter are summarized on the below evaluation matrix according to their significance/likelihood, with minimal or least likely impacts represented in the lightest blue, and the most probably or significant impacts in the darkest blue.

Table 5 Receiving Water Evaluation Matrix

Parameter/ impact	Existing Site Barrier River	Site 1 Barrier River West	Site 2 Spence Lake	Site 3 Barrier River East
Dilution	• Fall discharge not supported – low flow.	• Fall discharge not supported – low flow.	• NA - no seasonal restrictions.	• Fall discharge not supported – low flow.
Ammonia (toxic to aquatic life)	• Potential aquatic life impacts along ~3.5 km of the river.	• Potential aquatic life impacts along ~6.5 km of the river.	• NA - aquatic life not a known or significant use of the lake.	• Potential aquatic life impacts along ~1.5 km of the river.
cBOD (depletes oxygen which impacts aquatic life)	• Potential impacts to aquatic life in downstream Kipabiskau Lake.	• Potential impacts to aquatic life in downstream Kipabiskau Lake.	• NA - aquatic life not a known or significant use of the lake.	• Potential impacts to aquatic life in downstream Kipabiskau Lake.
Bacteria (there are bacterial limits for agricultural and recreational use)	• Recreation and agriculture not known or likely uses of the river. • Potential impacts to recreational use in downstream Kipabiskau Lake, though moderate attenuation likely along 3.5 km flow path.	• Recreation and agriculture not known or likely uses of the river. • Potential impacts to recreational use in downstream Kipabiskau Lake, though significant attenuation likely along 6.5 km flow path.	• NA – agriculture and recreation not known or significant uses of the lake.	• Recreation and agriculture not known or likely uses of the river. • Potential impacts to recreational use in downstream Kipabiskau Lake, though some attenuation likely along 1.5 km flow path.
TSS (impacts aquatic life)	• Potential aquatic life impacts along ~3.5 km of river, though attenuation likely along flow path.	• Potential aquatic life impacts along ~6.5 km of river, though attenuation likely along flow path.	• NA – aquatic life not a known or significant use of the lake.	• Potential aquatic life impacts along ~1.5 km of river, though attenuation likely along flow path.
Nutrients (impacts aquatic life and recreation through algal blooms, dissolved oxygen depletion)	• Aquatic life and agriculture not known or likely uses of the river. • Nutrient loading to Kipabiskau is a documented concern.	• Aquatic life and recreation not known or likely uses of the river.	• NA - aquatic life and recreation not known or significant uses of the lake.	• Aquatic life and agriculture not known or likely uses of the river. • Nutrient loading to Kipabiskau Lake is a documented concern.

Based on the above assessment, Spence Lake is the most favorable receiving water for the lagoon discharge. This is in most part because aquatic life and recreation were not identified as significant present uses of Spence Lake while those were documented and important uses of the Barrier River and downstream Kipabiskau Lake.

Discharge to the Barrier River is not precluded by this assessment, but additional study would be strongly recommended, particularly to evaluate background ammonia concentrations and pH, should discharge to the river be considered in the future. Consultation with the downstream Kipabiskau (hamlet) community may also be prudent given their concern for nutrient loading to the lake.

It emphasized that this feasibility assessment was based solely on evaluation of potential downstream impacts of the lagoon discharge to the receiving waters and their uses. Other disposal options, such as subsurface injection, were not assessed. However, it is noteworthy that Spence Lake is nearest to proposed lagoon site 2, which was the only previously identified potential lagoon site for which no direct impacts to cultural resources were identified through the community engagement process.

3.0 FOCUSED DOWNSTREAM USE AND IMPACT ASSESSMENT

Results from the feasibility assessment were summarized in a memo and presented to KSN at their February 2, 2022 meeting. At the meeting, KSN and BCL confirmed plans to move forward with locating the new lagoon at proposed site 2 with discharge to Spence Lake. The following DUIS was developed specifically for a new lagoon system at site 2 with discharge to Spence Lake via an unlined ditch.

This DUIS was completed in general accordance with WSA DUIS guidance and included the following steps, which are discussed in detail in the sections below:

- Characterize expected lagoon effluent quality and maximum expected effluent concentrations (Section 3.1).
- Define discharge regimes (frequency and duration) for assessment and comparison (Section 3.2).
- Estimate dilutions required to meet ambient water quality criteria (provincial WQOs and WQGs from CCME) and compare required dilutions to the available dilutions (Section 3.3).
- Perform hydrodynamic modeling to predict the distances at which ambient criteria will be met in the receiving water (Section 3.4).
- Make design and discharge recommendations based on results (Section 3.5).

As discussed in Section 2.2, the downstream uses that ambient criteria are designed to protect (i.e., aquatic life, agriculture, and recreation) were not identified as present or significant uses of Spence Lake, therefore; this criteria-based approach is conservative and protective of potential uses rather than current uses. In accordance with WSA guidance, the DUIS focuses on the WSER-regulated parameters discussed in Section 1.2 (cBOD, TSS, and unionized ammonia). Given the high value the KSN community places on its natural and cultural resources, additional parameters including nutrients and bacteria were also considered.

3.1 Effluent Quality

Because the existing lagoon is leaking into surrounding soils, regular discharges do not occur. Potential lagoon effluent quality has been assessed annually in the fall by collecting samples directly from the lagoon. A summary of the historical lagoon quality is presented below on Table 6. Also shown for comparison are the federal WSER effluent limits, effluent limits from the Saskatchewan *Waterworks and Sewage Works Regulations*, and WSA performance guidelines for well-operated lagoons from the *Saskatchewan Sewage Works Design Standard*.

The lagoon water consistently met effluent limits and performance guidelines for pH, ammonia, BOD5 and cBOD. Lagoon water exceeded the WSER TSS effluent limit in two of four samples, exceeded the WSA performance guidelines for nitrogen in two of four samples, and exceeded the WSA performance guidelines for total coliform in all samples. The exceedances are likely because the existing lagoon is undersized and leaking. These data are presented for reference only; effluent quality from the new lagoon system is expected to meet all effluent limits and performance criteria.

Table 6 Existing Lagoon Effluent Quality, 2010 through 2019

Parameter	WSER Limit[1]	SK Limit[2]	SK Performance Guidelines[3]	Historical Results[4]
pH (s.u.)	none	none	6 to 9	8.1 to 8.4
Total NH_3 (mg/L as N)	none	none	none	12.8 to 17.9
uNH_3 (mg/L N)	**1.24**	1.24	none	0.443 to 1.15
BOD5 (mg/L)	none	**30**	25 to 70 spring 10 to 30 fall	8.3 to 19.6
cBOD (mg/L)	**25**	25	None	8.3 to 15.5
TSS (mg/L)	**25**	30	20 to 60 spring 10 to 40 fall	6 to 39
Total Nitrogen (mg/L)	none	none	20 to **35** spring 5 to **20** fall	no spring data 10 to 28
Total Phosphorus (mg/L)	none	none	3.5 to **7** spring 2 to **5** fall	no spring data fall: 2.8 to 3.7
Total Coliform (/100mL)	none	none	2,000 to **200,000** spring 200 to **20,000** fall	no spring data fall: 1,246 to 198,900
E-coli (/mL)	none	none	none	~2 to 170

Notes: **Bold** denotes value used as the effluent concentration when estimating required dilutions. It represents the strictest effluent limit, where limits apply, or the upper end of the WSA performance guideline range when there are no effluent limits.

1 Effluent limit from the federal *Wastewater System Effluent Regulations* (Government of Canada, 2016).

2 Effluent limit from the Saskatchewan *Waterworks and Sewage Works Regulations* (Government of Saskatchewan, 2015).

3 Performance guidelines from the Saskatchewan *Sewage Works Design Standar*d EPB503 (WSA, 2012).

4 Historical results summarized for the period including 2010, 2013, 2014, and 2019. No samples were collected in the intervening years because the lagoon secondary cell was empty, likely due to leakage. All data were collected in September or October. The total number of samples is 4, except for ammonia, for which there were three samples.

3.2 Discharge Regimes

As discussed in Section 2.4, this DUIS assesses potential impacts from a 40,700 m^3 lagoon discharging twice per year in the spring and fall and a larger 68,000 m^3 lagoon discharging once per year in either the spring or fall. It is assumed that the smaller 40,700 m^3 lagoon is preferred since it would have a smaller footprint. However, both designs were assessed to compare relative impacts, which may inform the final design selection. For each of the potential lagoon designs scenarios, discharge durations ranging from two to four weeks were also assessed as shown below on Table 7.

Table 7 Matrix of Potential Discharge Scenarios

Scenario	Discharge Volume (m^3)	Discharge Season	Discharge Duration (weeks)
1	40,700 In Fall AND Spring	Fall	2
2			3
3			4
4		Spring	2
5			3
6			4
7	68,000 In Fall OR Spring	Fall	2
8			3
9			4
10		Spring	2
11			3
12			4

3.3 Required And Available Dilutions

Dilutions required to meet ambient criteria were estimated based on maximum expected lagoon effluent concentrations. For parameters with effluent limits, this corresponded to the stricter of the federal WSER or the Saskatchewan *Waterworks and Sewage Works Regulation* limits. For parameters without effluent limits, this corresponded to the upper end of the performance guideline ranges presented in the WSA *Sewage Works Design Standard* for well operated lagoons.

Results are presented below on Table 8. Of the regulated parameters in the effluent (those with effluent limits: unionized ammonia, TSS, and BOD), unionized ammonia requires the most dilution, 76:1, to meet ambient criteria. Based on this, unionized ammonia has been identified as the governing parameter in the discharge.

As discussed in Section 2.4.2, total available dilution in Spence Lake was estimated as 109:1 for the once-per year discharge volume and 183:1 for the twice per year discharge volume. Since available dilution is greater than required dilution, the results suggest there is adequate capacity in Spence Lake to receive discharge from either potential lagoon (40,700 m^3 or 68,000 m^3 capacity) without adverse impacts related to unionized ammonia in the effluent. Since the other regulated parameters in the effluent (TSS and cBOD/BOD) require less dilution than unionized ammonia, the same is true for them.

Table 8 Required Dilutions

Parameter[1]	Assessment Criteria[2]	Ambient[3]	Effluent[4]	Required Dilution
Parameters with Effluent Limits				
uNH_3 (mg/L)	0.019	0.00285	1.24	76:1
TSS (mg/L)	+5	0	25	4:1
BOD (mg/L)	DO = 9.5	DO = 10.1	30	49:1
Parameters with WSA Performance Guidelines (but no Effluent Limits)				
Total P (mg/L)	+50%	0.2	7 spring 5 fall	67:1 spring 47:1 fall
Total N (mg/L)	+50%	7.3	35 spring 20 fall	6.6:1 spring 2.5:1 fall
Total coliform (/100 mL)	1,000	150	200,000 spring 20,000 fall	234:1 spring 22:1 fall

Notes:

1 Since cBOD is a subset of BOD, impacts related to DO depletion were based on BOD in the effluent, for which the effluent limit is higher (30 mg/L) than that of cBOD (25 mg/L) and is therefore more conservative. Impacts of BOD of ambient DO we estimated assuming each mg/L BOD results in an immediate 1 mg/L reduction in DO. Required dilutions were not estimated for *E. coli* because there are no WSER effluent limits or WSA performance guidelines for *E. coli.*

2 When multiple ambient criteria exist, the strictest criterion was used in the assessment, including the long-term criterion of +5 mg/L for TSS and a DO minimum of 9.5 mg/L for protection of cold-water biota in early life stages. There are no ambient criteria for N. The applied maximum 50% increase was used for consistency among nutrients (i.e., N and P).

3 Ambient concentrations used for assessment of N and P were the concentrations measured in November 2021. For TSS, an ambient concentration of zero was used, which is the most conservative approach since it requires the most dilution. For BOD, the ambient DO concentration used in the assessment was 10.1 mg/L, which corresponds to the concentration at saturation for water at 15°C. For uNH_3 15% of the strictest criterion was used to represent ambient concentrations. uNH_3 exceeded the ambient criterion for protection of aquatic life when sampled in November 2021, but more study would be needed to make definitive conclusions about concentrations during the spring and fall, when lagoon discharges would likely occur. This is largely because there was ice cover on the lake when it was sampled. Ice cover frequently results in lower DO concentrations due to a lack of air exchange at the surface, and lower dissolved oxygen levels are typically associated with higher ammonia due to lack of denitrification. Based on this, an ambient concentration equal to 15% the criterion (15% of 0.019 mg/L; 0.00285 mg/L) was used to estimate required dilutions for uNH_3. There is no guidance for characterizing ambient concentrations in DUIS in Saskatchewan or the neighbouring province, Alberta, but it is the approach recommended in the US state of Alaska when adequate ambient data aren't available (Tetra Tech, 2014). If aquatic life had been identified as significant use of Spence Lake, additionally study would be recommended. Since it is not, this approach is considered adequately conservative. The same approach was taken for total coliform, which also exceeded the ambient criterion for protection of agricultural uses when sampled in November 2021. Agriculture was not identified as a present use.

4 Effluent concentrations used in the assessment are based on worst-case conditions. Specifically, they correspond to the stricter of the effluent limits (WSER or *Saskatchewan Waterworks and Sewage Works Regulation*) if limits exist, or the upper end of the performance guidelines range for well operated lagoons as presented in the WSA *Sewage Works Design Standar*d.

5 Required dilutions expressed as R:1 where R is calculated as $[(C_e - C_a)/(WQO-C_a)]$-1 with Ce and Ca being the effluent and ambient concentrations, respectively.

As shown above on Table 8, required dilutions for parameters without effluent limits (phosphorus, nitrogen, and total coliform) are all higher for a spring discharge than for a fall discharge. This is because the WSA performance guideline ranges used to represent effluent concentrations in the assessment are higher for spring discharges than fall discharges, reflecting the greater degree of treatment (higher effluent quality) provided by lagoon systems for fall effluents.

Required dilutions ranged from 2.5:1 for nitrogen in a fall discharge to 234:1 for total coliform in a spring discharge. Except for total coliform in a spring discharge, the results suggest there is adequate capacity in Spence Lake to receive discharge from either potential lagoon design without adverse impacts (exceedances of the strictest ambient criteria) for these parameters.

With respect to total coliform, the 234:1 dilution required to meet criteria for protection of agricultural use exceeds the estimated available dilutions in Spence Lake for both once (109:1) and twice (183:1) per year spring release volumes. According to the WSA (2012), typical effluent concentrations spring effluents from well-operated lagoons range from 2,000 to 200,000/100 mL, which is an order of magnitude higher than for a fall release. At the high end of this range there isn't enough available dilution in Spence Lake to meet the ambient criterion. However, when assessed using the approximate midpoint of the range adequate dilution is available. Because of this, and since there were other conservative assumptions in the assessment (i.e., the maximum 20-year projected release volume was used), it is unlikely that a spring release would result in adverse impacts to the lake with respect to total coliform. It is also recognized that this assessment is based on protection of agricultural use, specifically irrigation, which is not a present use of water from Spence Lake, making the assessment highly conservative.

3.4 Hydrodynamic Plume Modelling

According to the Saskatchewan WQOs, ambient criteria should be met within 100 m of an effluent outfall so as to minimize the spatial extent of potential impacts. Natural currents in the lake, especially wind-driven currents along the shore, are expected to move water past the discharge point and therefore spread and enhance dilution of the effluent plume. The extent to which this occurs was estimated using CORMIX hydrodynamic modelling software to predict dilutions along the effluent plume in Spence Lake. CORMIX is the most commonly used dilution model for effluent discharges.

Dilution modeling was performed for the maximum 20-year projected discharge volumes of 40,700 m^3 (twice per year) and 68,000 m^3 (once per year) discharging for two, three, or four weeks. Detailed CORMIX input values are shown in Appendix B. Dilutions were predicted 100 m from the discharge point for comparison to the required 76:1 required dilution estimated for the governing parameter in the effluent, unionized ammonia, as identified in Section 3.3. Results are summarized below on Table 9.

Table 9 Predicted Dilutions 100 m from Discharge Point

Discharge Scenario	2-week discharge	3-week discharge	4-week discharge
Twice per year	48:1	85:1	114:1
Once per year, spring	2:1	45:1	64:1

Results indicate that the required 76:1 dilution for unionized ammonia would be met within 100 m of the discharge location for the twice per year discharge volume released over three or four weeks. There was no modeled scenario in which the once per year release volume achieved a 76:1 dilution within 100 m, though the four-week release came close with a predicted dilution of 64:1. It is noted that the minimum 76:1 required dilution was conservatively estimated assuming an effluent concentration equal to the WSER effluent limit of 1.24 mg/L. If operated under a modified effluent limit of 1.05 mg/L, the

predicted 64:1 dilution at 100 m would be adequate to meet ambient water quality criteria for unionized ammonia.

3.5 Summary And Recommendations

The Kinistin Salteaux Nation currently operates a sewage lagoon system northeast of the community core. The existing system is undersized and leaking. A community engagement process was undertaken to identify culturally significant areas of the community and other community concerns to help guide the site selection process for a new lagoon. A feasibility assessment was conducted simultaneously to assess potential lagoon disposal locations based on potential impacts to downstream uses and users.

Through the community engagement and feasibility assessment, a site in the northeast corner of the reserve was selected for the lagoon with discharge to Spence Lake. The lagoon site was selected because it was the only potential site for which no direct impacts to cultural resources were identified through the community engagement. Similarly, Spence Lake was selected as the disposal location because it was the only potential site for which no direct impacts to downstream uses and users were identified through the feasibility assessment.

Effluent from the expanded lagoon system is expected to meet WSER effluent limits, Saskatchewan *Waterworks and Sewage Work Regulation* limits, and WSA performance guidelines for well operated lagoons. Potential impacts of the lagoon discharge on water quality in the Spence Lake were evaluated by estimating required dilutions to meet water quality criteria, comparing required dilutions to the available dilution in Spence Lake, and using hydrodynamic modeling to predict whether the required dilutions can be met within 100 m of the discharge location, as required in the Saskatchewan WQOs. This assessment was highly conservative since it was based on the projected 20-year design volumes and effluent concentrations equal to the effluent limits (for parameters without effluent limits, the upper ends of the WSA performance guideline ranges were uses).

Results of the assessment were that 76:1 minimum required dilution for unionized ammonia could be achieved within 100 m of the discharge location for the twice per year release of 40,700 m^3 if discharged over three or four weeks and if the effluent met the WSER effluent limit of 1.24 mg/L. There was no scenario in which the once per year release volume of 68,000 m^3achieved a 76:1 dilution within 100 m of the discharge, though the four-week release came close with a predicted dilution of 64:1. If operated under a modified effluent limit of 1.05 mg/L, the predicted 64:1 dilution at 100 m would be adequate to meet ambient water quality criteria for unionized ammonia. Similarly, if operated with a modified unionized ammonia effluent limit of 0.80 mg/L, the twice per year lagoon volume of 40,700 m^3 could be released over two weeks. Modified effluent ammonia limits have been recommended and adopted for other community lagoon systems in Saskatchewan, and a limit of either 0.8 or 1.05 mg/L should be achievable, particularly for a fall discharge.

The below recommended lagoon design and discharge options have been developed based on the above assessment. There are options for both once per year and twice per year discharges, with recommendations for minimum discharge duration and effluent discharge objectives (EDOs). Under these scenarios, ambient criteria for ammonia, TSS, dissolved oxygen, nutrients, and bacteria are all predicted to be met within 100 m of the discharge location. If designed to discharge twice per year for a minimum duration of three weeks, the existing federal provincial effluent limits are adequate. If discharge within two weeks is preferred, it is recommended that the system be operated with an EDO of 0.80 mg/L for unionized ammonia. If designed to discharge once per year, it is recommended that the release occur over four weeks with an EDO of 1.05 mg/L for unionized ammonia. It is also recommended that a

once-per year release occur in the fall, when lagoon effluent quality, particularly for bacteria, is expected to be better.

Table 10 Recommended Discharge Options

Discharge Frequency	Minimum Discharge Duration	Effluent Discharge Objectives
68,000 m^3 Once per year in the fall	4 weeks	**1.05 mg/L uNH_3** 25 mg/L cBOD and TSS 30 mg/L BOD WSA nutrient and bacteria performance guidelines
40,700 m^3 Twice per year in the spring & fall	3 weeks	1.24 mg/L uNH_3 25 mg/L cBOD and TSS 30 mg/L BOD WSA nutrient and bacteria performance guidelines
40,700 m^3 Twice per year in the spring & fall	2 weeks	**0.80 mg/L uNH_3** 25 mg/L cBOD and TSS 30 mg/L BOD WSA nutrient and bacteria performance guidelines

Notes: **Bold** denotes EDO that is stricter than the federal WSER effluent limit.

4.0 REFERENCES

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5.0 STATEMENT OF LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by SLR Consulting (Canada) Ltd. (SLR) for Kinistin Saulteaux Nation. The report has been prepared in accordance with the Scope of Work and agreement between SLR and Kinistin Saulteaux Nation. It is intended for the sole and exclusive use of Kinistin Saulteaux Nation. Other than by the Kinistin Saulteaux Nation and as set out herein, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted unless payment for the work has been made in full and express written permission has been obtained from SLR.

This report has been prepared for specific application to this site and site conditions existing at the time work for the report was completed. Any conclusions or recommendations made in this report reflect SLR's professional opinion.

Information contained within this report may have been provided to SLR from third party sources. This information may not have been verified by a third party and/or updated since the date of issuance of the external report and cannot be warranted by SLR. SLR is entitled to rely on the accuracy and completeness of the information provided from third party sources and no obligation to update such information.

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The Kinistin Saulteaux Nation may submit this report to the Saskatchewan Water Security Agency and/or related Saskatchewan and Federal environmental regulatory authorities or persons for review and comment purposes.

DRAWINGS

Downstream Use and Impact Study

Kinistin Saulteaux Nation

Kinistin Saulteaux Nation Sewage Lagoon Upgrade

SLR Project No: 208.30024.00000

NOTES:
TOPOGRAPHIC MAP SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.

KINISTIN SAULTEAUX NATION
KINISTIN SAULTEAUX NATION SEWAGE LAGOON
KINISTIN SAULTEAUX NATION, SASKATCHEWAN

DOWNSTREAM USE AND IMPACT STUDY
KINISTIN SAULTEAUX NATION
SEWAGE LAGOON UPGRADE

SITE LOCATION PLAN

0 2.5 5 10 15 20 25 km

SCALE 1:400,000
WHEN PLOTTED CORRECTLY ON A 11 x 17 PAGE LAYOUT
NAD 1983 UTM Zone 13N

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

SLR

Date: May 18, 2022	Drawing No. 1
Project No. 208.30024.00000	

Cadfile name: S_208-30024-00000-A1.dwg

NOTES:
IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY.
IMAGE DATE: APRIL 25, 2017

LEGEND:

EXISTING LAGOON

0 1 2 4 6 km

SCALE 1:100,000
WHEN PLOTTED CORRECTLY ON A 11 x 17 PAGE LAYOUT
NAD 1983 UTM Zone 13N

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

KINISTIN SAULTEAUX NATION
KINISTIN SAULTEAUX NATION SEWAGE LAGOON
KINISTIN SAULTEAUX NATION, SASKATCHEWAN

DOWNSTREAM USE AND IMPACT STUDY
KINISTIN SAULTEAUX NATION
SEWAGE LAGOON UPGRADE

SITE PLAN

Date: May 18, 2022

Project No. 208.30024.00000

Drawing No. 2

Cadfile name: S_208-30024-00000-A1.dwg

APPENDIX A

Environmental Mapping

Downstream Use and Impact Study

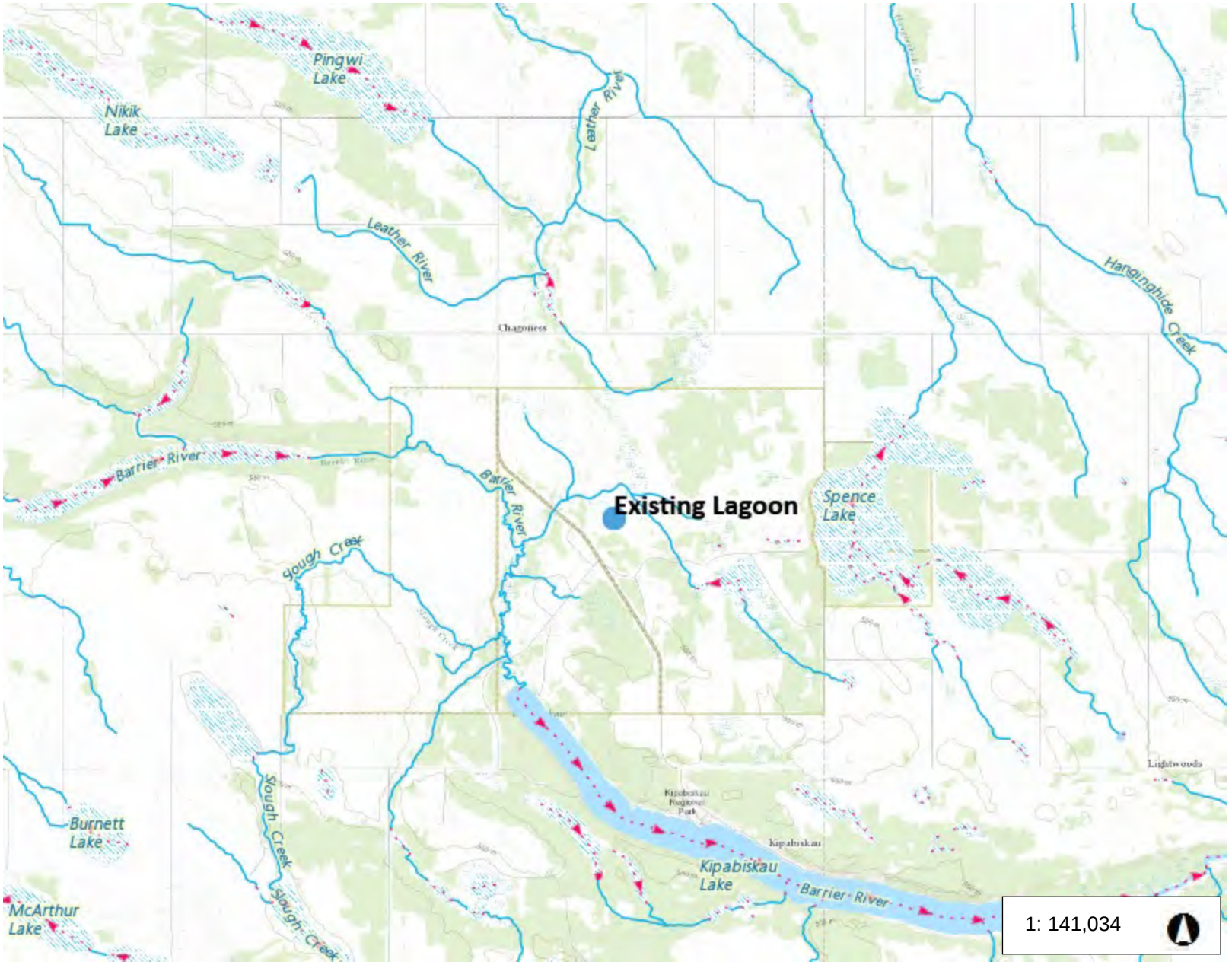
Kinistin Saulteaux Nation

Kinistin Saulteaux Nation Sewage Lagoon Upgrade

SLR Project No: 208.30024.00000

HABISask
hunting | angling | biodiversity

Water Flow



Legend

- Provincial Boundary
- National Park
- Provincial Park

Notes

7.2 0 3.58 7.2 Kilometers

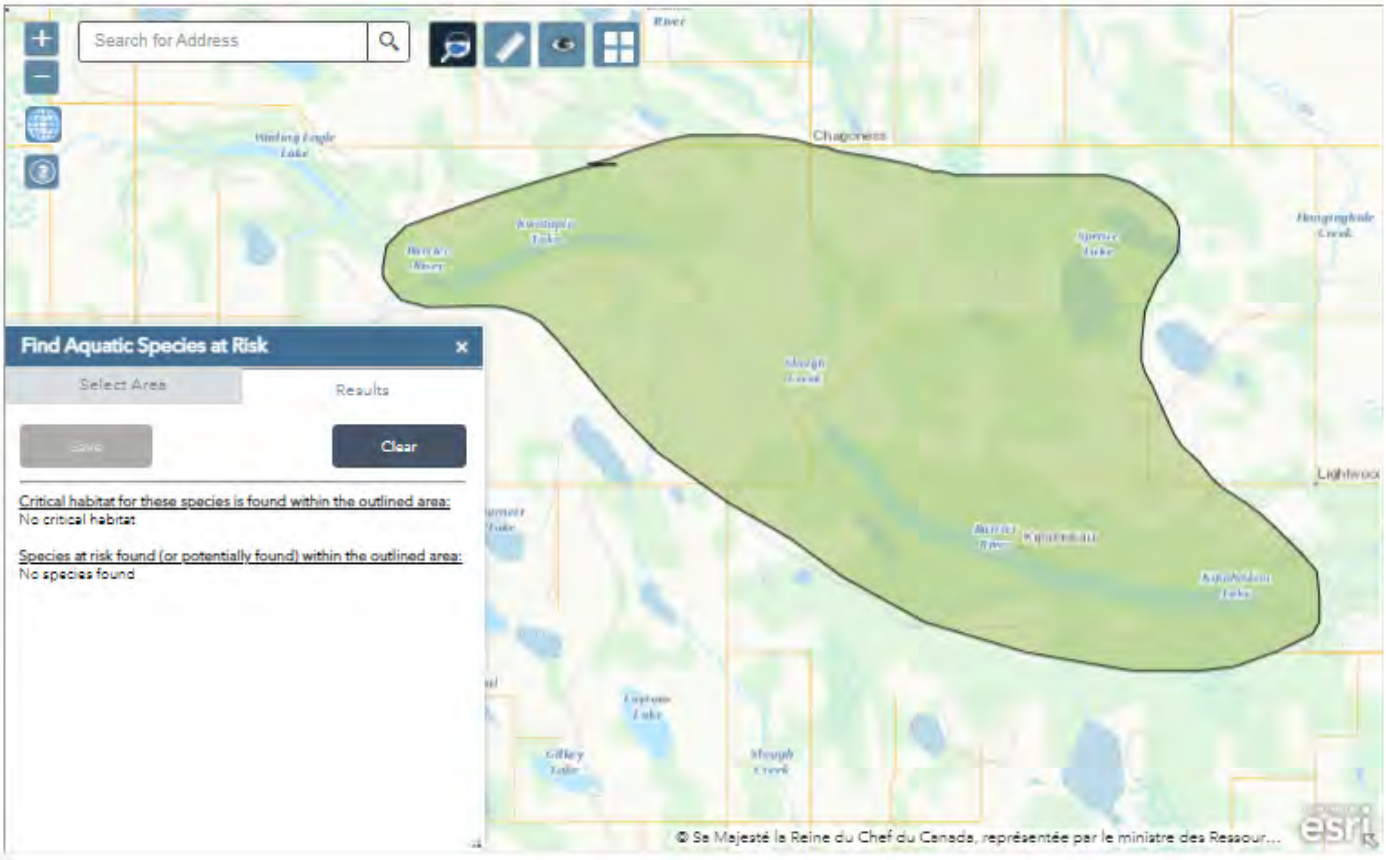
WGS_1984_Web_Mercator_Auxiliary_Sphere

Aquatic species at risk map

We've compiled critical habitat and distribution data for aquatic species listed under the Species at Risk Act (SARA). This map is intended to provide an overview of the distribution of aquatic species at risk and the presence of their critical habitat within Canadian waters. The official source of information is the Species at Risk Public Registry.

If you encounter an aquatic species at risk in an area that isn't currently mapped, please notify your regional Fisheries Protection Program office to ensure that you're compliant with SARA.

▶ **Information and legend**



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Critical Terrestrial Habitat

Legend

- Black-footed Ferret
- Burrowing Owl (Generalized)
- Chestnut-collared Longspur
- Dusky Dune Moth
- Eastern Yellow-bellied Racer
- Gold-edged Gem
- Greater Sage-Grouse (Genera
- Greater Short-horned Lizard
- Loggerhead Shrike
- Mountain Plover
- Piping Plover
- Red-headed Woodpecker
- Red Knot
- Slender Mouse-ear Cress - Tra bursifolia ssp. Virgate
- Small-flowered Sand-verbena micranthus
- Smooth Goosefoot - Chenopoc
- Sprague's Pipit
- Swift Fox
- Tiny Cryptantha - Cryptantha n
- Western Spiderwort - Tradesca var. occidentalis

Notes

None found

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

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Fisheries Information

Legend

- Fisheries - Species Info
- Fisheries - No Lake Info

1: 141,034

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

Notes

Fathead minnow, ninespine stickleback, and white sucker in Kwatapiu Lake and common carp, northern pike, walleye, white sucker, and yellow perch in Kipabiskau Lake

Fisheries - Lake Report

Kipabiskau Lake

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Fish Species

The following fish species are known to inhabit this waterbody:

Common Carp | Northern Pike | Walleye | White Sucker | Yellow Perch

Fish Stocking History

The following is a list of fish stocking activities for this waterbody:

Species	Size	Date	Number	Species	Size	Date	Number
Walleye	Fry	26-05-2017	500,000	Walleye	Fry	26-05-2015	730,000
Walleye	Fry	10-06-2013	250,000	Walleye	Fry	01-06-2011	500,000
Walleye	Fry	09-06-2009	1,500,000	Walleye	Fry	25-05-2007	500,000
Walleye	Fry	02-06-2005	1,000,000	Walleye	Fry	02-06-2003	1,000,000
Walleye	Fry	29-05-2001	1,000,000	Walleye	Fry	01-06-1999	1,000,000
Walleye	Fry	03-06-1997	1,000,000	Walleye	Fry	26-05-1993	1,000,000
Walleye	Fry	31-05-1991	1,000,000	Walleye	Fry	29-05-1989	2,000,000
Walleye	Fry	20-05-1987	50,000	Walleye	Fry	09-05-1987	250,000
Walleye	Fry	31-05-1984	300,000	Walleye	Fry	30-05-1981	200,000
Walleye	Fry	21-06-1979	250,000	Walleye	Fry	21-05-1977	200,000
Walleye	Fry	18-06-1965	300,000	Walleye	Fry	06-06-1963	400,000
Walleye	Fry	06-06-1961	500,000	Walleye	Fry	06-06-1960	300,000
Walleye	Fry	31-05-1958	1,000,000	Walleye	Fry	01-05-1957	500,000
Walleye	Fry	01-05-1956	1,197,000	Walleye	Fry	31-05-1955	500,000
Walleye	Fry	01-05-1954	500,000	Northern Pike	Fry	01-05-1952	100,000
Walleye	Fry	01-05-1952	500,000	Walleye	Fry	05-06-1951	800,000
Walleye	Fry	13-06-1950	500,000	Walleye	Fry	29-05-1949	1,000,000
Walleye	Eyed Eggs	21-05-1948	910,000	Walleye	Fry	05-06-1945	500,000
Walleye	Fry	28-05-1944	400,000	Walleye	Fry	05-06-1943	450,000

Mercury Consumption

Mercury is a naturally occurring element found in the earth's bedrock and soils and may enter the environment through industrial and human activities. Frequent consumption of fish with elevated mercury is a potential human health concern, especially for infants and unborn children who may be exposed to mercury through their mothers. Mercury consumption guidelines are expressed as the number of servings per month based on the size and species of fish. A serving size is considered to be 8 ounces, or half a pound. The sensitive population listed refers to women who are or could become pregnant, women who are breastfeeding, and children under the age of 12. All others belong to the general population listing.

Species	Population	< 20cm	20-30cm	30-40cm	40-50cm	50-60cm	60-70cm	70-80cm	> 80cm
Pike	General	16	16	16	16				4
Pike	Sensitive	8	8	8	8	4	4	4	2

Walleye	General	16	16	8	8	4	2
Walleye	Sensitive	8	8	4	4	2	0
Perch	General	16	8	4			
Perch	Sensitive	8	4	2			

Bathymetric Map

Bathymetric Map: http://gisappl.saskatchewan.ca/BathyMaps/Kipabiskau.pdf

Bathymetric Map: http://gisappl.saskatchewan.ca/BathyMaps/Kipabiskau_1968.pdf

Fisheries - Lake Report

Kwatapiu Lake

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Fish Species

The following fish species are known to inhabit this waterbody:

Fathead Minnow	Ninespine Stickleback	White Sucker

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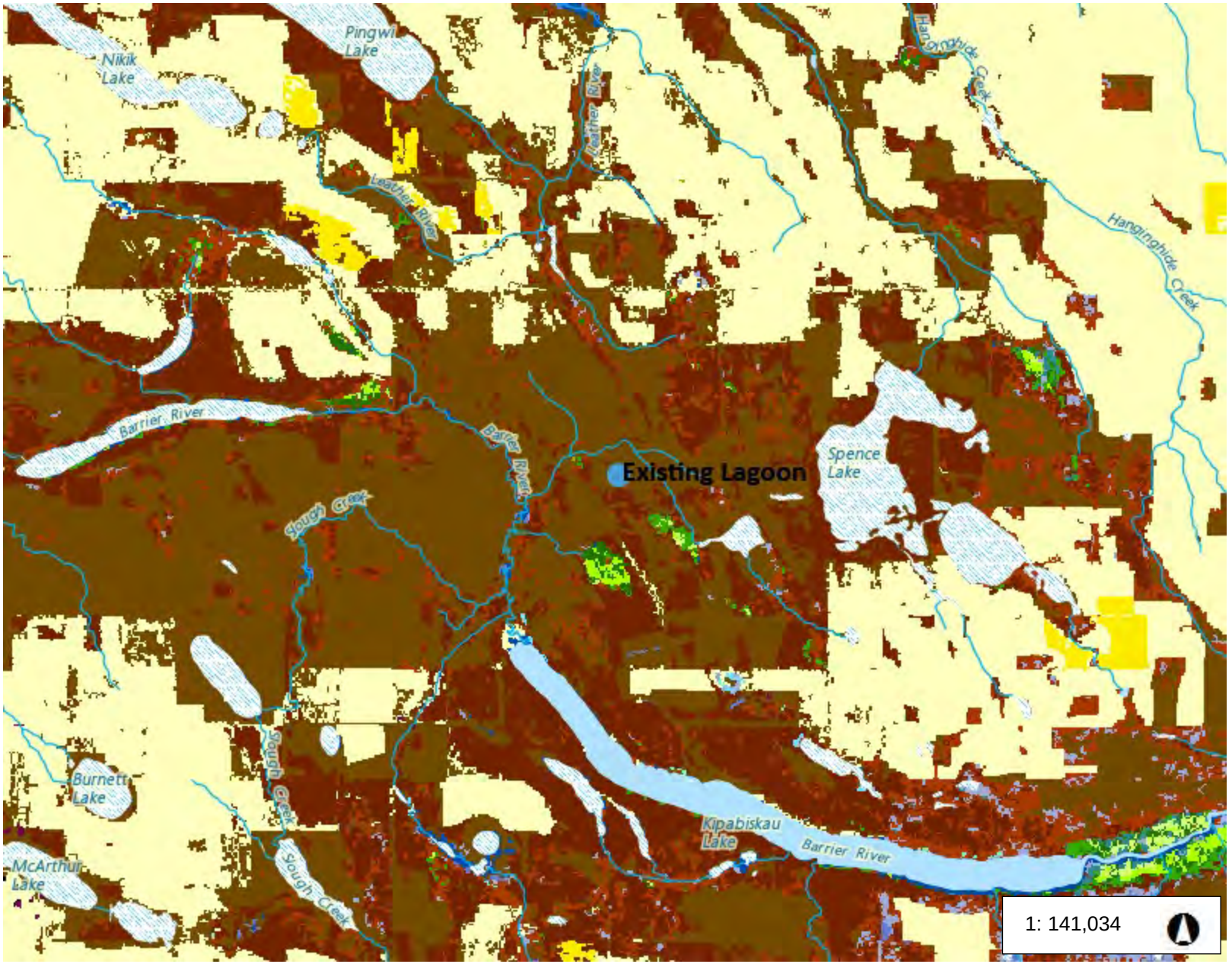
Land Use



Legend

Sask Digital Land Cover

- Agriculture
- Hay Crops (Forage)
- Native Dominant Grasslands
- Tall Shrubs
- Pasture (Seeded Grass Lands)
- Hardwoods (Open Canopy)
- Hardwoods (Closed Canopy)
- Jackpine (Closed Canopy)
- Jackpine (Open Canopy)
- Spruce (Closed Canopy)
- Spruce (Open Canopy)
- Mixed Woods
- Treed Rock
- Recent Burns
- Revegetating/Regeneration Burn
- Cutovers
- Water
- Marsh
- Herbaceous Fen
- Mud/Sand/Saline
- Shrub Fen (Treed Swamp)
- Treed Bog
- Open Bog
- Farmstead
- Unclassified

Notes

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.
THIS MAP IS NOT TO BE USED FOR NAVIGATION

Rare and Endangered Species Report

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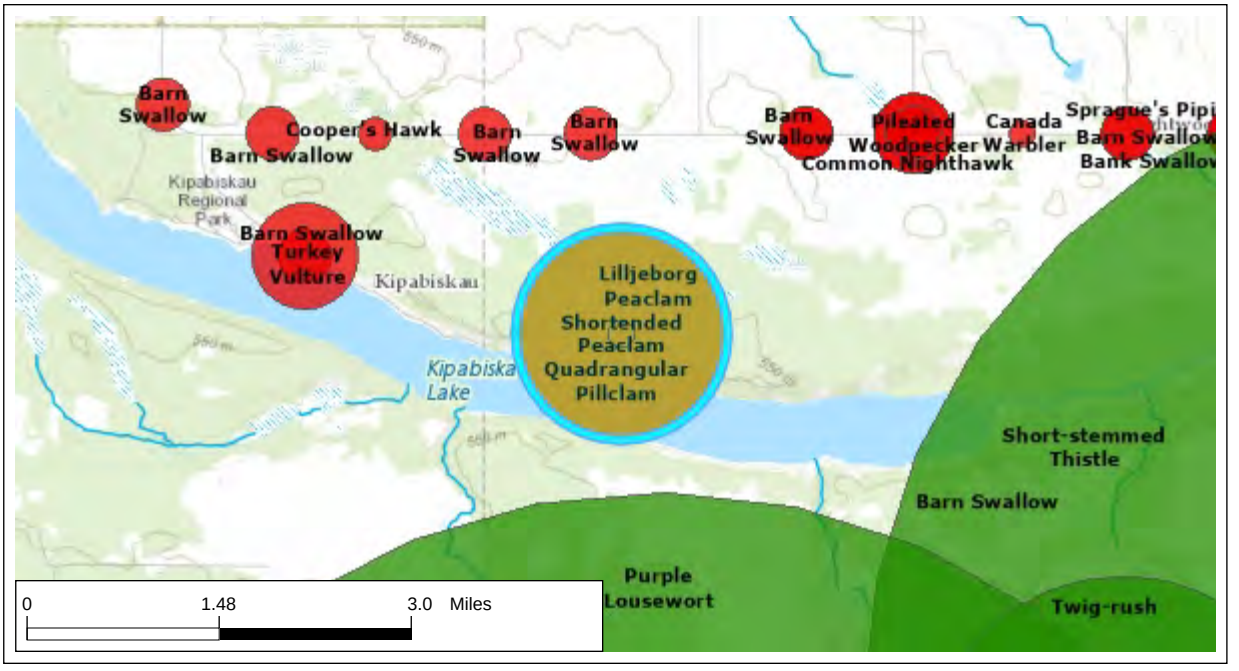
The absence of information provided by the Saskatchewan Conservation Data Centre (SKCDC) does not categorically mean the absence of sensitive species or features. The quantity and quality for data collected by the SKCDC are dependent on the research and observations of many individuals and organizations. SKCDC reports summarize the existing natural heritage information, known to the SKCDC, at the time of the request.

SKCDC data should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments. The user therefore acknowledges that the absence of data may indicate that the project area has not been surveyed, rather than confirm that the area lacks natural heritage resources.

Rare and Endangered Species Area of Interest



Rare and Endangered Species Report

Scientific Name: *Euglesa lilljeborgii*
Common Name: Lilljeborg Peaclam
Provincial Rank: SU **Global Rank:** G5
Observation: **First:** 1905-03-14 **Last:** 1905-03-14

Occurrence ID: 9999101280
Occurrence Class: Invertebrate Animal
Occurrence Type:
Occurrence Rank:

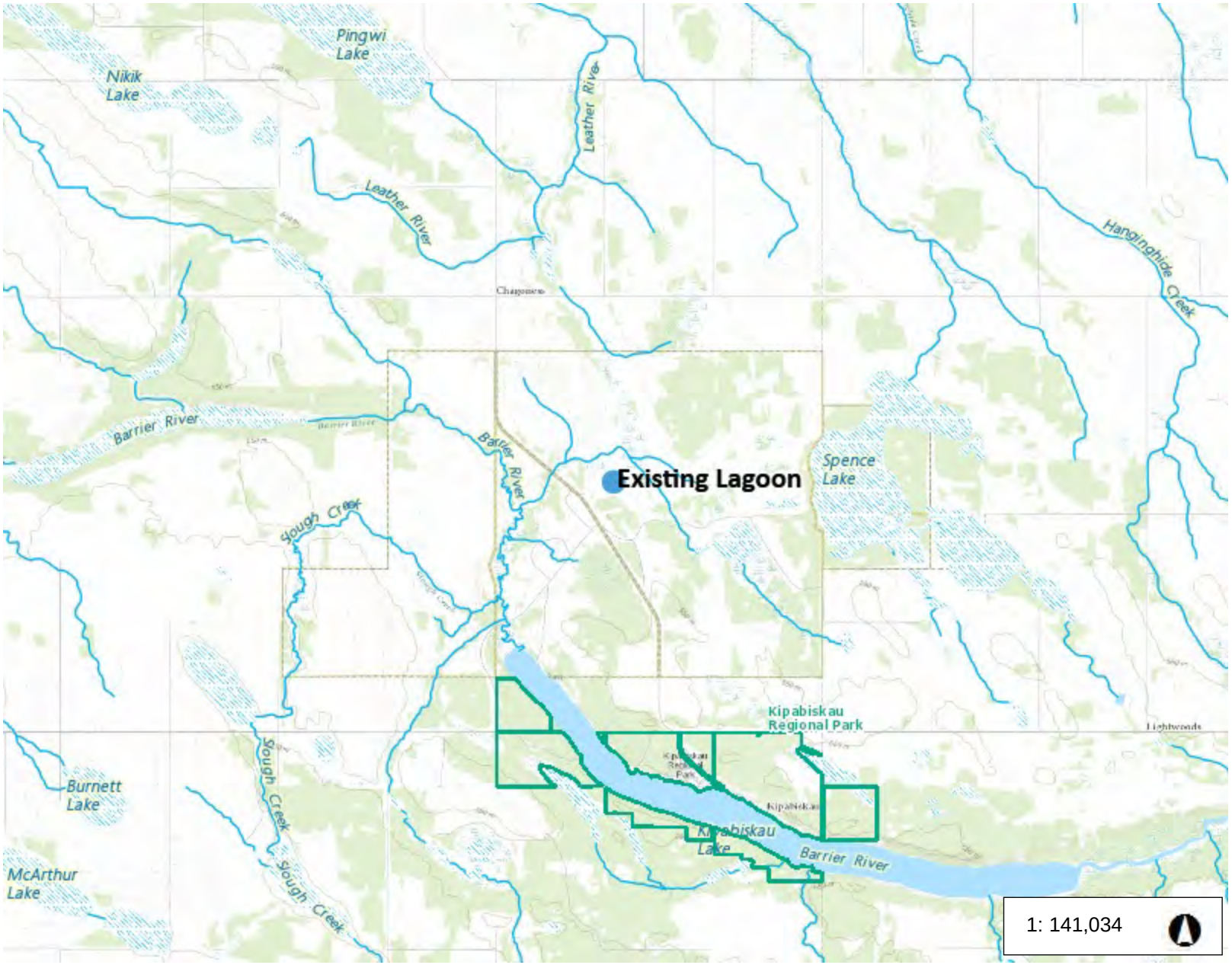
Provincial Legal Status:
Species at Risk Act Status:
COSEWIC Status:
General Description:
1 Unknown Sex/Age; (1905)

Occurrence Data:

Directions:
S31, T48, R15, W2: Kipabiskau Lake

HABISask
hunting | angling | biodiversity

Parks and Recreation



Legend

- National Park
- Provincial Park
- Recreation Site
- Protected Area
- Authority
- Historic Site
- Regional Park

Notes

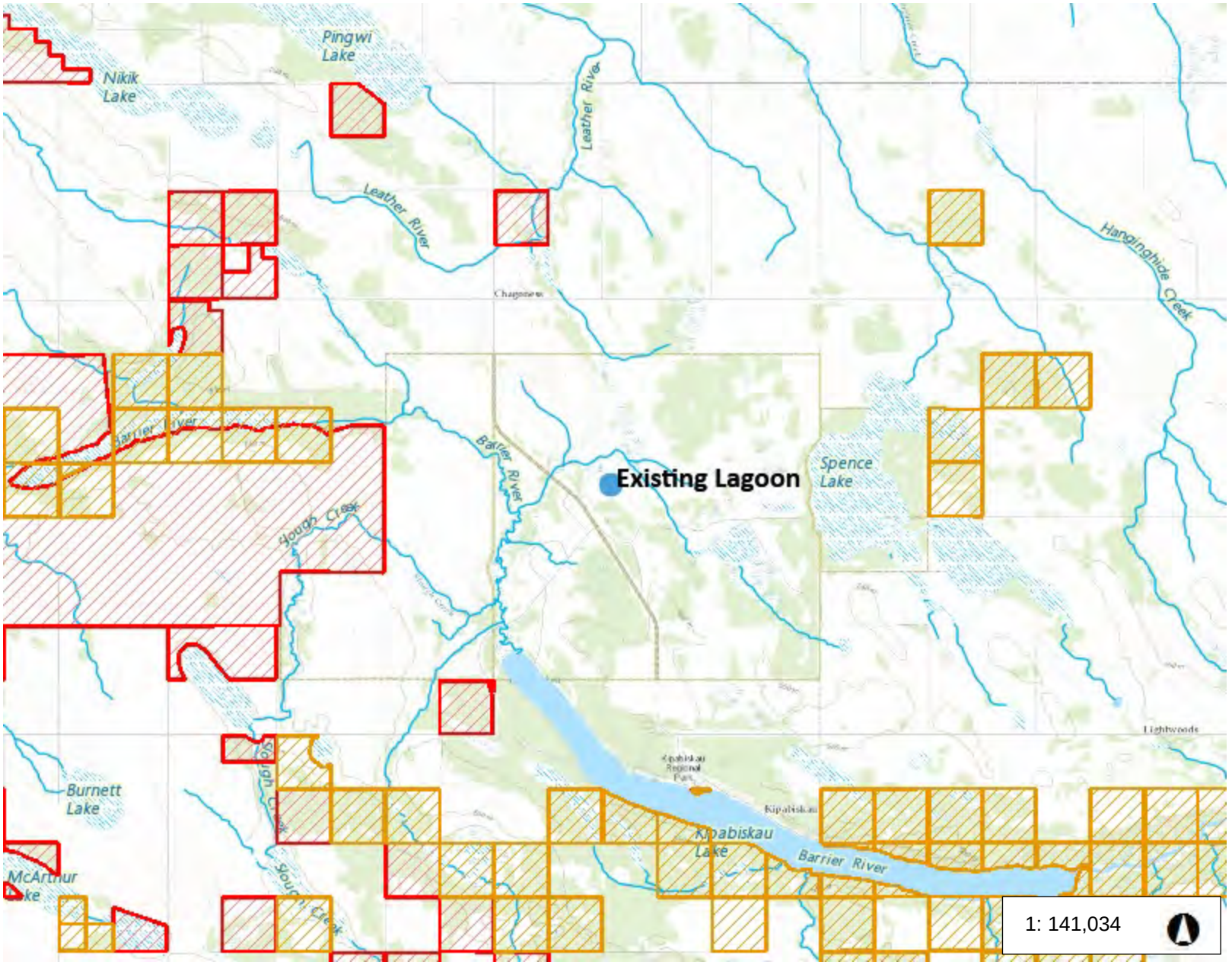
7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.
THIS MAP IS NOT TO BE USED FOR NAVIGATION

HABISask
hunting | angling | biodiversity

Protected Areas



Legend

- Game Preserve
- National Wildlife Area
- Migratory Bird Sanctuary
- Ecological Reserves
- Wildlife Habitat Protection (WHPA)
- Wildlife Refuge
- Protected and Conserved Area

Notes

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

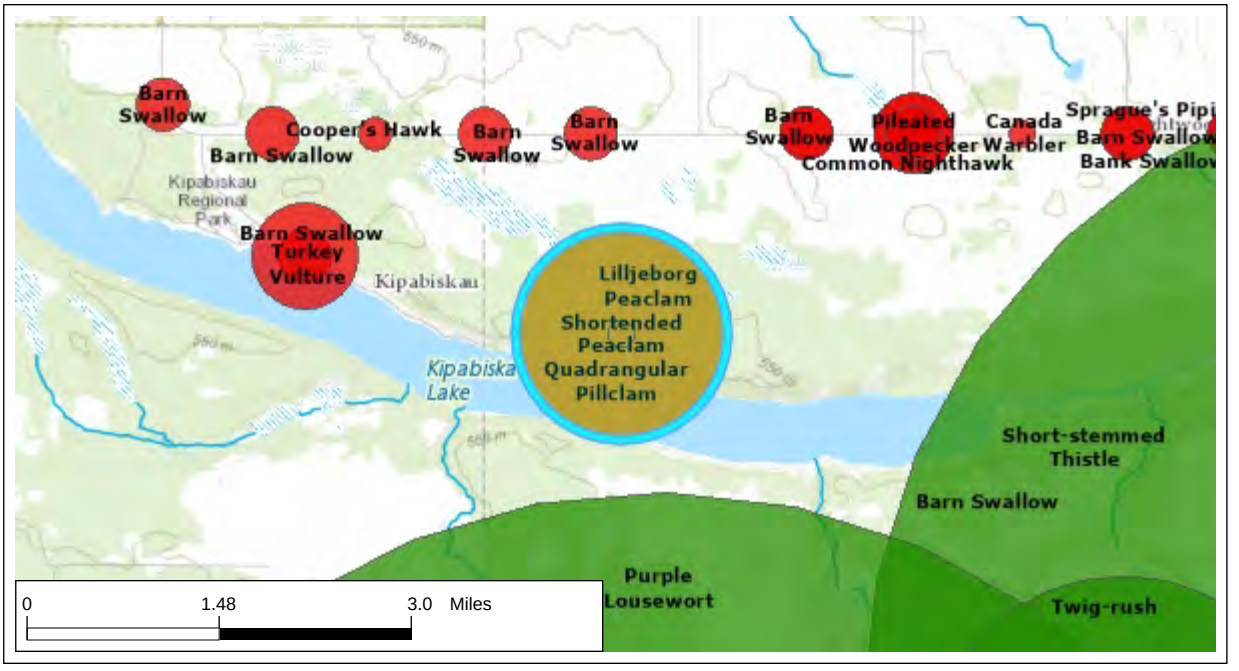
Rare and Endangered Species Report

Report Generated: 2/15/2022 11:46:16 AM

The absence of information provided by the Saskatchewan Conservation Data Centre (SKCDC) does not categorically mean the absence of sensitive species or features. The quantity and quality for data collected by the SKCDC are dependent on the research and observations of many individuals and organizations. SKCDC reports summarize the existing natural heritage information, known to the SKCDC, at the time of the request.

SKCDC data should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments. The user therefore acknowledges that the absence of data may indicate that the project area has not been surveyed, rather than confirm that the area lacks natural heritage resources.

Rare and Endangered Species Area of Interest



Rare and Endangered Species Report

Scientific Name: *Pisidium milium*
Common Name: Quadrangular Pillclam
Provincial Rank: SU **Global Rank:** G5
Observation: **First:** 1905-03-14 **Last:** 1905-03-14

Occurrence ID: 9999101281
Occurrence Class: Invertebrate Animal
Occurrence Type:
Occurrence Rank:

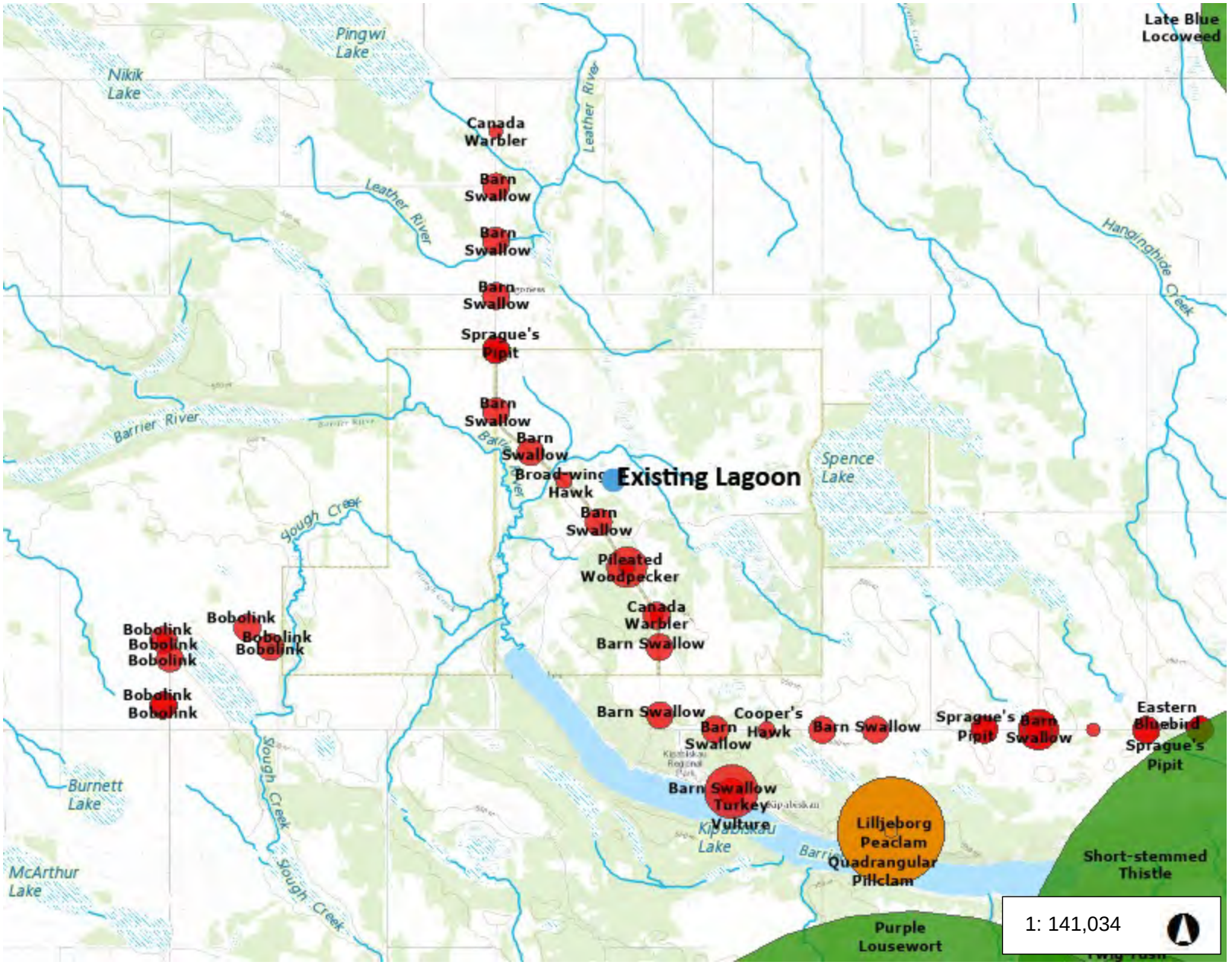
Provincial Legal Status:
Species at Risk Act Status:
COSEWIC Status:
General Description:
1 Unknown Sex/Age; (1905)

Occurrence Data:

Directions:
S31, T48, R15, W2: Kipabiskau Lake

HABISask
hunting | angling | biodiversity

Rare and Endangered Species



Legend

Rare and Endangered Species

- Vertebrate Animal
- Invertebrate Animal
- Animal Assemblage
- Vascular Plant
- Nonvascular Plant
- Other (Botanical)
- Fungus

Notes

1: 141,034

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

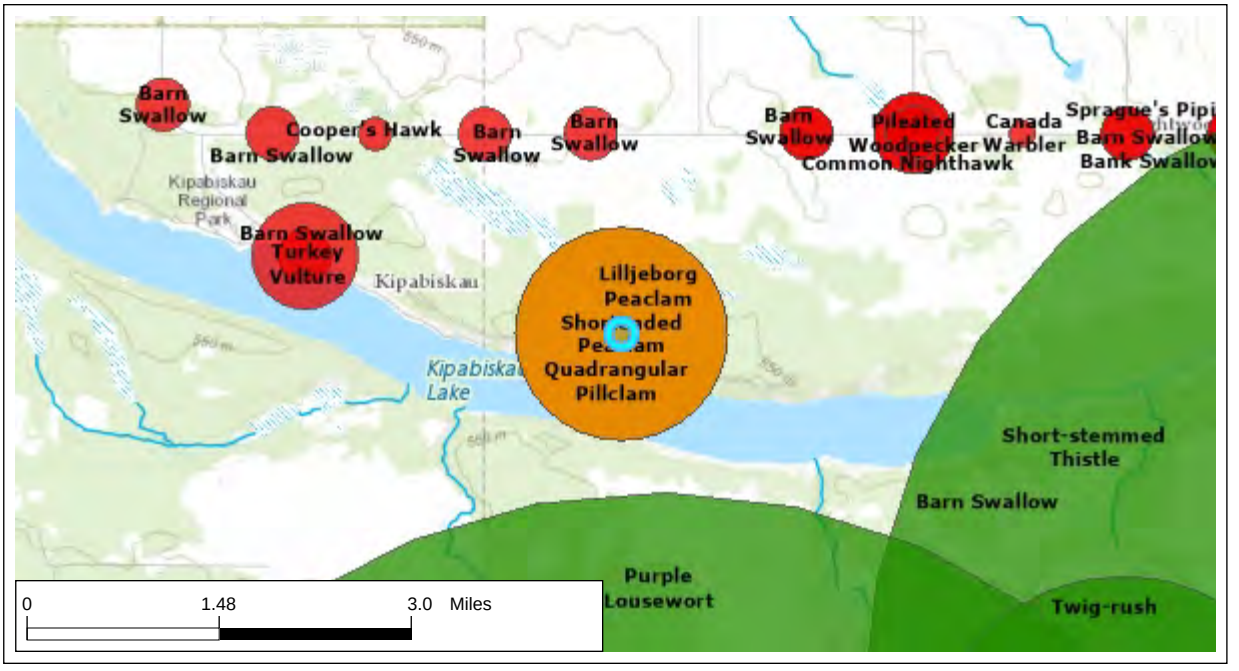
Rare and Endangered Species Report

Report Generated: 2/15/2022 11:48:12 AM

The absence of information provided by the Saskatchewan Conservation Data Centre (SKCDC) does not categorically mean the absence of sensitive species or features. The quantity and quality for data collected by the SKCDC are dependent on the research and observations of many individuals and organizations. SKCDC reports summarize the existing natural heritage information, known to the SKCDC, at the time of the request.

SKCDC data should never be regarded as final statements on the elements or areas being considered, nor should they be substituted for on-site surveys required for environmental assessments. The user therefore acknowledges that the absence of data may indicate that the project area has not been surveyed, rather than confirm that the area lacks natural heritage resources.

Rare and Endangered Species Area of Interest



Rare and Endangered Species Report

Scientific Name: *Euglesa subtruncata*
Common Name: Shortended Peaclam
Provincial Rank: SU **Global Rank:** G5
Observation: **First:** Unknown **Last:** Unknown

Provincial Legal Status:
Species at Risk Act Status:
COSEWIC Status:
General Description:
Species detected

Occurrence ID: 9999101472
Occurrence Class: Invertebrate Animal
Occurrence Type:
Occurrence Rank:

Occurrence Data:

Directions:
S31, T48, R15, W2: Kipabiskau Lake

HABISask
hunting | angling | biodiversity

Terrestrial Wildlife Habitat Inventory

Legend

Terrestrial Wildlife Habitat Inve

Notes

Sharp-tailed grouse near Spence Lake and white-tailed dear along Kipabiskau Lake

7.2 0 3.58 7.2 Kilometers

WGS_1984_Web_Mercator_Auxiliary_Sphere

APPENDIX B

CORMIX Model Input and Output

Downstream Use and Impact Study

Kinistin Saulteaux Nation

Kinistin Saulteaux Nation Sewage Lagoon Upgrade

SLR Project No: 208.30024.00000

CORMIX Model Inputs

Model Case		1	2	3	4	5	6
Effluent							
discharge frequency	--	2/yr	2/yr	2/yr	1/yr	1/yr	1/yr
discharge duration	weeks	2	3	4	2	3	4
discharge volume	m^3	40700	40700	40700	68000	68000	68000
discharge flow rate	m^3/s	0.0336	0.0224	0.0168	0.0562	0.0375	0.0281
temperature	C	15	15	15	15	15	15
Ambient							
average depth	m	3	3	3	3	3	3
depth at discharge	m	2.1	2.1	2.1	2.1	2.1	2.1
wind speed	m/s	2	2	2	2	2	2
current speed	m/s	0.01	0.01	0.01	0.01	0.01	0.01
temperature	C	15	15	15	15	15	15
Maning's n	--	0.025	0.025	0.025	0.025	0.025	0.025
Discharge							
bank on	--	right	right	right	right	right	right
horizontal angle	deg	90	90	90	90	90	90
channel width	m	2	2	2	2	2	2
channel depth	m	1.5	1.5	1.5	1.5	1.5	1.5
bottom slope	%	3	3	3	3	3	3
depth at outlet	m	1.5	1.5	1.5	1.5	1.5	1.5
Mixing Zone							
distance	m	100	100	100	100	100	100
region of interest	m	1000	1000	1000	1000	1000	1000
output steps	--	500	500	500	500	500	500
Results							
Dilution at 100 m		48:1	85:1	114:1	2:1	45:1	64:1

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 12.0GTD
HYDRO3:Version-12.0.0.0 December,2020
SITE NAME/LABEL:
DESIGN CASE: 1
FILE NAME: N:\Portland\Projects\BCL Engineering\Projects\2021 Kinistin Saulteaux FN DUIS - SK\03. Modleing and Analyses\Spence Lake.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 03/03/2022--11:23:04
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3 m
Depth at discharge HD = 2.1 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0340
Calculated from Manning's n = 0.025
Wind velocity UW = 2 m/s
Stratification Type STRCND = U
Surface temperature = 15 degC
Bottom temperature = 15 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.1011 kg/m^3
Bottom density RHOAB = 999.1011 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = right bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.5 m
Bottom slope at discharge SLOPE = 1.72 deg
Rectangular discharge:
Discharge cross-section area A0 = 3 m^2
Discharge channel width B0 = 2 m
Discharge channel depth H0 = 1.5 m
Discharge aspect ratio AR = 0.75
Discharge flowrate Q0 = 0.0336 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 15 degC
Corresponding density RHO0 = 999.1011 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 100 %
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 1.73 m Lm = 1.94 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 1.12

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = no
Regulatory mixing zone = yes
Regulatory mixing zone specification = distance
Regulatory mixing zone value = 100 m (m^2 if area)
Region of interest = 1000 m

****

HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at WATER SURFACE and at centerline of discharge channel:
0 m from the right bank/shore.
Number of display steps NSTEP = 500 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 64.460100 %
Dilution at edge of NFR s = 1.6
NFR Location: x = 16.72 m
(centerline coordinates) y = 0 m
z = 0 m
NFR plume dimensions: half-width (bh) = 3.68 m
thickness (bv) = 1.5 m
Cumulative travel time: 2557.3477 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 18.68 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.

********** TOXIC DILUTION ZONE SUMMARY **********
No TDZ was specified for this simulation.
********** REGULATORY MIXING ZONE SUMMARY **********
The plume conditions at the boundary of the specified RMZ are as follows:
Pollutant concentration c = 2.023056 %
Corresponding dilution s = 49.4
Plume location: x = 100 m
(centerline coordinates) y = 0 m
z = 0 m
Plume dimensions: half-width (bh) = 55.37 m
thickness (bv) = 3 m
Cumulative travel time: 10885.8467 sec.

Note:
Plume concentration c and dilution s values are reported based on prediction file values - assuming linear interpolation between predicted points just before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account for this linear interpolation. Step size can be controlled by increasing (reduces the prediction step size) or decreasing (increases the prediction step size) the - Output Steps per Module - in CORMIX input.

********** FINAL DESIGN ADVICE AND COMMENTS **********
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 12.0GTD
HYDRO3:Version-12.0.0.0 December,2020
SITE NAME/LABEL:
DESIGN CASE: 2
FILE NAME: N:\Portland\Projects\BCL Engineering\Projects\2021 Kinistin Saulteaux FN DUIS - SK\03. Modleing and Analyses\Spence Lake.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 03/03/2022--11:24:01
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3 m
Depth at discharge HD = 2.1 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0340
Calculated from Manning's n = 0.025
Wind velocity UW = 2 m/s
Stratification Type STRCND = U
Surface temperature = 15 degC
Bottom temperature = 15 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.1011 kg/m^3
Bottom density RHOAB = 999.1011 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = right bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.5 m
Bottom slope at discharge SLOPE = 1.72 deg
Rectangular discharge:
Discharge cross-section area A0 = 3 m^2
Discharge channel width B0 = 2 m
Discharge channel depth H0 = 1.5 m
Discharge aspect ratio AR = 0.75
Discharge flowrate Q0 = 0.0224 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 15 degC
Corresponding density RHO0 = 999.1011 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 100 %
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 1.73 m Lm = 1.29 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 0.75

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = no
Regulatory mixing zone = yes
Regulatory mixing zone specification = distance
Regulatory mixing zone value = 100 m (m^2 if area)
Region of interest = 1000 m

****

HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at WATER SURFACE and at centerline of discharge channel:
0 m from the right bank/shore.
Number of display steps NSTEP = 500 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 70.555800 %
Dilution at edge of NFR s = 1.4
NFR Location: x = 4.67 m
(centerline coordinates) y = 0 m
z = 0 m
NFR plume dimensions: half-width (bh) = 3.70 m
thickness (bv) = 1.5 m
Cumulative travel time: 1262.2281 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 6.66 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.

********** TOXIC DILUTION ZONE SUMMARY **********
No TDZ was specified for this simulation.
********** REGULATORY MIXING ZONE SUMMARY **********
The plume conditions at the boundary of the specified RMZ are as follows:
Pollutant concentration c = 1.165262 %
Corresponding dilution s = 85.8
Plume location: x = 100 m
(centerline coordinates) y = 0 m
z = 0 m
Plume dimensions: half-width (bh) = 64.08 m
thickness (bv) = 3 m
Cumulative travel time: 10795.6963 sec.

Note:
Plume concentration c and dilution s values are reported based on prediction file values - assuming linear interpolation between predicted points just before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account for this linear interpolation. Step size can be controlled by increasing (reduces the prediction step size) or decreasing (increases the prediction step size) the - Output Steps per Module - in CORMIX input.

********** FINAL DESIGN ADVICE AND COMMENTS **********
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXX

CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 12.0GTD
HYDRO3:Version-12.0.0.0 December,2020

SITE NAME/LABEL:
DESIGN CASE: 3
FILE NAME: N:\Portland\Projects\BCL Engineering\Projects\2021 Kinistin Saulteaux FN DUIS - SK\03. Modleing and Analyses\Spence Lake.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 03/03/2022--11:24:42

****

SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3 m
Depth at discharge HD = 2.1 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0340
Calculated from Manning's n = 0.025
Wind velocity UW = 2 m/s
Stratification Type STRCND = U
Surface temperature = 15 degC
Bottom temperature = 15 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.1011 kg/m^3
Bottom density RHOAB = 999.1011 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = right bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.5 m
Bottom slope at discharge SLOPE = 1.72 deg
Rectangular discharge:
Discharge cross-section area A0 = 3 m^2
Discharge channel width B0 = 2 m
Discharge channel depth H0 = 1.5 m
Discharge aspect ratio AR = 0.75
Discharge flowrate Q0 = 0.0168 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 15 degC
Corresponding density RHO0 = 999.1011 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 100 %
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 1.73 m Lm = 0.97 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 0.56

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = no
Regulatory mixing zone = yes
Regulatory mixing zone specification = distance
Regulatory mixing zone value = 100 m (m^2 if area)
Region of interest = 1000 m

****

HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at WATER SURFACE and at centerline of discharge channel:
0 m from the right bank/shore.
Number of display steps NSTEP = 500 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 72.661300 %
Dilution at edge of NFR s = 1.4
NFR Location: x = 2.94 m
(centerline coordinates) y = 0 m
z = 0 m
NFR plume dimensions: half-width (bh) = 3.64 m
thickness (bv) = 1.5 m
Cumulative travel time: 1467.8590 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 4.93 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.

********** TOXIC DILUTION ZONE SUMMARY **********
No TDZ was specified for this simulation.
********** REGULATORY MIXING ZONE SUMMARY **********
The plume conditions at the boundary of the specified RMZ are as follows:
Pollutant concentration c = 0.868037 %
Corresponding dilution s = 115.2
Plume location: x = 100 m
(centerline coordinates) y = 0 m
z = 0 m
Plume dimensions: half-width (bh) = 64.53 m
thickness (bv) = 3 m
Cumulative travel time: 11174.1025 sec.

Note:
Plume concentration c and dilution s values are reported based on prediction file values - assuming linear interpolation between predicted points just before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account for this linear interpolation. Step size can be controlled by increasing (reduces the prediction step size) or decreasing (increases the prediction step size) the - Output Steps per Module - in CORMIX input.

********** FINAL DESIGN ADVICE AND COMMENTS **********
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 12.0GTD
HYDRO3:Version-12.0.0.0 December,2020
SITE NAME/LABEL:
DESIGN CASE: 4
FILE NAME: N:\Portland\Projects\BCL Engineering\Projects\2021 Kinistin Saulteaux FN DUIS - SK\03. Modleing and Analyses\Spence Lake.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 03/03/2022--11:34:32
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3 m
Depth at discharge HD = 2.1 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0340
Calculated from Manning's n = 0.025
Wind velocity UW = 2 m/s
Stratification Type STRCND = U
Surface temperature = 15 degC
Bottom temperature = 15 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.1011 kg/m^3
Bottom density RHOAB = 999.1011 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = right bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.5 m
Bottom slope at discharge SLOPE = 1.72 deg
Rectangular discharge:
Discharge cross-section area A0 = 3 m^2
Discharge channel width B0 = 2 m
Discharge channel depth H0 = 1.5 m
Discharge aspect ratio AR = 0.75
Discharge flowrate Q0 = 0.0562 m^3/s
Discharge velocity U0 = 0.02 m/s
Discharge temperature (freshwater) = 15 degC
Corresponding density RHO0 = 999.1011 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 100 %
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 1.73 m Lm = 3.24 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 1.87

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = no
Regulatory mixing zone = yes
Regulatory mixing zone specification = distance
Regulatory mixing zone value = 100 m (m^2 if area)
Region of interest = 1000 m

****

HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at WATER SURFACE and at centerline of discharge channel:
0 m from the right bank/shore.
Number of display steps NSTEP = 500 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 42.231200 %
Dilution at edge of NFR s = 2.4
NFR Location: x = 160.19 m
(centerline coordinates) y = 0 m
z = 0 m
NFR plume dimensions: half-width (bh) = 6.00 m
thickness (bv) = 1.5 m
Cumulative travel time: 13665.7168 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 175.31 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.

********** TOXIC DILUTION ZONE SUMMARY **********
No TDZ was specified for this simulation.
********** REGULATORY MIXING ZONE SUMMARY **********
The plume conditions at the boundary of the specified RMZ are as follows:
Pollutant concentration c = 46.232254 %
Corresponding dilution s = 2.2
Plume location: x = 100 m
(centerline coordinates) y = 0 m
z = 0 m
Plume dimensions: half-width (bh) = 5.38 m
thickness (bv) = 1.5 m
Cumulative travel time: 8453.7881 sec. (RMZ is within NFR)

Note:
Plume concentration c and dilution s values are reported based on prediction file values - assuming linear interpolation between predicted points just before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account for this linear interpolation. Step size can be controlled by increasing (reduces the prediction step size) or decreasing (increases the prediction step size) the - Output Steps per Module - in CORMIX input.

Regulatory Mixing Zone Analysis:
The specified RMZ occurs within the near-field region (NFR). This RMZ specification may be highly restrictive.

********** FINAL DESIGN ADVICE AND COMMENTS **********
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 12.0GTD
HYDRO3:Version-12.0.0.0 December,2020
SITE NAME/LABEL:
DESIGN CASE: 5
FILE NAME: N:\Portland\Projects\BCL Engineering\Projects\2021 Kinistin Saulteaux FN DUIS - SK\03. Modleing and Analyses\Spence Lake.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 03/03/2022--11:35:01
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3 m
Depth at discharge HD = 2.1 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0340
Calculated from Manning's n = 0.025
Wind velocity UW = 2 m/s
Stratification Type STRCND = U
Surface temperature = 15 degC
Bottom temperature = 15 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.1011 kg/m^3
Bottom density RHOAB = 999.1011 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = right bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.5 m
Bottom slope at discharge SLOPE = 1.72 deg
Rectangular discharge:
Discharge cross-section area A0 = 3 m^2
Discharge channel width B0 = 2 m
Discharge channel depth H0 = 1.5 m
Discharge aspect ratio AR = 0.75
Discharge flowrate Q0 = 0.0375 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 15 degC
Corresponding density RHO0 = 999.1011 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 100 %
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 1.73 m Lm = 2.17 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 1.25

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = no
Regulatory mixing zone = yes
Regulatory mixing zone specification = distance
Regulatory mixing zone value = 100 m (m^2 if area)
Region of interest = 1000 m

****

HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at WATER SURFACE and at centerline of discharge channel:
0 m from the right bank/shore.
Number of display steps NSTEP = 500 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 67.575300 %
Dilution at edge of NFR s = 1.5
NFR Location: x = 20.79 m
(centerline coordinates) y = 0 m
z = 0 m
NFR plume dimensions: half-width (bh) = 3.49 m
thickness (bv) = 1.5 m
Cumulative travel time: 2813.5906 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 38.42 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.

********** TOXIC DILUTION ZONE SUMMARY **********
No TDZ was specified for this simulation.
********** REGULATORY MIXING ZONE SUMMARY **********
The plume conditions at the boundary of the specified RMZ are as follows:
Pollutant concentration c = 2.198351 %
Corresponding dilution s = 45.5
Plume location: x = 100 m
(centerline coordinates) y = 0 m
z = 0 m
Plume dimensions: half-width (bh) = 56.87 m
thickness (bv) = 3 m
Cumulative travel time: 10734.3145 sec.

Note:
Plume concentration c and dilution s values are reported based on prediction file values - assuming linear interpolation between predicted points just before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account for this linear interpolation. Step size can be controlled by increasing (reduces the prediction step size) or decreasing (increases the prediction step size) the - Output Steps per Module - in CORMIX input.

********** FINAL DESIGN ADVICE AND COMMENTS **********
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the CORMIX predictions on dilutions and concentrations (with associated plume geometries) are reliable for the majority of cases and are accurate to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges the design configuration as highly complex and uncertain for prediction.

CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXX
CORMIX MIXING ZONE EXPERT SYSTEM
CORMIX Version 12.0GTD
HYDRO3:Version-12.0.0.0 December,2020
SITE NAME/LABEL:
DESIGN CASE: 6
FILE NAME: N:\Portland\Projects\BCL Engineering\Projects\2021 Kinistin Saulteaux FN DUIS - SK\03. Modleing and Analyses\Spence Lake.prd
Using subsystem CORMIX3: Buoyant Surface Discharges
Start of session: 03/03/2022--11:35:39
****
SUMMARY OF INPUT DATA:

AMBIENT PARAMETERS:
Cross-section = unbounded
Average depth HA = 3 m
Depth at discharge HD = 2.1 m
Ambient velocity UA = 0.01 m/s
Darcy-Weisbach friction factor F = 0.0340
Calculated from Manning's n = 0.025
Wind velocity UW = 2 m/s
Stratification Type STRCND = U
Surface temperature = 15 degC
Bottom temperature = 15 degC
Calculated FRESH-WATER DENSITY values:
Surface density RHOAS = 999.1011 kg/m^3
Bottom density RHOAB = 999.1011 kg/m^3

DISCHARGE PARAMETERS: Surface Discharge
Discharge located on = right bank/shoreline
Discharge configuration = flush discharge
Distance from bank to outlet DISTB = 0 m
Discharge angle SIGMA = 90 deg
Depth near discharge outlet HD0 = 1.5 m
Bottom slope at discharge SLOPE = 1.72 deg
Rectangular discharge:
Discharge cross-section area A0 = 3 m^2
Discharge channel width B0 = 2 m
Discharge channel depth H0 = 1.5 m
Discharge aspect ratio AR = 0.75
Discharge flowrate Q0 = 0.0281 m^3/s
Discharge velocity U0 = 0.01 m/s
Discharge temperature (freshwater) = 15 degC
Corresponding density RHO0 = 999.1011 kg/m^3
Density difference DRHO = 0 kg/m^3
Buoyant acceleration GP0 = 0 m/s^2
Discharge concentration C0 = 100 %
Surface heat exchange coeff. KS = 0 m/s
Coefficient of decay KD = 0 /s

DISCHARGE/ENVIRONMENT LENGTH SCALES:

LQ = 1.73 m Lm = 1.62 m Lbb = 0 m
LM = 99999 m

NON-DIMENSIONAL PARAMETERS:
Densimetric Froude number FR0 = 99999 (based on LQ)
Channel densimetric Froude no. FRCH = 99999 (based on H0)
Velocity ratio R = 0.94

MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
Toxic discharge = no
Water quality standard specified = no
Regulatory mixing zone = yes
Regulatory mixing zone specification = distance
Regulatory mixing zone value = 100 m (m^2 if area)
Region of interest = 1000 m

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HYDRODYNAMIC CLASSIFICATION:

| FLOW CLASS = SA1 |

****

MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

X-Y-Z Coordinate system:
Origin is located at WATER SURFACE and at centerline of discharge channel:
0 m from the right bank/shore.
Number of display steps NSTEP = 500 per module.

NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing. It has no regulatory implication. However, this information may be useful for the discharge designer because the mixing in the NFR is usually sensitive to the discharge design conditions.
Pollutant concentration at NFR edge c = 67.167000 %
Dilution at edge of NFR s = 1.5
NFR Location: x = 9.22 m
(centerline coordinates) y = 0 m
z = 0 m
NFR plume dimensions: half-width (bh) = 3.74 m
thickness (bv) = 1.5 m
Cumulative travel time: 1759.1062 sec.

Buoyancy assessment:
The effluent density is equal or about about equal to the surrounding ambient water density at the discharge level.
Therefore, the effluent behaves essentially as NEUTRALLY BUOYANT.

FAR-FIELD MIXING SUMMARY:
Plume becomes vertically fully mixed ALREADY IN NEAR-FIELD at 11.20 m downstream and continues as vertically mixed into the far-field.

PLUME BANK CONTACT SUMMARY:
Plume in unbounded section contacts nearest bank at 0 m downstream.

********** TOXIC DILUTION ZONE SUMMARY **********
No TDZ was specified for this simulation.
********** REGULATORY MIXING ZONE SUMMARY **********
The plume conditions at the boundary of the specified RMZ are as follows:
Pollutant concentration c = 1.533897 %
Corresponding dilution s = 65.2
Plume location: x = 100 m
(centerline coordinates) y = 0 m
z = 0 m
Plume dimensions: half-width (bh) = 61.07 m
thickness (bv) = 3 m
Cumulative travel time: 10837.2588 sec.

Note:
Plume concentration c and dilution s values are reported based on prediction file values - assuming linear interpolation between predicted points just before and just after the RMZ boundary has been detected.

Please ensure a small step size is used in the prediction file to account for this linear interpolation. Step size can be controlled by increasing (reduces the prediction step size) or decreasing (increases the prediction step size) the - Output Steps per Module - in CORMIX input.

********** FINAL DESIGN ADVICE AND COMMENTS **********
REMINDER: The user must take note that HYDRODYNAMIC MODELING by any known technique is NOT AN EXACT SCIENCE.
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