MANITOBA INFRASTRUCTURE

# Assessment of Passive Treatment Options for Cattle Operations Runoff in Vicinity of the LMOC– Final Report

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***Assessment of Passive Treatment Options for Cattle Operations Runoff in the Vicinity of the LMOC***

Please find attached the Assessment of Passive Treatment Options for Cattle Operations Runoff in the Vicinity of the LMOC, which describes the existing cattle operations located west of the Lake Manitoba Outlet Channel, the sampling program undertaken to help identify nutrient-laden runoff impacts and conceptual design options considered for treating cattle operations runoff.

If you have any questions or comments please contact the undersigned at (204) 453 3201 ext. 4043 or via email at cpogue@dillon.ca.

Sincerely,

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# 1.0 Background

In 2011, widespread flooding occurred across much of southwestern Manitoba in the Assiniboine River and Lake Manitoba basins, resulting in unprecedented high inflows into Lake Manitoba and Lake St. Martin. These record high flows extended well into the summer and overwhelmed the capacity of the existing water control and protection infrastructure. Flooding on both lakes resulted in hundreds of homes and other buildings being destroyed or damaged, thousands of acres of agricultural land being flooded and the long-term evacuation of some surrounding communities.

Following the 2011 flood, the Province of Manitoba began to embark upon a flood protection initiative aimed at reducing the potential for flooding on Lake Manitoba and Lake St. Martin during periods of high runoff. This initiative centers around the design and construction of two (2) separate flood control channels and associated gated control structures to improve the conveyance of flood waters from these areas into Lake Winnipeg.

Manitoba Infrastructure (MI) selected the design team lead by Hatch Ltd. (Hatch) to undertake the Preliminary Design of the LMOC. The team is supported by Trek Geotechnical Inc. (Trek), Stantec Consulting Ltd. (Stantec), Dillon Consulting Ltd. (Dillon) and J.D. Mollard and Associates (2010) Ltd. (Mollard) and is collectivity referred to as the Hatch Team.

The proposed LMOC alignment is an approximately 24 Kilometers (km) long channel that will connect Watchorn Bay on Lake Manitoba to Birch Bay on Lake St. Martin near the outlet of Birch Creek. The Channel alignment will run in a north-easterly direction and is located just to the west of low-lying wetland areas.

An outside drain between Lake Manitoba and Lake St. Martin is being designed by Stantec on the west side of the LMOC to intercept the runoff arriving from the west and convey it directly to Lake Manitoba or Lake St. Martin. The outside drain will prevent runoff (potentially high in nutrients) from directly entering the LMOC. Construction of the outside drain prior to construction of the channel simplifies surface water management during construction.

Cattle ranching is a common agricultural practice in the region where the LMOC will be located. Cattle are typically overwintered in confined pens called feedlots. During the spring melt, runoff from feedlots can transport large amounts of manure-laden sediment to natural wetlands and municipal drains that discharge into Lake Manitoba and Lake St. Martin. In some areas there are existing natural wetlands between cattle operations and Lake Manitoba that are believed to provide some level of nutrient reduction based on visual observations of water quality and a limited number of samples from the area. The channel construction will sever this drainage route and provide a more direct route for the nutrient laden runoff between the farms and the lakes. It is believed that runoff from agricultural operations currently contributes significantly to the overall nutrient loading to Lake Manitoba.

Runoff from feedlot areas may also contain high levels of harmful bacteria such as fecal coliforms, which during overland flooding events, presents a risk to potable wellheads or watering ponds. Since these bacteria are detrimental to human and animal health, they should be minimized or removed from cattle feedlot runoff to help maintain the downstream ecosystems.

This study investigates potential passive treatment options that could be implemented to reduce the impact of cattle operations runoff.

# 2.0 Introduction

Nutrient management is one of the principal environmental concerns related to the operation of agricultural sites and their associated surface water runoff in North America. The Lake Manitoba Outlet Channel (LMOC), and specifically the outside drain on the west side of the LMOC right of way, will receive stormwater runoff from a number of agricultural properties located near or in some cases adjacent to the LMOC. There is a risk of nutrient-laden runoff entering the LMOC outside drain and affecting downstream lake ecosystems, primarily through eutrophication, unless properly monitored and mitigated. Given the size and scale of the project, Dillon Consulting Limited (Dillon) was requested to investigate passive (i.e. minimal power) treatment options that could be implemented to reduce risk.

Constructed wetlands and natural filtration systems have been implemented across North America to provide a relatively low lifecycle cost option for nutrient and suspended solids reduction in stormwater runoff, wastewater and greywater systems. These types of systems could be implemented as part of the LMOC construction to reduce the impact of agricultural operations on lake ecosystems. To further evaluate the feasibility of such systems, Dillon completed a study to determine the viability for three (3) passive treatment alternatives.

Due to the nature of the project and climatic conditions experienced in spring 2021 (low rainfall and minimal runoff), baseline field data is difficult to collect and interpret. Dillon took surface water samples downstream of and in close proximity of five (5) cattle operations between Lake St. Martin and Lake Manitoba on May 21, 2021. The water quality samples were used in combination with available literature data to estimate typical runoff quality. Samples were collected from roadside ditches downstream of existing livestock operations. Dillon then used existing baseline water quality data from Watchorn Creek summarized in the *LMOC 2020 Surface Water and Groundwater Monitoring Report.* Dillon took an additional sample from Watchorn Creek during the May 21, 2021 site visit to supplement BOD/COD background values not provided in existing data.

This report provides a summary of potential design concepts for reducing the impacts of cattle pen runoff and a recommendation of a preferred option.

# 3.0 Methodology and Approach

## 3.1 Ongoing Outside Drain Design

It is acknowledged that the outside drain design is an evolving process being completed in parallel to this study. As such, the information available to Dillon during the drafting of this report is as follows:

- Preliminary design for local surface water management was referenced for the design depths and the slope of the outside drain;
- Stantec provided drainage sub-watersheds west of the LMOC, 10% design flows, average design flows (April) and the outside drain width based on the design under consideration in May 2021; and,
- Dillon's Assessment of Passive Treatment Options for Cattle Operations Runoff report should need to be updated if there is any change to the width of the outside drain, but it is unlikely to change the recommendations of the report.

## 3.2 Cattle Operations in LMOC Drainage Area

Dillon located cattle operations on the west side of the LMOC through consultation with project team members Coenraad Fourie (Dillon) and Jackie Hickman (MI). In total, there were seven (7) cattle operations identified that could potentially contribute nutrient and sediment-laden runoff to the outside drain. The locations were confirmed based on the May 21, 2021 site investigation and the feedlot areas were estimated from Google Earth satellite imagery. The cattle operations are listed in **Table 1** below and shown on **Figure A1** and **A2** (appended).

**Table 1: Cattle Operations Located West of the LMOC**

| Cattle Operation | Legal Description | Contributing Sub-watershed | Flow Direction | Feedlot Area ($km^2$) |
|---|---|---|---|---|
| Operation #1 | NW30-26-8W | W150-west | South | 0.029 |
| Operation #2 | NE31-26-8W | W150-west | South | 0.019 |
| Operation #3 | NE18-27-8W | W150-west | South | 0.018 |
| Operation #4 | NE30-27-8W | W840-west | South | 0.023 |
| Operation #5 | NE12-28-9W | W840-west | South | 0.025 |
| Operation #6 | NE25-28-9W | W610-west | North | 0.021 |
| Operation #7 | NE35-28-9W | W530-west | North | 0.029 |

Dillon received drainage sub-watersheds west of the LMOC from Stantec based on design of the outside drain in May 2021. Operations #6 and #7 were identified as within the W530-west and W610-west sub-watersheds flowing north to Lake St. Martin. These properties are approximately 3.9 km and 2.1 km


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west of the proposed outside drain and it is anticipated that there will be minimal impacts to the existing drainage routes, however this should be monitored by MI.

For comparison purposes the estimated risk of environmental impacts from runoff at each cattle operation located west of the LMOC is shown in **Table 2**. The rationale for the rankings is based solely on distance from the cattle operation to the outside drain and receiving lake. A score of 1 indicates a low risk considering distance from the lake and outside drain, while a score of 3 indicates a high risk of pollution.

- Risk of 1 – >1,000 Meters (m) from Outside Drain and/or >5,000 m from Water Body.
- Risk of 2 – 500 to 1,000 m from Outside Drain and/or 3,000 to 5,000 m from Water Body; and
- Risk of 3 – <500 m from Outside Drain and/or <3,000 m from Water Body.

**Table 2: Risk of Pollution at Cattle Operations**

| | Operation #1 | Operation #2 | Operation #3 | Operation #4 | Operation #5 | Operation #6 | Operation #7 |
|---|---|---|---|---|---|---|---|
| **Distance from Outside Drain** | 300 m | 200 m | 30 m | 300 m | 1,500 m | 2,100 m | 3,900 m |
| **Distance from Receiving Lake** | 200 m | 1,500 m | 2,500 m | 6,200 m | 11,300 m | 7,900 m | 8,200 m |
| **Risk of Runoff Pollution** | 3 | 3 | 3 | 3 | 1 | 1 | 1 |

There are four (4) properties identified with an increased risk for nutrient pollution to the outside drain (and ultimately Lake Manitoba) i.e. Operations #1, #2, #3 and #4 that are located at the legal descriptions in **Table 1** above. Drainage routes will be severed from existing natural wetlands that are located on the east side of the LMOC, which are believed to currently provide some level of treatment prior to entering Watchorn Creek and eventually Lake Manitoba. Operations #5, #6 and #7 are located between 1.5 and 3.9 km away from the LMOC respectively. The disruption to their existing drainage paths is minimal and some settling and natural filtration will likely occur in drainage ditches prior to entering the outside drain. It is believed there is less risk for pollution from these properties and MI's priority should be the high risk four (4) locations identified.

This report focuses on passive treatment options for cattle operations with the highest risk for pollution and runoff flowing south towards Lake Manitoba, i.e. Operation #1, #2, #3 and #4. Nutrient loading at the north end and south end of the outside drain should be confirmed as part of a long-term monitoring program following construction.

## 3.3 Existing Runoff Management Techniques

Management of onsite runoff is generally the responsibility of the land owner. Two (2) of the most common techniques implemented to reduce nutrient loading and contamination potential to nearby watercourses are:

- Vegetated buffer strips; and
- Bale grazing in pastures over winter (common at cattle operations).

Vegetated buffer strips have limited success during the spring melt for the following reasons:

- **Large volume of water** – spring melt often occurs quickly resulting in larger volumes of water compared to the summer precipitation events, for which buffer strips are typically designed;
- **Lower infiltration** – soil is still frozen during the spring melt, which significantly limits infiltration and natural filtering; and
- **Lower biological activity** – during the spring melt, plants and bacteria are mostly dormant and can contribute little to the reduction of nutrients and sediments in the melt water.

Bale grazing, the process of feeding cattle directly in the field over winter has gained popularity in recent years as it is thought to reduce nutrient runoff from the site during spring melt compared with overwintering cattle in pens. This in-field overwintering system was shown to increase retention and recycling of nutrients contained in feed because nutrients are applied directly to the field (as manure) instead of being lost in the pen. Unfortunately, this return of nutrients to the field during winter results in a buildup of nutrients in the upper layer of soil and results in elevated nutrient transport in runoff, especially during the spring snowmelt (Smith, 2011).

## 3.4 Passive Treatment Systems

Passive systems rely on biological and physical processes to treat collected runoff and have minimal (or sometimes none) power requirements. This study evaluated two (2) types of common passive treatment systems:

- Surface flow wetlands (both in-drain and point source); and
- Vertical flow passive filters.

### 3.4.1 Surface Flow Wetlands

Wetlands are defined as:

- A marsh, bog, fen, swamp or ponded shallow water, and
- Low areas of wet or water-logged soils that are periodically inundated by standing water and that are able to support aquatic vegetation and biological activities adapted to the wet environment in normal conditions.

A constructed wetland can be described as an "engineered" system that mimics nutrient cycling and biological processes that occur in natural wetlands to filter and remove nutrients, sediments and other pollutants from wastewater or impacted surface drainage. (Reedyk et al., 2017). However, many of the contaminants are captured in the bottom of the wetland and can be re-suspended if disturbed (such as during high rainfall events or construction activities). Wetland performance is also seasonally variable, with biological treatment (especially nitrification) effectively pausing over the winter, where the primary form of treatment comes from physical filtration.

These systems promote sediment deposition and settle other particulate matter out of impacted waters while plants and microorganisms create an environment that allows for transformation and utilization of nutrients. Constructed wetlands can also help increase biodiversity by providing habitat for insects, birds and other wildlife.

Subsurface and surface flow constructed wetlands have been found to be successful at reducing typical contaminants in agricultural, industrial and municipal wastewater, such as 5-day biochemical oxygen demand ($BOD_5$), total suspended solids (TSS), nutrients (phosphorus and nitrogen), coliforms and metals. These systems rely on naturally occurring energy from the sun and wind to aid in plant growth and provide oxygen for the aerobic processes carried out by microbial populations.

The effects of these wetlands vary based on the differences in climate, wastewater characteristics and wetland construction. Wetlands require a large land area, however little or no power is typically necessary at the site as the systems operate by gravity and retention time. In many instances, these constructed wetlands also enhance the existing landscape and create a naturalized area that can often be used as recreational space (walking paths), habitat for wildlife and promotes sustainable development within a community. Wetlands incorporate biomass uptake and adsorption principles to effectively reduce nutrient concentrations in the effluent. The primary maintenance task related to wetlands is harvesting overgrown plants and remove decaying matter/sediment buildup in order to prevent nutrients from re-entering treated water following storm events or biomass decay.

While wetlands cannot usually be accurately modelled similar to a mechanical treatment system, numerous studies have been completed to analyze the potential for wetlands to treat runoff from livestock operations. These include a study done by CH2M HILL from 1998 to 2000 in the Manitoba Interlake region, near the LMOC site. The three (3) year study was completed at two (2) wetlands, Site 1 near Riverton, Manitoba and Site 2 near Lake Manitoba Narrows. Site 1 is a wetland system with a 0.2 ha settling pond with a working volume of 1,500 $m^3$ and a 0.4 ha holding pond with a working volume of 3,200 $m^3$. The wetland is a single cell 0.5 ha system with an average depth of 0.3 m and a working volume of 1,500 $m^3$. Site 2 is a wetland system with a 0.25 ha holding pond and a working volume of approximately 3,300 $m^3$. The wetland consists of two 0.5 ha cells operating in parallel with an average depth of 0.3 m and a working volume of 3,000 $m^3$ (Pries, 2000).

- The average results from Site 1 recorded in 1998 and 2000, found a 70% reduction in $BOD_5$, 98% reduction in un-ionized ammonia, 55% reduction in TKN, 10% reduction in TP and a 71% reduction in TSS;
- TN was not tracked as part of the sampling program;
- The results from 1999 at Site 1 showed inconsistencies in effluent loading due to a dry year with little outflow from the wetland. During the 1999 operating year $BOD_5$ loading was shown to increase from inflow to outflow of the wetland;
- The average results from Site 2 recorded in 1999 and 2000 found a 77% reduction in $BOD_5$, 87% reduction in un-ionized ammonia, 45% reduction in TKN, 35% reduction in TP and a 64% reduction in TSS;
- On average, there was a lower reduction in the phosphorus concentration at Site 1 and Site 2 compared to removal efficiency of the other parameters; and
- The study recommended an upstream settling pond to reduce suspended solids, which are typically high in phosphorus and $BOD_5$, prior to entering the wetland.

### 3.4.2 Vertical Flow Passive Filter

A vertical flow passive filter can be used as a point source treatment system to reduce nutrients from wastewater effluent. A collection basin or a settling pond is required upstream of a filter to reduce suspended solids and to equalize flows to the filter. A settling pond is constructed down gradient from cattle feedlots to allow runoff to flow by gravity to the pond for settling and reduce loading to the filter.

A packed granular filter bed can be used downstream of a collection basin to reduce typical contaminants in agricultural, industrial and municipal effluents, such as $BOD_5$, TSS, nutrients and particulate metals. The filter is then planted with deep rooting native Manitoba grasses that are moisture and harvest tolerant. Typically the media bed consists of graded sand overtop a layer of granular media with an underdrain. The top of the sand is layered with a perforated pipe, with a layer of topsoil and native Manitoba grasses. The filter is intermittently dosed with wastewater that percolates downward in a single pass through the sand to the bottom of the filter. Effluent wastewater will collect in a perforated pipe at the base of the filter and flow by gravity to a discharge point such as a municipal drain or low lying area.

Dillon has designed passive filter systems in two (2) communities within the Interlake region: the Village of Dunnottar and Community of Fraserwood.

The Dunnottar passive filter is a two (2) cell passive filter, constructed as a tertiary treatment process at the back end of the lagoon to reduce nitrogen and phosphorus prior to discharge to the effluent ditch. Over six (6) years of operation, the filter has reduced TP by approximately 70%, TKN by 60%, $BOD_5$ by 60% and total coliforms by 80%.

The Fraserwood passive filter was constructed at a cattle operation located east of Fraserwood, Manitoba, with a 0.55 ha feedlot area. The feedlot area was graded to allow runoff to flow to a 1,000 $m^3$ collection basin where suspended solids are reduced prior to the passive filter. A lift station is located upstream of the filter where runoff from the cattle operation is pumped across a 150 $m^2$ filter area. The filter was constructed with a bed of recycled glass as a filter medium above a packed granular bed and perforated pipe. Water flows by gravity across the filter bed and out to a low lying area of the property. Performance data is not yet available for the pilot system.

# 4.0 Design Parameters

Acknowledging the variation in wetland/passive filter performance, along with the wide range of flow conditions related to the new drain, Dillon worked with the Hatch team (including Hatch and Stantec) and the project proponent (MI) to develop a basis of design. The conceptual design of the cattle pen runoff management system was based on three (3) main parameters:

1. Hydraulic loading;
2. Nutrient and organic loading; and
3. Treated runoff quality targets.

**Sections 4.1** to **4.3** will outline our approach to developing parameters 1-3 in further detail.

## 4.1 Hydraulic Loading

Stantec provided design information for the outside drain, under consideration in May 2021, including design flows and delineations of sub-watersheds. Design flows were estimated following established MI methodology for the Interlake region. Contributing sub-watersheds flowing south to Lake Manitoba include W150-west, W840-west, W610-west and W660-west and contributing sub-watersheds flowing north to Lake St. Martin include W550-west, W530-west, W510-west and W490-west. From Stantec's design, a one (1)-in-ten (10) year runoff event has been taken as the peak flow design. Average flows were determined using estimated monthly average flows specific to each sub-watershed, and using the month of April as the worst case average flow condition. The peak and average hydraulic loadings are shown in **Table 3**.

### Table 3: Hydraulic Loading to Outside Drain

| Contributing Sub-watershed | Flow Direction | Cumulative Area ($km^2$) | Cumulative Peak Flow ($m^3/s$) | Average Flow ($m^3/s$) |
|---|---|---|---|---|
| | | | *10% Design Flow* | *April Spring Melt (4% of Peak Flow to South, 7% of Peak Flow to North)* |
| W840A-west-S | South | 3.1 | 0.5 | 0.01 |
| W840-west | South | 23.9 | 3.0 | 0.10 |
| W150-west | South | 26.6 | 3.1 | 0.12 |
| **Total Flows to Lake Manitoba (South)** | | | **3.1** | **0.12**[1] |
| W840A-west-N | North | 2.0 | 0.4 | 0.01 |
| W610-west | North | 19.8 | 2.2 | 0.09 |
| W550-west | North | 23.3 | 2.4 | 0.10 |
| W530-west | North | 42.8 | 2.6 | 0.19 |
| W510-west | North | 43.9 | 2.7 | 0.19 |
| W490-west | North | 54.5 | 3.6 | 0.24 |
| W490A-west | North | 55.0 | 3.6 | 0.24 |
| **Total Flows to Lake St. Martin (North)** | | | **3.6** | **0.24**[2] |

**Notes:**

[1] Relationship between peak and average flows calculated as 4% of peak flows to the south (Lake Manitoba).

[2] Relationship between peak and average flow are calculated as 7% of peak flows to the north (Lake St. Martin).

The runoff flows from the cattle operations within the sub-watersheds contributing to the outside drain were estimated using the Rational Method, as referenced from the *Integration of Rational Method and Regional Flood Curve Design Discharges* (Harrison & Harden, Jan 1986).

$$Q_p = 0.0028CiA$$

Where $Q_p$ = peak flow in $m^3/s$

A = feed lot in Ha

i = rainfall intensity in mm/hr

C = runoff coefficient (factor that reflects the slope, soil and land use)

A runoff coefficient of 0.3 was used and is consistent with the preliminary design for local surface water management. The rainfall Intensity-Duration-Frequency (IDF) curve for Gimli, Manitoba was referenced to select a rainfall intensity of 9.5 mm/hr based on a 6 hour runoff event.

The feedlot areas were estimated from Google Earth imagery and validated based on the May 21, 2021 site investigation. The peak flow was estimated as a one (1) in-ten (10) year runoff event, while the average flow was calculated at 4% of the peak flows to the south (Lake Manitoba) and 7% of peak flows to the north (Lake St. Martin), based on the relationship developed by Stantec for April snow melt. The estimated hydraulic loadings from the cattle operations identified as being of higher risk for nutrient pollution are shown in **Table 4**.

**Table 4: Estimated Hydraulic Loading from Individual Cattle Operations**

| Cattle Operation | Contributing Sub-watershed | Flow Direction | Feedlot Area ($km^2$) | Peak Flow ($m^3/d$) | Average Flow ($m^3/d$) |
|---|---|---|---|---|---|
| | | | | *10% Design Flow, six (6) hour storm* | *April Spring Melt (4% of Peak Flow to South)* |
| Cattle Operation #1 | W150-west | South | 0.029 | 2,013 | 76 |
| Cattle Operation #2 | W150-west | South | 0.019 | 1,338 | 50 |
| Cattle Operation #3 | W150-west | South | 0.018 | 1,241 | 47 |
| Cattle Operation #4 | W840-west | South | 0.023 | 1,613 | 61 |

## 4.2 Nutrient and Organic Loading

Nutrient and organic loadings were estimated for cattle runoff and background concentrations using the following sources.

- Literature values of typical cattle feedlot runoff;
- Surface water sampling event, on May 21, 2021;
- Background nutrient and chemical loadings at Watchorn Creek from review of Stantec's LMOC 2020 Surface Water and Groundwater Monitoring Report; and
- Diluted runoff loadings based on the combination of Watchorn Creek background samples and literature values of typical cattle feedlot runoff.

Surface water samples were collected and used to compare in situ results against literature values of typical cattle runoff. The background nutrient and chemical loadings from Watchorn Creek were used in conjunction with the literature values of typical cattle runoff to complete a mass loading exercise to estimate diluted runoff loadings in the outside drain. The nutrient and organic loadings are described in **Sections 4.2.1** to **4.2.4**.

### 4.2.1 Literature Review of Typical Cattle Feedlot Runoff

Dillon completed a literature review to determine typical nutrient loading from cattle operation runoff. One (1) round of samples was also taken on May 21, 2021 in an effort to verify that literature values are representative of site conditions. The following table indicates the expected chemical and physical characteristics of the feedlot runoff. These values are based on literature reference, water quality results from Agriculture Canada's *Management of Runoff Wastewater from Confined Livestock Winter Feeding Sites: A review of treatment technologies* (Nylen and Reedyk, 2013). Nylen and Reedyk documented the chemical composition of wastewater over two (2) years in eleven (11) holding ponds designed for capturing runoff water from livestock feedlot sites. The study was not designed to assess the treatment performance of the ponds in reducing concentrations from runoff, but to characterize raw water quality to help inform secondary treatment options. The average values from the literature were used to design for the spring melt runoff (worst case) from the cattle pens.

**Table 5: Typical Cattle Pen Runoff Quality (Nylen and Reedyk, 2013)**

| Parameter | Typical Cattle Pen Runoff | | |
|---|---|---|---|
| | *Low (mg/L)* | *Average/Medium (mg/L)* | *High (mg/L)* |
| $BOD_5$ | 5 | 112 | 710 |
| Total Phosphorus (TP) | 0.1 | 10 | 56.4 |
| Total Kieldjal Nitrogen (TKN) | 0.4 | 50 | 244 |
| Ammonia – N ($NH_3$-N) | 0.05 | 17 | 88 |
| Total Suspended Solids (TSS) | 5 | 242 | 2,550 |

Spring melt runoff is expected to contain higher concentrations of contaminants than the summer-fall precipitation runoff. Over the winter manure is deposited in layers and trampled into the snow in the feedlot. This results in a large amount of particulate matter buildup which does not decompose due to the cold temperatures over the winter. During the melting period, this manure is washed away in a relatively short time, resulting in higher nutrient, organic and particulate mass loading in the spring melt runoff compared to runoff from discrete rain events during the spring-fall seasons.

### 4.2.2 Surface Water Sampling Event

Dillon collected surface water grab samples near five (5) cattle operations between Lake Manitoba and Lake St. Martin on May 21, 2021. The in situ samples were used in conjunction with available literature to support the notion that literature values are representative of site conditions. Samples were collected from roadside ditches downstream of existing livestock operations as shown on **Figure A1** and **A2** (appended). **Figure 1** below shows the turbidity of sample W7 taken in close proximity to the cattle feedlots at Operation #2.

Figure 1: W7 Surface Water Sample

The sampling results and associated cattle operations are summarized in **Table 6**.

**Table 6: Surface Water Sampling Results**

| Parameter | Surface Water Sampling Results | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *M2* | *M3* | *W7* | W1 | *MT4* | *B5* | *S6* |
| | *Units* | *Typical Loading* [1] | *Op #1* | *Op #1* | *Op #2* | *Op #2* | *Op #3* | *Op #4* | *Op #5* |
| pH | | - | 7.88 | 7.92 | - | 8.5 | 8.02 | 8.24 | 8.41 |
| Temperature | °C | - | 6.3 | 3.7 | - | 8.2 | 7.7 | 5.8 | 7.9 |
| Dissolved Oxygen | mg/L | - | 2.35 | 3.36 | - | 4.51 | 6.2 | 7.15 | 17.85 |
| Alkalinity | mg/L | - | 957 | 514 | 9,590 | 309 | 478 | 398 | 393 |
| $BOD_5$ | mg/L | 5-710 | 32.2 | 12.2 | <1,500[2] | 2.6 | 45 | 10.5 | 3.7 |
| Total Phosphorus (TP) | mg/L | 0.1-56.4 | 12.5 | 8.18 | 29.7 | 0.082 | 8.51 | 1.16 | 0.269 |
| Total Kieldjal Nitrogen (TKN) | mg/L | 0.4-244 | 43.9 | 18.6 | 380 | 1.77 | 16.8 | 4.3 | 4.33 |
| Ammonia – N | mg/L | 0.05-88 | 9.29 | 3.93 | 7.70 | 0.015 | 0.41 | 0.103 | 0.057 |
| Total Suspended Solids (TSS) | mg/L | 5-2,550 | 60.6 | 44.4 | 806 | 3.8 | 440 | 106 | 12.4 |
| Nitrate | mg/L | - | <0.40 | <0.20 | <0.40 | <0.020 | <0.040 | <0.040 | <0.020 |
| Nitrite | mg/L | - | <0.20 | <0.10 | <0.20 | <0.010 | <0.020 | <0.020 | <0.010 |

| Parameter | | | Surface Water Sampling Results | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | *M2* | *M3* | *W7* | W1 | *MT4* | *B5* | *S6* |
| | *Units* | *Typical Loading* [1] | *Op #1* | *Op #1* | *Op #2* | *Op #2* | *Op #3* | *Op #4* | *Op #5* |
| Total Nitrogen (TN) | mg/L | - | 43.9 | 18.6 | 380 | 1.77 | 16.8 | 4.3 | 4.33 |
| Fecal Coliforms | MPN/ 100 mL | - | 100 | 60 | - | 52 | 2140 | 30 | <10 |
| Chemical Oxygen Demand (COD) | mg/L | - | 1,180 | 588 | 1,260 | 60 | 590 | 138 | 169 |
| Sample Proximity to Cattle Feedlots | | | High | Med | High | Low | High | Med | Low |
| General Sample Strength | | | Med | Med | High | Low | Med | Low | Low |

**Notes:**

[1] Water quality results from Agriculture Canada's *Management of Runoff Wastewater from Confined Livestock Winter Feeding Sites: A review of treatment technologies* (Nylen and Reedyk, 2013).

[2] Laboratory made incorrect assumption for dilution of W7 sample based on turbidity of sample, leading to an increased detection limit.

As discussed previously, due to the nature and size of the project, baseline field data is difficult to collect and interpret without significant costs. The second from bottom row in **Table 6** provides a visual representation of sample proximity to cattle feedlots.

- Green (Low) – Ditch near cattle feedlots (low proximity >50 m);
- Yellow (Medium) – Ditch directly downstream of cattle feedlots (medium proximity 20 to 50 m); and
- Red (High) – Runoff directly from cattle feedlots (high proximity 0 to 20 m).

The general sample strength (bottom row) compares surface water sampling results to typical cattle runoff loadings summarized in **Table 5**. To simplify the ranking, the sample strength was only compared for TP and TKN.

- Green (Low) – TP 0.1-5.1 mg/L and TKN 0.4-25.2 mg/L;
- Yellow (Medium) – TP 5.1-33.2 mg/L and/or TKN 25.2 mg/L-147 mg/L; and
- Red (High) – TP 33.2-56.4 mg/L and/or TKN 147 mg/L-244 mg/L.



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**Figure 2** shows a comparison of $BOD_5$, TKN and field DO. There appears to be a strong connection between $BOD_5$/TKN and DO, specifically at the sample locations at the highest proximity to the cattle feedlots. M2, M3 and MT4 show that high loadings of $BOD_5$ and TKN result in a low DO loading. Sample S6 shows that a higher loading of DO results in a lower loading of $BOD_5$ and TKN. A higher oxygen demand should lead to lower DO and higher $BOD_5$/TKN, while a lower oxygen demand should lead to a higher $BOD_5$/TKN.

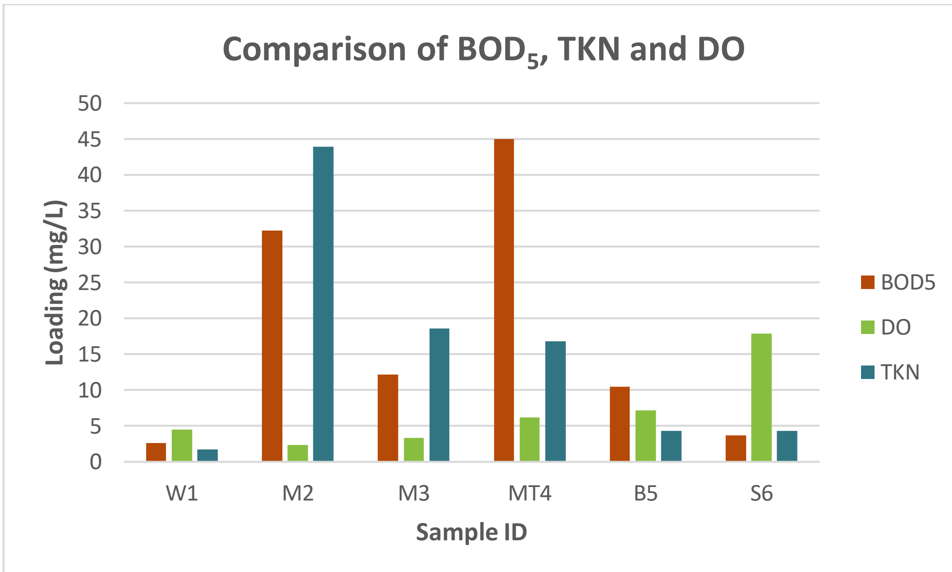


**Figure 2: Comparison of $BOD_5$, TKN and DO**

Study scheduling required that the sampling occur in late spring; conditions during May 2021 were unusually dry and may not be indicative of typical cattle operations runoff throughout the life of the project. The concentrations of most of all water samples taken were on the lower end of literature data, which may be due to these dry conditions or other factors. The average literature values, which are more conservative than the surface water sampling results, were therefore used to size and develop conceptual design options.

Water samples M2 and M3 were taken at Operation #1 and support the idea of treatment in the existing natural wetland. Sample M2 (high proximity) was taken on the north side of the access road, directly downstream of the cattle feedlots, while sample M3 (medium proximity) was taken from the natural wetland, south of the access road approximately 100 m southeast (downstream) of sample M2. Based on limited sampling, the following reductions were observed between the two (2) samples:

- BOD5 – 62%;
- TP – 35%;
- TKN – 58%;
- NH3-N – 58%; and
- TSS – 27%.

Onsite observations, lab data and literature demonstrate that the existing wetland provides some level of organic treatment between the cattle operation and Lake Manitoba. However, it cannot be overlooked that the sample size is quite small, and grab samples are not necessarily comprehensive of average conditions. The natural wetland is not isolated from other inputs, and external contaminant contributions were not investigated or considered when calculating percent reductions between samples M2 and M3.

#### *4.2.2.1* Particle Size Distribution (PSD)

Passive treatment performance is generally more favorable when contaminants are particulate or attached to suspended solids, as they settle more quickly and can be removed by natural clarification and filtration. PSD testing provides insight into the average particle size, generally anything larger than 1.5 µm is considered TSS, while anything lower is considered TDS. However, this varies slightly by lab.

Smaller particles in the range of 5 to 10 µm are difficult to remove using filters without chemical aids or physical modifications. Three (3) samples were analyzed for PSD south of Township Road at Operation #1 and #2. The results show that approximately 85 to 92% of sample particles were under 1 µm, suggesting that some contaminants may be difficult to remove and require a longer Hydraulic Retention Time (HRT). Similar to previous samples, these PSD tests were taken during a dry period after a long duration without rainfall or runoff. Larger solids may have settled and therefore may not have been disturbed by the rainfall event and may not have presented during our tests.

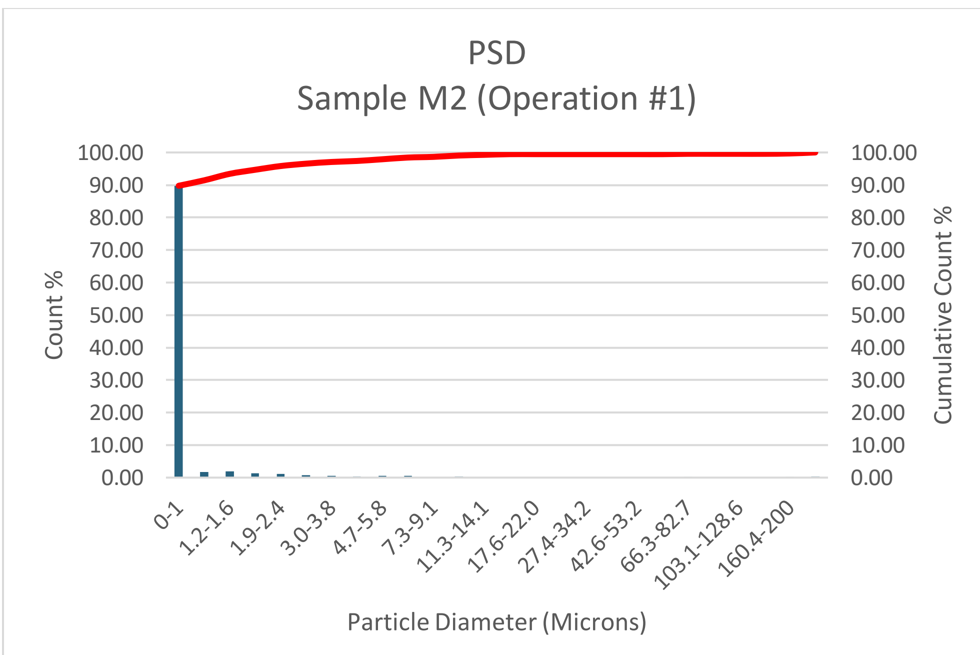


**Figure 3: PSD - Sample M2 (Operation #1)**

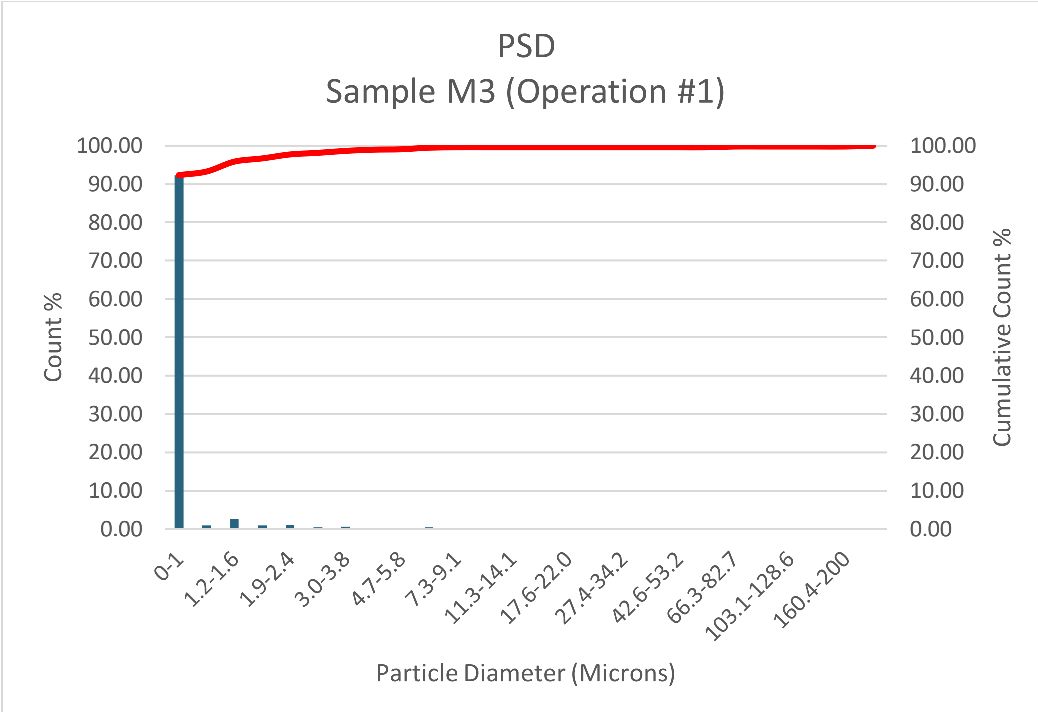


**Figure 4: PSD - Sample M3 (Operation #1)**

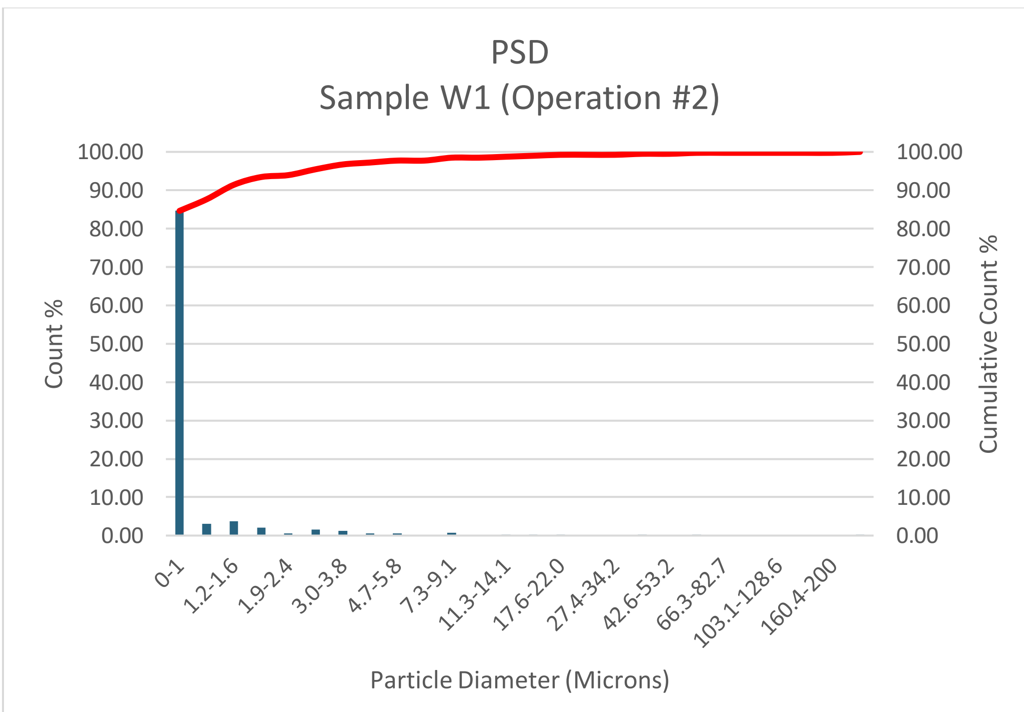


**Figure 5: PSD - Sample W1 (Operation #2)**

The samples taken at Operation #1 (M2 and M3) show PSD at 90% <1µm. To supplement this data, further samples should be taken going forward, specifically after spring freshet or a rainfall to determine if any larger particle distributions are found in runoff.

### 4.2.3 Background Nutrient and Chemical Loadings

Dillon used baseline water quality data from Watchorn Creek as background nutrient and chemical loading for comparison to the cattle runoff literature values. The baseline data was collected by Stantec and summarized in the *LMOC 2020 Surface Water and Groundwater Monitoring Report.* Dillon took one (1) additional sample from Watchorn Creek during the May 21, 2021 site visit to supplement background values referenced in the report. The background nutrient and chemical loading from Watchorn Creek is summarized in **Table 7.**

**Table 7: Background Nutrient and Chemical Loadings from Watchorn Creek**

| Parameter | Background Loadings from Watchorn Creek | | | |
|---|---|---|---|---|
| | *Low (mg/L)* | *Average (mg/L)* | *High (mg/L)* | *May 21, 2021 (mg/L)* |
| $BOD_5$ | 8[1] | - | 10[1] | <2.0 |
| Total Phosphorus (TP) | 0.03 | 0.12 | 0.19 | 0.06 |
| Total Kjeldahl Nitrogen (TKN)[2] | 1.14 | 1.81 | 2.85 | 1.35 |
| Ammonia – N ($NH_3$-N) | 0 | 0.04 | 0.09 | 0.035 |
| Total Suspended Solids (TSS) | 0 | 9.73 | 36.9 | - |

**Notes:**
[1]$BOD_5$ loadings are referenced from Metcalf and Eddy Wastewater Engineering 5th Edition, Table 3-12, Page 225, Typical $BOD_5$ loading for stormwater runoff, as this parameter was not collected during the 2020 monitoring program.
[2]TN loadings are assumed to be close or equal to TKN for the purposes of this study, as Nitrate and Nitrite are undetectable in surface water samples from Watchorn Creek.

### 4.2.4 Diluted Runoff Calculations

In consideration of an in-drain treatment option for the outside drain, Dillon considered the runoff from the drainage area running south towards Lake Manitoba, including three (3) sub-watersheds, W150-west, W840-west and W840A-west-S. There are four (4) cattle operations identified in the sub-watersheds flowing south in the outside drain, with the highest risk for pollution. Operation #5, located in sub-watershed W840-west, has not been included in the analysis because there is a lower risk for pollution.

- W150-west – Operations #1, #2, #3; and
- W840-west – Operation #4.

Dilution calculations were completed to estimate the concentration of nutrient and chemical loadings from cattle runoff entering the outside drain and eventually Lake Manitoba. The calculations include the following assumptions:

- Based on annual April average flows or 4% of peak design flow from sub-watersheds and cattle feedlots;
- No consideration for settling or filtering of cattle runoff prior to entering outside drain;
- Background nutrient and chemical loadings resemble measurements from Watchorn Creek;
- All sheet runoff from sub-watersheds will drain to the outside drain; and
- No existing onsite treatment systems at the five (5) cattle operations including Vegetated Filter Strips (VFS) or settling ponds.

The diluted nutrient and chemical loadings are summarized in **Table 8**.

**Table 8: Diluted Loadings in Outside Drain at Lake Manitoba**

| Parameter | Diluted Loadings at Lake Manitoba | | |
|---|---|---|---|
| | *Low (mg/L)* | *Average (mg/L)* | *High (mg/L)* |
| $BOD_5$ | 9.85 | 13.03 | 30.79 |
| Total Phosphorus (TP) | 0.12 | 0.41 | 1.79 |
| Total Kieldjahl Nitrogen (TKN)[1] | 1.77 | 3.24 | 9.01 |
| Ammonia – N ($NH_3$-N) | 0.04 | 0.54 | 2.65 |
| Total Suspended Solids (TSS) | 9.58 | 16.63 | 85.19 |

[1]TN loadings are assumed to be close or equal to TKN, as Nitrate and Nitrite are undetectable in surface water samples from Watchorn Creek.

Based on theoretical dilution calculations, it is estimated that low-average loading concentrations presented in **Table 8** may be below Manitoba Water Quality Tier I quality guideline values, summarized in **Table 9**, prior to reaching Lake Manitoba. These values are theoretical in nature and should be confirmed once the channel and outside drain are constructed. If an in-drain wetland is constructed, wetland influent and effluent surface water sampling should be completed and included in the surface water management and aquatics effects monitoring plans.

## 4.3 Effluent Limits

### 4.3.1 Guidelines/Code Review

A review of Manitoba Climate and Conservation (MCC) and federal regulations was completed for effluent discharge limits, as specific effluent limits for agricultural runoff are not set in Manitoba. A review of the *Canadian Water Quality Guidelines for Freshwater Aquatic Life (CWQG-FAL)* and *Manitoba*

*Water Quality Standards, Objectives and Guidelines (MSOG)* was undertaken to help in identifying applicable water quality targets. The MSOG classify water quality targets in terms of tiers:

- Tier I Water Quality Standards (MSOG-Tier I) – Follow current and existing provincial and federal legislation and regulations which form a legal basis for controlling pollutants entering Manitoba waters from a variety of sources. Typically defined for wastewater discharge;
- Tier II Water Quality Objectives (MSOG-Tier II) – Provide additional restrictions to protect surface and ground water uses (e.g., protection of aquatic life) for a limited number of common pollutants in Manitoba that are routinely controlled through the licensing process under The Manitoba Environment Act where protection is required beyond the Tier I Standards. Defined for a limited number of common pollutants in Manitoba. Typically defined to protect important uses of ground or surface water beyond those defined under Tier I; and
- Tier III Water Quality Guidelines (MSOG-Tier III) – Provide science-based numeric limits or narrative statements for chemical constituents (e.g., trace elements, pesticides) and water quality conditions (e.g., pH, temperature) aimed to protect various water uses including:
    - Source of drinking water;
    - Recreation;
    - Fish and other aquatic life;
    - Sediment quality;
    - Agriculture (e.g., irrigation and livestock watering); and
    - Human and wildlife consumption of tissue residues.

The effluent quality targets for treated effluent from wastewater lagoons (MSOG-Tier 1 quality standards) was used for the runoff management treatment system as a conservative limit given the lack of applicable guidelines. Treated runoff quality targets may need to be adjusted in the future depending on further research and updates to agricultural runoff guidelines.

The MSOG-Tier III effluent quality limits indicate “total phosphorus should not exceed 0.025 mg/L in any reservoir, lake or pond, or in a tributary at the point where it enters such bodies of water unless it can be demonstrated that total phosphorus is not a limiting factor, considering the morphological, physical, chemical or other characteristics of the water body”. There were eight (8) background samples taken from Watchhorn Creek between 2019 and 2020 collected by Stantec and summarized in the *LMOC 2020 Surface Water and Groundwater Monitoring Report.* All samples indicate TP concentrations above 0.025 mg/L. A case could be made that the treatment system demonstrates a “nutrient reduction strategy”, since the background TP concentration is above the limit of 0.025 mg/L.

### 4.3.2 Treated Runoff Quality Targets

The federal and provincial guidelines limits (CWQG-FAL and MSOG-Tier I-III) are summarized in **Table 9**.

**Table 9: Effluent Quality Limits**

| Parameter | CWQG-FAL (mg/L) | MSOG-Tier I (mg/L) | MSOG-Tier II (mg/L) | MSOG-Tier III (mg/L) |
|---|---|---|---|---|
| $BOD_5$ | n/a | 25 | n/a | n/a |
| Total Phosphorus (TP) | n/a | 1[A] | n/a | 0.025[B] |
| Total Kjeldahl Nitrogen (TKN) | n/a | n/a | n/a | n/a |
| Unionized Ammonia | varies[C] | 1.25 | n/a | n/a |
| Total Ammonia – N | n/a | n/a | varies[D] | n/a |
| Total Nitrogen (TN) | n/a | 15[E] | n/a | n/a |
| Total Suspended Solids (TSS) | n/a | 25 | n/a | n/a |
| Fecal Coliforms (MPN/100 mL) | n/a | 200 | n/a | n/a |

**Notes:**

[A] Or a demonstrated nutrient reduction strategy for systems discharging less than 820 kg total phosphorus per year, or less than 2,000 people equivalents (P.E.).

[B] MSOG Tier III - Total phosphorus should not exceed 0.025 mg/L in a reservoir, lake or pond, or in a tributary at the point where it enters such bodies of water.

[C] Unionized ammonia limits shall not exceed a site specific limit derived from CWQG-FAL, calculated based on pH and temperature.

[D] Total ammonia limits shall not exceed a site specific limit derived from the MSOG-Tier II, calculated based on pH and temperature.

[E] For systems releasing more than 33,000 kg of total nitrogen per year, or less than 10,000 P.E.

Based on preliminary calculations, the system will likely discharge less than 820 kg TP per year and it is assumed that a demonstrated reduction of phosphorus in the effluent would be acceptable and that the total nitrogen limit would not be applied (notes A and E in the above table). However, one of the main objectives of the runoff management system is to reduce nutrient discharge from the site and ultimately reduce downstream mass loading, so these effluent limits will serve as quality targets for the design. Therefore, the treated runoff quality targets have been taken to be the Tier 1 effluent quality limits as shown in **Table 9**.

The ammonia limits are governed by MSOG-Tier II. Ammonia limits are defined by specific equations that are pH and temperature dependent (note D in table above). There are six (6) equations for total ammonia quality discharged to a *Cool Water Aquatic Life and Wildlife Surface Water* based on varying exposure, duration and river design flow. Equation 1 for chronic exposure produces the most stringent ammonia concentration objectives. Equation 1 is based on a river 30Q10 hydrologically based design flow, where 30Q10 is the lowest thirty (30) day average flow that occurs (on average) once every ten (10) years. Dillon reviewed seven (7) background surface water samples from Watchorn Creek for pH and temperature to determine the total ammonia limits. These limits are summarized in **Table 10**.

**Table 10: Tier II MSOG-FAL Total Ammonia Limits**

| Parameter | June 2019 | Aug 2019 | Oct 2019 | May 2020 | July 2020 | Oct 2020 | May 2021 | Average |
|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) |
| pH | 8.54 | 8.67 | 7.75 | 7.69 | 7.08 | 7.85 | 8.24 | - |
| Temperature | 20.6 | 14.6 | 9.2 | 6.9 | 22.2 | 11.2 | 7.2 | - |
| Ammonia – N | 0.63 | 0.75 | 3.18 | 3.58 | 3.50 | 2.78 | 1.52 | 2.28 |

# 5.0 Conceptual Design Options

## 5.1 Alternative 1 – In-Drain Wetland

### 5.1.1 Description of System

An in-drain surface flow wetland can be used as a passive treatment option for cattle operation runoff into the outside drain. The wetland would be constructed directly in the outside drain, and would receive all upstream flow from Carne Ridge Road (new PR 239) to Lake Manitoba, including sub-watersheds W150-west, W840-west and W840A-west-S. The wetland would be sized to treat diluted cattle runoff flow from four (4) cattle operations: Operations #1-4.

### 5.1.2 Typical Operation and Maintenance (O&M) Requirements

Typical O&M requirements for an in-drain wetland include the following:

- Wetland plant harvesting;
- Solids removal;
- Inspection and repair of embankments and structures for burrowing animals such as muskrats;
- Setting of water depth control structures;
- Vector control;
- Cleaning and maintenance of inlet and outlet structures; and
- Operating range of water levels, including acceptable ranges of fluctuation.

Wetland channels and control structures require routine inspection and semi-regular maintenance, primarily related to ensuring unobstructed flow through the plant area. It is common in constructed wetlands for the Owner to cull or harvest a certain area of plants every 1-3 years to ensure that the channel does not become blocked with plant material or other debris. When completing these harvests, care must be taken as to not disturb the adjacent sediment into the receiving water.

### 5.1.3 Wetland Depth

Based on typical design parameters for surface flow wetlands, a depth of 0.1 m to 0.6 m is recommended for optimum wetland treatment performance. Under peak flows and high water levels the wetland would be almost fully submerged and likely not perform to treatment design goals (Alberta Environment, 2000). The outside drain water depth decreases as the wetland extends north towards new PR 239. Operating water levels extending north from Lake Manitoba should be confirmed once design of the outside drain is complete, as there is risk that wetland vegetation may not thrive or survive if water depth in the drain drops below 0.1 m.

### 5.1.4 Vegetation

Dillon completed a review of the current revegetation design, to gain a better understanding of the existing and suggested vegetation specific to the outside drain. Vegetation observed throughout existing wetlands in the surrounding area, including ditches and streams, was dominated by shallow graminoid marsh communities and consisted of:

- Narrowleaf cattail (*Typha angustifolia*);
- Woolgrass (*Scirpus cyperoides*);
- Canada bluejoint (*Calamagrostis canadensis*);
- Tussock sedge (*Carex stricta*); and
- Hardstem bulrush (*Shoenoplectus acutus*).

A grassland prescription consisting of a native and agronomic seed mix was suggested to revegetate the above-water portions of the outside drain, while a mix of grasses and wet tolerant species were suggested for the periodically flooded portions of the outside drain.

Based upon the existing and suggested vegetative species, and in accordance with the *Management of Runoff Wastewater from Confined Livestock Winter Feeding Sites* (Reedyk et al., 2017), bulrushes (Scirpus spp. or Shoenoplectus spp.), cattails (Typha spp.) and reeds (Phragmites spp.) would be recommended as the dominant vegetation for a constructed surface flow wetland. Such vegetation will help to facilitate nutrient reduction, filter solids and provide a substrate for the growth of microorganisms to further encourage natural treatment processes. Specific species are subject to detailed design and should be selected in accordance with applicable legislation and guidelines relevant to invasive plant species in Manitoba, such as Manitoba's *Noxious Weeds Act*.

### 5.1.5 Hydraulic Retention Time

Level to slightly sloping, uniform topography is preferred for wetland sites because free water systems are generally designed with level basins or channels, and plant roots generally must stay submerged year round (Environment Canada, 2006). A bottom slope of less than 0.1% is recommended and a flat side-to-side bottom to promote sheet flow through the system. Based on Stantec's May 2021 design, the outside drain between Carne Ridge Road and Lake Manitoba will have a bottom slope less than or equal to 0.1%.

As referenced from the document *Guidelines for the Approval and Design of Natural and Constructed Wetlands for Water Quality Improvement* (Alberta Environment, 2000), the recommended minimum HRT for various types of wetlands is as follows:

- Surface flow wetlands – seven (7) to ten (10) days;
- Sub-surface flow wetlands – two (2) to four (4) days; and
- Natural wetlands – fourteen (14) to twenty (20) days.

The nominal HRT is defined as the ratio of useable wetland water volume to the average flow rate ($Q_{ave}$). The theoretical HRT can be calculated as:

$$HRT = (Vw)(\epsilon)/(Qave)$$

Where: $Q_{ave}$ = Average Flow Rate (m3/d);
$V_w$ = A x D = Volume ($m^3$);
A = Wetland Area ($m^2$);
D = Wetland Depth (m) (typically 0.1 to 0.6 m); and
ε = Porosity (average wetland porosity values are usually greater than 0.95, and a value of 1.0 can be used as a good approximation).

The above formula can be adjusted to solve for wetland depth (D) based on a minimum HRT of seven (7) days. To maintain an HRT of seven (7) days, the conceptual wetland depth will require a depth of 0.3 m. A porosity of 1.0 has been assumed for the calculation of HRT based on April spring melt (average flows).

### 5.1.6 Conceptual Sizing of System

As discussed in **Section 4.2.4**, theoretical dilution calculations for nutrient and chemical concentrations to the outside drain are shown to not exceed MSOG Tier I values before reaching Lake Manitoba. Conversations with MCC should confirm whether an in-drain wetland design would be required to meet MSOG Tier III for TP concentrations. These values are theoretical in nature and should be confirmed once the channel and outside drain are constructed. While the diluted runoff concentrations (TP, TKN and $NH_3$-N) are shown to be below MSOG Tier I and II values, the overall nutrient loadings to Lake Manitoba may still be above acceptable guideline values. It is therefore expected that the regulator will require a nutrient reduction strategy for this alternative to mitigate cattle impacted runoff to Lake Manitoba.

The in-drain wetland conceptual sizing is based on an average flow condition (annual April flows) and a 25% target reduction in influent nutrient concentration. Background water quality samples were analyzed from Watchorn Creek and initially identified as the target effluent limits. It was noted that designing to meet these targets would increase the in-drain wetland footprint substantially. The 25% reduction in influent nutrient concentration was identified as a practical wetland sizing target, and results in a demonstrated nutrient reduction strategy. The system is sized based on the average loading concentrations from referenced literature data.

As no Manitoba guideline exists, the document *Guidelines for the Approval and Design of Natural and Constructed Wetlands for Water Quality Improvement* (Alberta Environment, 2000) was used as a reference to determine conceptual sizing of the wetlands. This document provides preliminary guidance for the design process of treatment wetlands. The model is based upon a simple k-C* first order biokinetic model, which utilizes areal rate constants and contaminant loading rates to estimate the land area required by the wetland to meet desired effluent objectives. The required wetland area is calculated based on the following equation:

$$A = \left|\frac{0.0365\ x\ Q}{k}\right|\ x \ln\frac{Ci - C*}{Ce - C*}$$

Where: Q = Design Flow ($m^3$/d);
$C_i$ = Influent Concentration (mg/L);
$C_e$ = Target Effluent Concentration (mg/L);
C* = Wetland Background Limit (mg/L); and
k = Areal Rate Constant @ 20°C (m/year).

When used in treatment performance modelling, areal rate constants describe the rate at which contaminants are attenuated throughout the wetland treatment area. The areal rate constants for each water constituent of concern, provided within the model template, were compared to reported values for similar systems. The rates provided were deemed acceptable for the preliminary sizing as they appeared consistent with those suggested by Kadlec and Knight (1996) and were similar to those utilized for sizing other livestock wastewater treatment wetlands (Knight et al., 1999). It should be noted that treatment rates for many wastewater parameters are temperature dependant, and were maintained at 20°C in the preliminary sizing calculations. During the lower temperature winter month's biological activity (especially nitrification) essentially pause, and the primary mechanism of removal is through solids attenuation.

While the model does not account for HRT or water depth within the wetland, the guidelines specify an active treatment depth of 0.1 to 0.6 m and a HRT of seven (7) to ten (10) days for constructed surface flows wetlands. Once the preliminary sizing was complete, an approximate water depth was calculated based upon the preliminary wetland area, the design (runoff) flow, a minimum suggested HRT of seven (7) to ten (10) days, and assuming saturation of the surface layer (i.e. a porosity of 1). The calculated water depth was then compared to the range suggested by Alberta Environment (2000) to ensure that the wetland area was feasible based upon both the suggested design considerations (HRT and depth).

The treatment parameters for the in-drain wetland alternative are detailed in **Table 11**.

### Table 11: Treatment Parameters for In-Drain Wetland

| | TSS | $BOD_5$ | TP | $NH_3$-N |
|---|---|---|---|---|
| | *(mg/L)* | *(mg/L)* | *(mg/L)* | *(mg/L)* |
| Influent Concentration | 16.6 | 13.0 | 0.41 | 0.54 |
| Target Effluent Concentration (25% Reduction) | 12.5 | 9.8 | 0.31 | 0.40 |
| Background Concentration (from Watchorn Creek) | 9.7 | 2.0 | 0.12 | 0.04 |
| Areal rate constant at 20°C (m/yr) | 1000 | 34 | 12 | 18 |

A sensitivity analysis was completed to analyze wetland footprint requirements at 25%, 50%, 75% and 100% of average flow. The required land area is calculated for each parameter (TSS, $BOD_5$, TP and $NH_3$-N), the maximum land area is the governing case and was taken as the selected wetland area. It is important to note phosphorus removal in a wetland system is not a simple process and can be inconsistent. It does not degrade like BOD and nitrogen, but rather must be sequestered in the wetland. A variety of mechanisms contribute to the phosphorus removal in wetland treatment systems: sedimentation, adsorption, consumption, and burial. Long term phosphorus removal is achieved through accretion and burial within sediments. Due to the complexity for phosphorus removal, a 30% safety factor has been applied to the sizing of wetland footprints. These area calculations are detailed in **Table 12**.

### Table 12: Wetland Areas for In-Drain Wetland

| | Flow | TSS | | $BOD_5$ | | TP[2] | | $NH_3$-N | | Max Area | Max Wetland Length[1] | HRT | Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *$m^3/d$* | *Ha* | *km* | *Ha* | *km* | *Ha* | *km* | *Ha* | *km* | *Ha* | *km* | *days* | *m* |
| 100% of Average Flow | 10,083 | 0.4 | 0.3 | 5 | 3 | 21 | 14 | 8 | 6 | 21 | 14 | 7 | 0.33 |
| 75% of Average Flow | 7,562 | 0.3 | 0.2 | 4 | 2 | 16 | 11 | 6 | 4 | 16 | 11 | 7 | 0.33 |
| 50% of Average Flow | 5,041 | 0.2 | 0.1 | 2 | 2 | 11 | 7 | 4 | 3 | 11 | 7 | 7 | 0.33 |
| 25% of Average Flow | 2,521 | 0.1 | 0.1 | 1 | 1 | 5 | 4 | 2 | 1 | 5 | 4 | 7 | 0.33 |

**Notes:**

[1] Max wetland length calculated based on a drain width of 15 m based on Stantec's design from May 2021.

[2] Governing case for sizing wetland is TP removal.

At 100% of average flow, the wetland would need to occupy approximately 14 km of the outside drain, which is greater than the length available, assuming a drain bottom width of 15 m, extending north from Lake Manitoba. In addition to this, operating water levels in a portion of the outside drain north of Township Road, will be below 0.1 m and thus there is risk that some of the wetland vegetation may not thrive or survive, thereby negating its ability to effectively treat runoff. Furthermore, there is additional risk that cattle operations located south and directly north of Township Road could short circuit or circumvent the treatment area during instances of high flows (i.e. spring freshet). A smaller treatment area, sized to accept 25% to 75% of average flow is still believed to provide some level of treatment before cattle feedlot runoff reaches Lake Manitoba. It is unclear how effective this wetland treatment area would be at treating runoff from properties south and immediately north of Township Road. The TP loading is the limiting parameter, and requires a wetland with over twice the footprint of the other parameters (TSS, $BOD_5$, $NH_3$-N) to meet a 25% reduction in influent loading.

Based on Stantec's May 2021 outside drain design, the wetland depth of 0.33 m will not be consistently met to achieve an HRT of 7 days. At a low water level in Lake Manitoba, the water level in the outside drain is approximately 0.1-0.5 m over the first 4 km of the drain. At a high water level in Lake Manitoba, the water level in the outside drain is approximately 0.15-1.1 m over the first 10 km of the drain. The HRT of the wetland will fluctuate based on Lake Manitoba water levels and will likely not consistently perform to treatment design goals.

### 5.1.7 Hydraulic Performance Implications

In-drain vegetation has the potential to significantly impact the hydraulic performance of the outside drain. While vegetation such as bulrushes, cattails and reeds are ideal for treatment of runoff, they can disrupt runoff flows by growing in excess density within the drain. As such, regular harvesting of plants will likely be needed to reduce impacts to hydraulics.

In addition, harvesting of wetland vegetation that is obstructing or blocking flow will temporarily reduce the treatment capabilities of the system. Therefore, harvesting would be recommended to occur annually during dry weather periods, in the weeks/months following spring freshet, where the highest cattle runoff loading would be expected. Harvested material would need to be disposed of in a location away from the outside drain, such as a landfill, to ensure nutrients do not re-enter the water system.

The impact of the wetland vegetation on outside drain hydraulics, the operation and maintenance requirements to alleviate this, and the associated temporary reduction in treatment capability that conflicts with the intended purpose of the in-drain wetland, make this alternative a less feasible/practical solution to capturing nutrient runoff from cattle operations.

## 5.2 Alternative 2 – Point Source Wetlands

### 5.2.1 Description of System

A surface flow wetland treatment system could be used as a point source treatment system on each of the cattle operations near the outside drain. The wetlands would be sized for each individual operation and would receive flow directly from the cattle feedlots. This option would require site grading of the feedlot area and collection ditches, and likely acquisition of private property or maintenance contracts with the land owner.

### 5.2.2 Typical Operation and Maintenance (O&M) Requirements

Typical O&M requirements for a wetland include the following:

- Wetland plant harvesting;
- Solids accumulation/removal;
- Inspection and repair of embankments and structures for burrowing animals such as muskrats;
- Setting of water depth control structures;
- Cleaning and maintenance of inlet and outlet structures; and
- Operating range of water levels, including acceptable ranges of fluctuation.

### 5.2.3 Site Grading and Collection Ditches

The feedlots and surrounding area would be graded to direct drainage from the feedlots to the wetland via collection ditches at each cattle operation. These ditches would surround the feedlot area and direct runoff to the wetland facility.

### 5.2.4 Collection Basin

Dillon strongly recommends construction of a collection basin upstream of the treatment wetland, although depending on the specific site design one may not be required. The collection basin would allow for initial removal of settleable contaminants, such as those leading to increased levels of phosphorus and $BOD_5$ within the contaminated runoff. It would also provide storage where the contaminated storm water can accumulate during the winter months before it is discharged at a controlled rate to the wetland for maximum removal efficiency.

The approach for this conceptual design is to provide a treatment option with minimal operational requirements and to mimic existing natural wetland processes. The collection basin would provide an additional level of complexity since a submersible pump may be required to discharge effluent to the wetland, depending on final topography. The use of a collection basin would require cooperation from the landowner to assist in operation and maintenance of the system. To provide the smallest footprint and reduce operational requirements, the collection basin has not been included as part of conceptual design Alternative 2.

### 5.2.5 Wetland Depth

As referenced from the document *Guidelines for the Approval and Design of Natural and Constructed Wetlands for Water Quality Improvement* (Alberta Environment, 2000), based on typical design parameters for surface flow wetlands, a depth of 0.1 m to 0.6 m is recommended for optimum wetland treatment performance.

### 5.2.6 Vegetation

Further to discussion for Alternative 1 and the in-drain wetland, a similar recommendation is made for the vegetation in Alternative 2. Vegetative species, bulrushes (*Scirpus spp. or Shoenoplectus spp.*), cattails (*Typha spp.)* and reeds (*Phragmites spp.)* would be recommended as the dominant vegetation for a constructed surface flow wetland. Such vegetation will help to reduce nutrients, filter solids and provide a substrate for the growth of microorganisms to further encourage natural treatment processes. Specific species should be selected in accordance with applicable legislation and guidelines relevant to invasive plant species in Manitoba, such as Manitoba's *Noxious Weeds Act* (Reedy, 2017).

### 5.2.7 Hydraulic Retention Time

As discussed in detail in **Section 5.1.5**. The recommended minimum HRT for various types of wetlands is as follows:

- Surface flow wetlands – seven (7) to ten (10) days;
- Sub-surface flow wetlands – two (2) to four (4) days; and
- Natural wetlands – fourteen (14) to twenty (20) days.

The nominal HRT is defined as the ratio of useable wetland water volume to the average flow rate ($Q_{ave}$). The theoretical HRT can be calculated as:

$$HRT = (Vw)(\epsilon)/(Qave)$$

Where: $Q_{ave}$ = Average Flow Rate ($m^3$/d);
$V_w$ = A x D = Volume ($m^3$);
A = Wetland Area ($m^2$);
D = Wetland Depth (m) (typically 0.1 to 0.6 m); and
ε = Porosity (average wetland porosity values are usually greater than 0.95, and a value of 1.0 can be used as a good approximation).

The theoretical HRT formula can be adjusted to solve for wetland depth (D) based on an HRT of ten (10) days. To maintain an HRT of ten (10) days, the conceptual wetland depth will require a depth of 0.1 m. A porosity of 1.0 has been assumed for the calculation of HRT based on April spring melt (average flows).

### 5.2.8 Conceptual Sizing of System

As discussed in detail in **Section 5.1.6**, the Alberta Environment document, *Guidelines for the Approval and Design of Natural and Constructed Wetlands for Water Quality Improvement*, was used as a reference to determine preliminary sizing of the wetlands (Alberta Environment, 2000). As no Manitoba guideline exists, the document was used as a reference to determine conceptual sizing of the wetlands. The required wetland area is calculated based on the following equation:

$$A = \left|\frac{0.0365\ x\ Q}{k}\right|\ x \ln\frac{Ci - C*}{Ce - C*}$$

Where:
Q = Design Flow ($m^3/d$);
$C_i$ = Influent Concentration (mg/L);
$C_e$ = Target Effluent Concentration (mg/L);
C* = Wetland Background Limit (mg/L); and
k = Areal Rate Constant @ 20°C (m/year).

The wetland systems are sized for each individual cattle operation to meet Manitoba Tier 1 Water Quality target effluent concentrations. The treatment parameters for the point source wetland alternative are detailed in **Table 13**.

**Table 13: Treatment Parameters for Point Source Wetland**

| | TSS (mg/L) | $BOD_5$ (mg/L) | TP (mg/L) | $NH_3$-N (mg/L) |
|---|---|---|---|---|
| Influent Concentration | 242 | 112 | 10 | 17 |
| Target Effluent Concentration | 25 | 25 | 1 | 1.25 |
| Background Concentration (from Watchorn Creek) | 9.7 | 2.0 | 0.12 | 0.04 |
| Areal rate constant at 20°C (m/yr) | 1,000 | 34 | 12 | 18 |

The required land area is calculated for each parameter (TSS, $BOD_5$, TP and $NH_3$-N), and the maximum land area is the governing case and was taken as the selected wetland area. It is important to note phosphorus removal in a wetland system is not a simple process and can be inconsistent. Due to the complexity for phosphorus removal, a 30% safety factor has been applied to the sizing of wetland footprints. The area calculations are detailed in **Table 14**.

**Table 14: Wetland Areas for Point Source Wetlands**

| | Flow | TSS | $BOD_5$ | TP | $NH_3$-N | Max Area | HRT | Depth |
|---|---|---|---|---|---|---|---|---|
| | $m^3/d$ | Ha | Ha | Ha | Ha | Ha | days | m |
| Operation #1 | 76 | 0.01 | 0.17 | 0.89 | 0.53 | 0.89 | 10 | 0.1 |
| Operation #2 | 50 | 0.01 | 0.11 | 0.59 | 0.35 | 0.59 | 10 | 0.1 |
| Operation #3 | 47 | 0.01 | 0.10 | 0.55 | 0.32 | 0.55 | 10 | 0.1 |
| Operation #4 | 61 | 0.01 | 0.13 | 0.71 | 0.42 | 0.71 | 10 | 0.1 |

As discussed in **Section 3.2**, it is likely that only four (4) properties (Operations #1, #2, #3 and #4) will have a direct outlet to the proposed outside drain. From review of Google Earth imagery and the LMOC alignment, it appears that an existing natural wetland may exist between the Operation #1 and #2 and the outside drain as shown in **Figure 6**. The existing wetlands could be utilized as a wetland treatment system to reduce runoff to the outside drain at these two (2) properties. It is understood from the meeting with the LMOC project team on June 10, 2021, that an additional triangle of land (approximately 3.4 Ha) has been acquired by MI between Operation #1 and the LMOC. This land could also be utilized as a location for a point source wetland system.

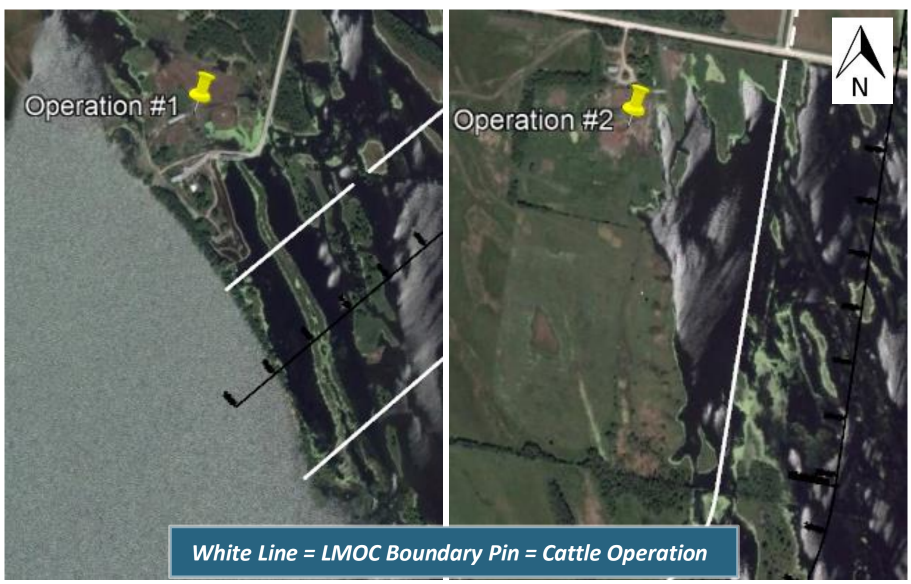


**Figure 6: Operation #1 and #2**

## 5.3 Alternative 3 – Point Source Collection Basin and Passive Filter

### 5.3.1 Description of System

A collection basin and vertical passive filter can be used as point source treatment option at each cattle operation near the outside drain. A passive filter treatment system will be sized for each individual cattle operation and will receive flow solely from the cattle feedlots. This option will require site grading of the feedlot area, collection ditches and collection basin with a controllable discharge point. Water from the collection basin would then be discharged to a vertical passive filter using a pump.

### 5.3.2 Typical Operation and Maintenance (O&M) Requirements

Typical O&M requirements for a point source collection basin and passive filter include the following:

- Harvesting or mowing of plants on filter surface;
- Inspection and repair of embankments and structures for burrowing animals such as muskrats;
- Replacement of filter media (estimated to be every ten (10) years); and
- Cleaning and maintenance of inlet and outlet structures, valving and monitoring devices.

An operating plan would be developed for each treatment system. A pump and lift station would likely be required to transfer liquid between the collection basin and the filter. The filter is designed for intermittent wetting, meaning flow would be pumped to the filter surface on a scheduled basis. This would typically be for twenty-four (24) hours a day, over four (4) days or twelve (12) hours a day over eight (8) days. The cattle operator would be required to manage the system. Effluent would discharge by gravity to a municipal drain or to a low lying area on the property.

### 5.3.3 Site Grading and Collection Ditches

The feedlots and surrounding area will be graded to direct drainage from the feedlots to a collection basin via collection ditches at each cattle operation. These ditches will surround the feedlot area and direct runoff to the storage facility.

### 5.3.4 Collection Basin

Feedlot runoff will be collected and conveyed to a storage facility constructed as a lined storage pond.

The pond will likely require an engineered liner if environmental licensing of the system is required. The liner could be re-compacted clay (if local soils are suitable), a geosynthetic clay liner, or a 60 mil HDPE geo-membrane. The HDPE liner is typically the most expensive option while the re-compacted clay liner is typically the least expensive option provided suitable clay soils are available at the site. Both options will provide sufficient containment and longevity for the lifecycle of the collection basin.

Naturalized systems rely on biological and physical processes to provide treatment to the collected runoff. The biological processes are typically dormant or very slow in the winter and spring due to cold ground and water temperatures. Collection and storage of the runoff can delay discharge until filter plant and bacterial activity increase in late spring. Storage of the runoff also promotes settling which can reduce suspended solids, nutrient content and $BOD_5$ (Reedyk et al., 2017).

### 5.3.5 Vertical Passive Filter

A vertical passive filter can be used after storage as a method to actively engage the biological and physical water treatment mechanisms for cattle runoff. Vertical flow filters can be incorporated after a storage pond to further reduce solids and $BOD_5$ of the runoff through biological and physical processes. Plants can be grown on the surface of the packed filter bed and harvested as a way to remove and recover nutrients (N, P) from the runoff. These crops could then be baled as hay for the cattle or processed (composted) to produce natural fertilizer for other crops.

A passive filter is typically constructed with three (3) layers:

- Root/vegetation zone containing topsoil;
- Reaction zone containing coarse sand; and
- Drainage zone containing granular material.

Water from the settling pond is drained by gravity, or pumped to a perforated pipe in the root/vegetation zone, where it drains vertically to a collection point at the bottom. As the water flows through the root zone and filter media, biological and physical processes reduce many of the contaminants. As summarized in **Section 3.4.2**, similar passive filter installation near the LMOC site have shown that vertical flow filter arrangements result in significant reductions of ammonia, $BOD_5$, fecal coliform and TP in the effluent.

### 5.3.6 Conceptual Sizing of System

As referenced in the *Manitoba Construction Requirements for Confined Livestock Areas and Collection Basins*, a collection basin must have a holding capacity of at least 0.075 m and no greater than 0.150 m of runoff (accumulated precipitation) from the collection (feedlot) area. A collection basin constructed larger than 0.150 m of accumulated precipitation holding capacity would be considered a manure storage facility (long-term storage) and be subjected to the requirements for obtaining a permit to construct a manure storage facility. The collection basins will be sized for the following parameters:

- 0.15 m of runoff (precipitation) from feedlots;
- 0.3 m freeboard;
- 1.2 m liquid depth;
- L:W ratio 4:1; and
- Horizontal interior slope 3:1

**Table 15** summaries the collection basin volume and footprints for four (4) cattle operations within sub-watersheds flowing south to Lake Manitoba.

**Table 15: Collection Basin Conceptual Volume and Footprints**

| Cattle Operation | Contributing Sub-Watershed | Feedlot Area | Min Storage Volume Required | Exterior Collection Basin Dimensions | |
|---|---|---|---|---|---|
| | | $km^2$ | $m^3$ | Length (m) | Width (m) |
| Operation #1 | W150-west | 0.029 | 4,380 | 119 | 35 |
| Operation #2 | W150-west | 0.019 | 2,910 | 99 | 30 |
| Operation #3 | W150-west | 0.018 | 2,700 | 95 | 29 |
| Operation #4 | W840-west | 0.023 | 3,510 | 107 | 32 |

The vertical passive filter is sized to handle intermittent flows from the collection basin. Water would flow by gravity to the passive filter or be pumped by a submersible pump depending on grades near the collection basins. For conceptual purposes, the filter was assumed to be square and sized for the following parameters:

- Trickling filter/passive filter design flow rate used – 0.02 $L/m^2/s$ (0.01-0.04 typical);
- Filter depth – 1 m;
- Max BOD5 Loading rate for trickling filter – 40 kg $BOD_5/100\ m^3/d$; and
- Influent $BOD_5$ loading (assume 50% knocked out by collection basin) – 56 mg/L.
    - Referenced from **Table 5**, average $BOD_5$ concentration from cattle runoff.

**Table 16** summarizes the vertical passive filter area, dimensions and $BOD_5$ loading.

**Table 16: Vertical Passive Filter Dimensions and Loading**

| Cattle Operation | Filter Area | Filter Dimensions | Effective Volume | $BOD_5$ Capacity | |
|---|---|---|---|---|---|
| | $m^2$ | LxW (m) | $m^3$ | kg/d | kg $BOD_5/100\ m^3/d$ |
| Operation #1 | 634 | 25 | 634 | 123.2 | 19.4 |
| Operation #2 | 441 | 21 | 441 | 86.2 | 19.5 |
| Operation #3 | 407 | 20 | 407 | 78.4 | 19.3 |
| Operation #4 | 514 | 23 | 514 | 99.7 | 19.4 |

**Table 17** summarizes the total footprint required for the collection basin and filter for each cattle operation.

Table 17: Total Footprint Required for Each Cattle Operation

| Cattle Operation | Collection Basin Area | Filter Area | Total Footprint Required |
|---|---|---|---|
| | $m^2$ | $m^2$ | $m^2$ |
| Operation #1 | 4,200 | 640 | 4,840 |
| Operation #2 | 3,000 | 450 | 3,450 |
| Operation #3 | 2,800 | 410 | 3,210 |
| Operation #4 | 3,500 | 520 | 4,020 |

The passive filter footprint is designed to meet typical trickling filter design flow rates (0.01-0.04 $L/m^2/s$), and the maximum $BOD_5$ loading rate. The collection basin and the passive filter will require the purchase of additional land or agreement from landowner to construct on private property and will require regular operation and maintenance to maintain flows across the filter.

## 5.4 Option Evaluation

### 5.4.1 Advantages and Disadvantages

The comparison of passive treatment options is presented in **Table 18** with the main advantages and disadvantages of each alternative.

Table 18: Passive Treatment System Advantages and Disadvantages

| | Alternative 1 – In-Drain Wetland (25% of average flow) | Alternative 2 – Point Source Wetlands | Alternative 3 – Point Source Collection Basin and Vertical Passive Filter |
|---|---|---|---|
| **Advantages** | • Relatively non-intrusive system built within outside drain;<br>• Avoid land purchase;<br>• Lowest capital cost;<br>• Natural system requiring no mechanical equipment, chemicals or daily maintenance;<br>• Typically 25 to 30 year lifespan;<br>• System can tolerate fluctuations in flows; and<br>• Provides habitat for wildlife. | • Existing wetlands could potentially be utilized at Operation #1 and #2;<br>• Typically 25 to 30 year lifespan;<br>• One of the more common technologies used for agriculture runoff;<br>• Depending on site topography, with an outlet weir the system can operate without the use of external power;<br>• Simple approach with minimum infrastructure requirement; and | • Can accept the highest level of nutrient, organics and solids removal from cattle runoff;<br>• Previous Manitoba installations have shown consistent phosphorus removal;<br>• Nutrient recovery possible from plant harvesting; and<br>• Design is currently licensed for nutrient reduction of municipal lagoon effluent so environmental approval in this context is likely. |

| | Alternative 1 – In-Drain Wetland (25% of average flow) | Alternative 2 – Point Source Wetlands | Alternative 3 – Point Source Collection Basin and Vertical Passive Filter |
|---|---|---|---|
| | | • Natural system requiring no mechanical equipment, chemicals or maintenance. | |
| **Disadvantages** | • Largest land area required;<br>• Requires a minimum depth of water to survive year round;<br>• More stringent regulatory requirements could be enforced, since discharge is directly to Lake Manitoba;<br>• Risk of plant washout in extreme flows;<br>• More frequent maintenance may be required (plant harvesting) to reduce impact on drain hydraulics;<br>• May have significant impact on overall drain hydraulics if wetland plants are not regularly harvested;<br>• Performance is impacted in the winter due to low biological activity/frozen conditions;<br>• Phosphorus removal is reduced in wetlands compared to filtration; and<br>• Risk of runoff from southern properties short circuiting wetland. | • Requires purchase of additional land or agreement from landowner to construct on private property;<br>• Power may be required if pump is used to transfer water from collection basin to wetland;<br>• Highest capital cost considering addition of upstream collection basin;<br>• Medium footprint required (larger than Alternative #3);<br>• Performance may be less consistent than Alternative #3;<br>• Phosphorus removal is reduced in wetlands compared to filtration; Performance is impacted in the winter due to low biological activity/frozen conditions;<br>• Build-up of solids could occur without upfront collection basin; and<br>• Environmental license and annual monitoring may be required. | • Requires purchase of additional land or agreement from landowner to construct on private property;<br>• Second highest cost alternative;<br>• Highest infrastructure requirements (pond, pumps and filter);<br>• Highest operation and maintenance requirements;<br>• Lifespan may be limited to 10 years compared to Alternative 1 and 2;<br>• Risk of filter clogging if not maintained by landowner;<br>• Risk of flooding and damage to mechanical equipment near southern properties;<br>• Environmental license and annual monitoring may be required; and<br>• Impacted by high groundwater tables. |

### 5.4.2 Suitability Comparison

Dillon evaluated the four (4) cattle operations to determine suitable passive treatment alternatives, with a focus on lower capital costs and as little possible energy/maintenance requirements, as directed by MI. The suitability comparison is detailed in **Table 19**.

**Table 19: Suitability of Passive Treatment Options at Cattle Operations**

| Options | | Operation #1 | Operation #2 | Operation #3 | Operation #4 |
|---|---|---|---|---|---|
| **Alternative #1 – In-Drain Wetland** | Suitability | Low | Low | Medium | High |
| | Rationale | Low HRT, (Short-circuiting) | Low HRT, (Short-circuiting) | Minimal HRT, (Short-circuiting) | High HRT available |
| **Alternative #2 – Point Source Wetlands** | Suitability | High | High | Medium | Medium |
| | Rationale | Natural wetlands can be utilized | Natural wetlands can be utilized | Land area available, no natural wetlands | Land area available, no natural wetlands |
| **Alternative #3 – Point Source Collection Basin and Vertical Passive Filter** | Suitability | Medium | Medium | Medium | Medium |
| | Rationale | Risk for flooding and damage to system | Risk for flooding and damage to system | Land area available, O&M required | Land area available, O&M required |

Based on the comparison of each treatment option, it appears that **Alternative 2 – Point Source Wetlands**, is the most suitable choice at this time. There are risks that properties located at the south end of the LMOC would short circuit/circumvent an in-drain wetland (Alternative 1). From historical observations, there is also a flooding risk due to natural lake level variations at Lake Manitoba which could damage the mechanical systems of the passive filter (Alternative 3) at the south end of the LMOC near Township Road, if a lift station is required. Alternative 3 would also require regular operation and maintenance to maintain a proper drainage rate across the filter. Landowners may not be receptive to operating a treatment system on private property, which could lead to performance issues. There are existing natural wetlands near both Operation #1 and #2 which could be modified for treatment. Point source wetlands could also be built on the other properties of concern, with little to no maintenance requirements for the landowners. For this reason, Alternative 2 would be the preferred option. It is noted that an upfront collection basin is recommended and would require operation and maintenance if a pumping system is required to transfer runoff from the basin to the wetland.

Although Alternative #1 would be simplest to construct, this alternative isn't recommended for the following reasons:

- The hydraulic impacts to the outside drain could be significant, requiring labor intensive, regular harvesting of wetland plants and solids by MI over a very large area;

- The regular harvesting of wetland plants has a negative impact on the treatment performance of the wetland, resulting in potential release of contaminants abound within the wetland sediment if not carefully managed;
- Further flattening of slope at the outside drain can increase HRT, but will lead to further build-up of solids sedimentation and standing water. This will further attract vectors, cause wetland vegetation to grow and further impact hydraulics compared to a sloped outlet; and
- Peak flows could result in loss of vegetation, erosion of the treatment wetlands and resuspension of sediment deposited during treatment. The predominant mechanism for contaminant removal in surface flow wetlands is sedimentation and filtration. A high runoff event could result in release of contaminants (e.g. phosphorus) into surface water downstream.

As discussed, **Alternative #2 – Point Source Wetlands** are the most suitable passive treatment system at this time. Additional planting of vegetation in the outside drain could be beneficial as a secondary measure, as long as the in-drain vegetation:

- Is regularly harvested and the condition of the drain is maintained;
- Is not relied upon for any regulatory treatment considerations; and
- Does not significantly impact the outside drain hydraulic function.

# 6.0 Monitoring Plan

Following the construction phase of the LMOC, long term surface water quality monitoring should be completed within the outside drain. Specific sampling locations and frequency would be determined in the detailed design, building on the construction monitoring program to include the downstream reaches of the outside drain.

Samples would be tested for standard effluent lagoon parameters and compared to federal and provincial water quality guidelines referenced in **Section 3** of this report. These parameters would include:

- Chemical Oxygen Demand (COD);
- Biochemical Oxygen Demand ($BOD_5$);
- Total Phosphorus (TP);
- Total Kjeldahl Nitrogen (TKN);
- Total Ammonia ($NH_3$-N);
- Total Nitrogen (TN);
- Nitrate/Nitrite;
- Fecal coliforms;
- Alkalinity;
- Total Suspended Solids (TSS);
- pH – field and lab;
- Dissolved Oxygen (DO) - field;
- Oxidation-Reduction Potential (ORP) – field;
- Electrical Conductivity (EC) – field; and
- Turbidity.

Surface water samples should be taken at a minimum of seven (7) to eight (8) strategic locations within the outside drain, upstream and downstream of cattle operations. The strategic sampling plan should maintain a strong focus on sampling locations at the south end of the outside drain, where the highest risk cattle operations are located. The sampling results would be used to confirm dilution calculations from **Section 4.2.4**. Additional monitoring throughout Lake Manitoba for dissolved oxygen and nutrient levels may also be justified, if it is thought that contaminant loadings continue to be a concern.

The long-term monitoring program should take place on an annual basis, with monthly samples taken during times when surface water is accessible. It is also important to capture water samples during the spring freshet to document the instances of highest loading of cattle runoff to the LMOC.

# 7.0 Risk Discussion

The following risks should be considered as part of the evaluation of passive treatment alternatives:

- There is risk to nutrient loading of Lake Manitoba if no treatment is pursued. The outside drain construction will sever some of the natural drainage routes and provide a direct route for nutrient laden cattle runoff between the farms and the lake.
- There is treatment performance variability in passive systems. A natural system will not consistently meet effluent targets in comparison to a mechanical system. There will likely be spikes in nutrient loadings released from these natural systems, typically several times per every year.
- Natural systems will lead to vector attraction, including birds, rodents and other animals which may live in the passive system and cause damage to liners or become a nuisance.
- Open systems like wetlands and collection basins may pose danger to humans. Fencing or signage would be required to deter humans from trespassing at the treatment site or where there is a risk of people coming into contact with wastewater.
- If a point source passive treatment system is constructed outside of the channel right of way, MI will need to determine whether to expropriate land or to create a contractual agreement with the landowner.
- Further discussion is required with MCC to determine whether a license is required for the passive treatment systems. If a license is needed, MCC will require either MI, the landowner or successor(s) in title to be named under the license. The entity named under the license will be responsible for meeting the conditions of the license and maintaining the treatment system.

# 8.0 Conclusions

Based on the comparison of passive treatment options, **Alternative 2 – Point Source Wetland**, is the recommended passive treatment approach for reducing nutrient loading in the proposed LMOC outside drain due to runoff from cattle feedlots. This includes the construction of a wetland treatment system downstream of each cattle operation of greatest proximity to the outside drain on the west side of the LMOC. It is recommended to construct a collection basin upstream of each treatment wetland, although one may not be required depending on site topography.

- There are four (4) cattle operations (Operations #1, #2, #3 and #4) in close proximity to discharge directly to the outside drain. Operations #1 and #2, south of Township Road are of the closest proximity to Lake Manitoba and pose the greatest risk for nutrient runoff.
- There are existing natural wetlands between the LMOC right of way and the cattle feedlots on Operations #1 and #2, which may be considered as wetland treatment systems by the regulator.
- Previous studies, including in the Interlake area, provide strong evidence that wetlands are an ideal method of reducing agricultural runoff impacts.
- The sampling event on May 21, 2021 suggested the following nutrient loading reductions at Operation #1 across the existing wetland ($BOD_5$ – 62%, TP – 35%, TKN – 58%, $NH_3$-N – 58%, TSS – 27%).
- A long term monitoring program should be implemented following construction to confirm nutrient and chemical loadings to the outside drain, specifically during the spring freshet. The monitoring program should confirm dilution calculations from **Section 4.2.4**.
- MCC may require a license for the passive treatment systems. The entity named under the license will be responsible for meeting the conditions of the license and maintaining the treatment system.
- The findings of this report are based on the current level of design related to the LMOC.

# 9.0 References

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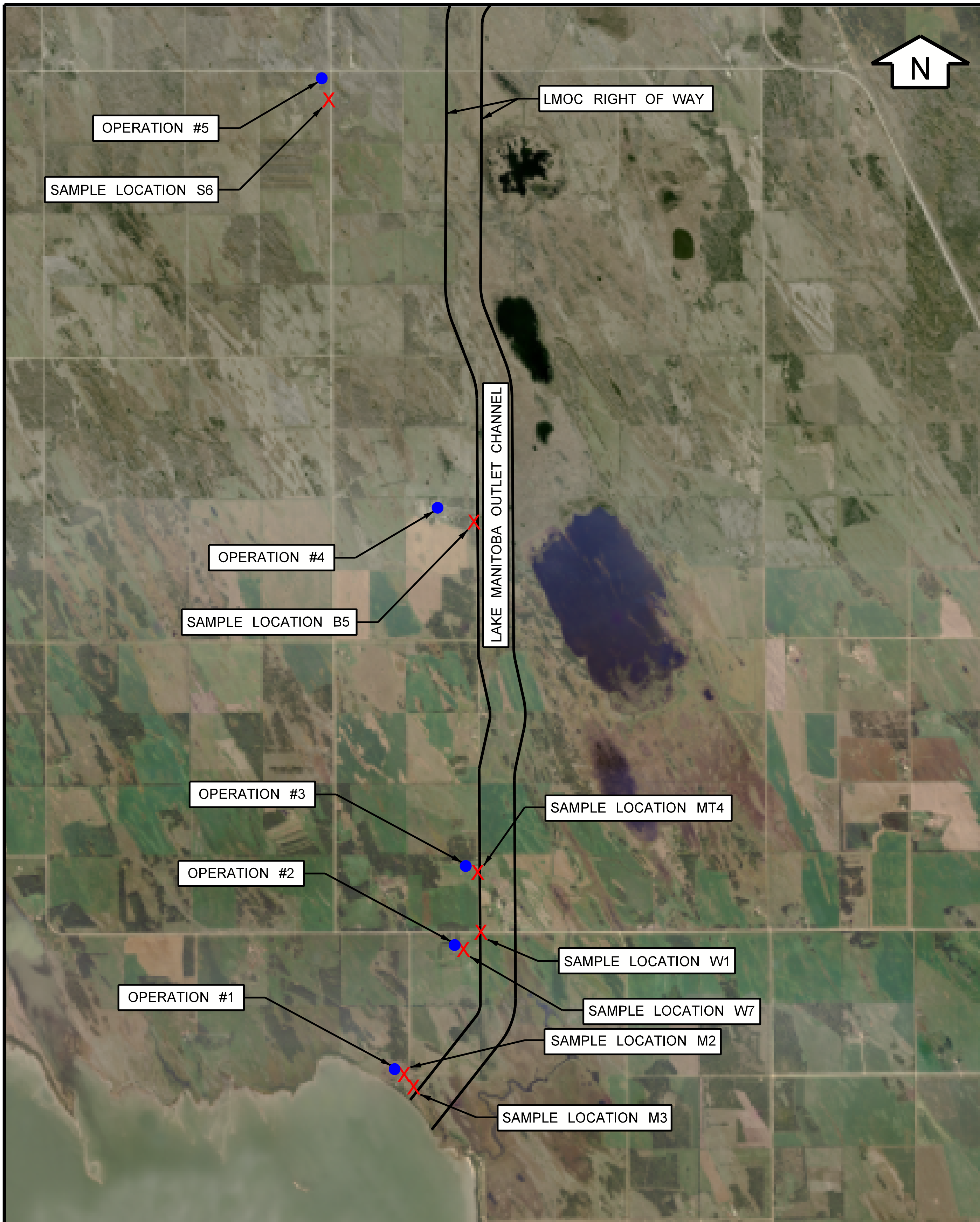
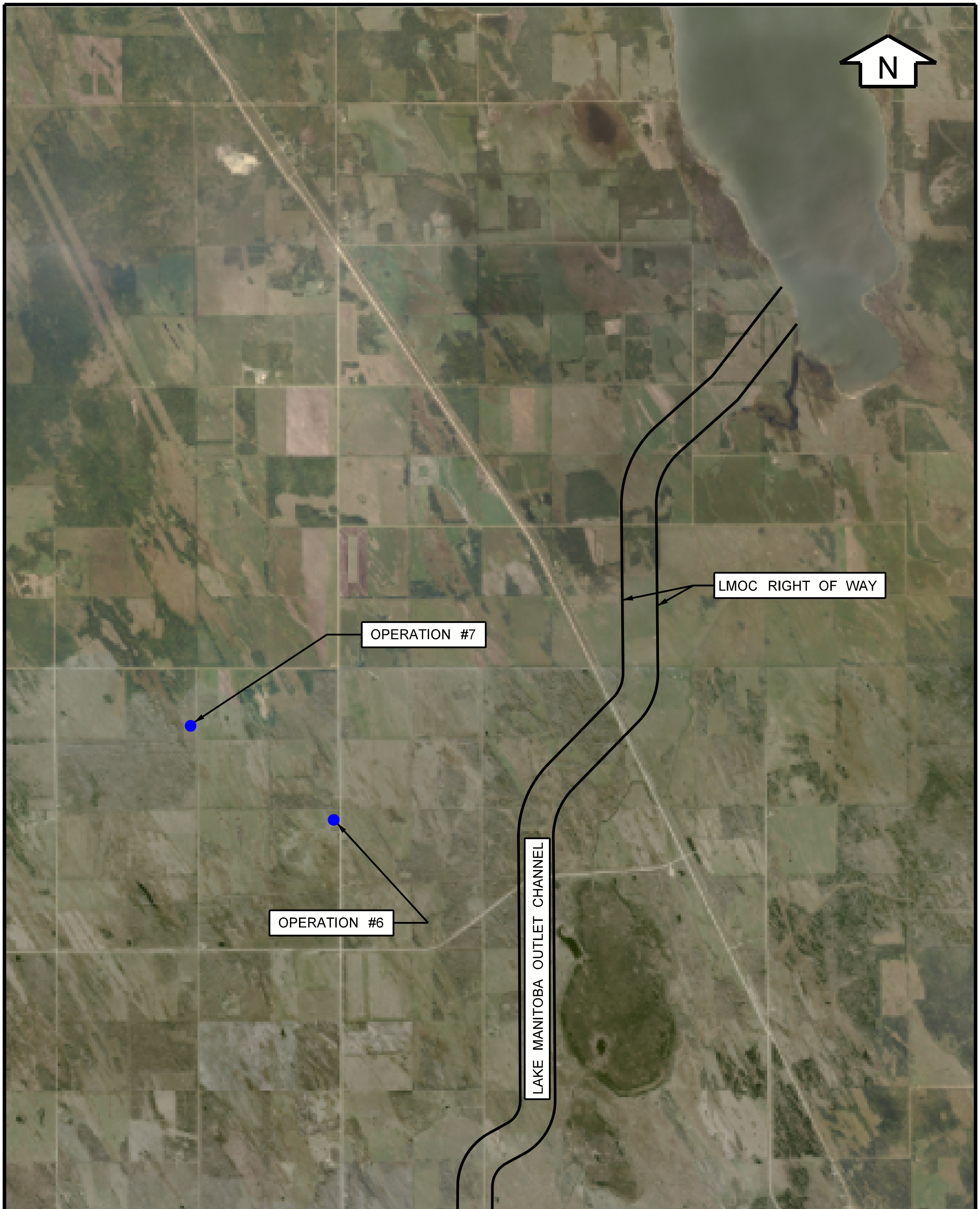
Smith, A. 2011. Nutrient export in run-off from an in-field cattle overwintering site in east-central Saskatchewan. Master of Science Thesis, University of Saskatchewan.

# Figures




| | | |
|---|---|---|
| DILLON CONSULTING | LAKE MANITOBA OUTLET CHANNEL | 19-9041 |
| SEPTEMBER 22, 2021 | CATTLE OPERATION LOCATIONS | FIGURE A1 |




| | | |
|---|---|---|
| DILLON CONSULTING | LAKE MANITOBA OUTLET CHANNEL | 19-9041 |
| SEPTEMBER 14, 2021 | CATTLE OPERATION LOCATIONS | FIGURE A2 |

# Appendix A

## *Laboratory Results*

Dillon Consulting Engineers-Winnipeg
ATTN: Charlie Pogue
1558 Willson Place
Winnipeg MB R3T 0Y4

Date Received: 21-MAY-21
Report Date: 07-JUN-21 11:04 (MT)
Version: FINAL

Client Phone: 204-453-2301

# Certificate of Analysis

Lab Work Order #: L2591293
Project P.O. #: NOT SUBMITTED
Job Reference: 19-9041-1726
C of C Numbers:
Legal Site Desc:

Hua Wo
Chemistry Laboratory Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2591293-1 W1 [redacted] | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Alkalinity species as HCO3, CO3, OH** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 377 | | 1.2 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 21-MAY-21 | |
| **Miscellaneous Parameters** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 309 | | 1.0 | mg/L | | 31-MAY-21 | R5475688 |
| Ammonia, Total (as N) | 0.015 | | 0.010 | mg/L | | 27-MAY-21 | R5471879 |
| Biochemical Oxygen Demand | 2.6 | | 2.0 | mg/L | | 22-MAY-21 | R5473517 |
| Chemical Oxygen Demand | 60 | | 10 | mg/L | | 26-MAY-21 | R5470556 |
| Fecal Coliforms | 52 | | 1 | MPN/100mL | | 21-MAY-21 | R5464162 |
| Phosphorus (P)-Total | 0.0820 | | 0.0030 | mg/L | | 03-JUN-21 | R5477818 |
| Special Request | See Attached | | | | | 06-JUN-21 | R5479586 |
| Total Suspended Solids | 3.8 | | 3.0 | mg/L | | 27-MAY-21 | R5475530 |
| **Nitrogen Total** | | | | | | | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.020 | | 0.020 | mg/L | | 24-MAY-21 | R5471397 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 27-MAY-21 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.010 | | 0.010 | mg/L | | 24-MAY-21 | R5471397 |
| **Total Kjeldahl Nitrogen** | | | | | | | |
| Total Kjeldahl Nitrogen | 1.77 | | 0.20 | mg/L | 29-MAY-21 | 30-MAY-21 | R5475341 |
| **Total Nitrogen Calculated** | | | | | | | |
| Total Nitrogen | 1.77 | | 0.20 | mg/L | | 30-MAY-21 | |
| L2591293-2 M2 ([redacted]) | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Alkalinity species as HCO3, CO3, OH** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 1170 | | 1.2 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 21-MAY-21 | |
| **Miscellaneous Parameters** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 957 | | 1.0 | mg/L | | 31-MAY-21 | R5475688 |
| Ammonia, Total (as N) | 9.29 | | 0.20 | mg/L | | 27-MAY-21 | R5471879 |
| Biochemical Oxygen Demand | 32.2 | | 6.0 | mg/L | | 22-MAY-21 | R5473517 |
| Chemical Oxygen Demand | 1180 | | 10 | mg/L | | 26-MAY-21 | R5470556 |
| Fecal Coliforms | 100 | | 10 | MPN/100mL | | 21-MAY-21 | R5465799 |
| Phosphorus (P)-Total | 12.5 | | 0.060 | mg/L | | 29-MAY-21 | R5475476 |
| Special Request | See Attached | | | | | 06-JUN-21 | R5479586 |
| Total Suspended Solids | 60.6 | | 3.0 | mg/L | | 27-MAY-21 | R5475530 |
| **Nitrogen Total** | | | | | | | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.40 | DLM | 0.40 | mg/L | | 24-MAY-21 | R5471397 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.45 | | 0.45 | mg/L | | 27-MAY-21 | |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2591293-2 M2 ([redacted]) | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.20 | DLM | 0.20 | mg/L | | 24-MAY-21 | R5471397 |
| **Total Kjeldahl Nitrogen** | | | | | | | |
| Total Kjeldahl Nitrogen | 43.9 | | 2.0 | mg/L | 29-MAY-21 | 30-MAY-21 | R5475341 |
| **Total Nitrogen Calculated** | | | | | | | |
| Total Nitrogen | 43.9 | | 2.0 | mg/L | | 30-MAY-21 | |
| L2591293-3 M3 ([redacted]) (W3 ON BOTTLES) | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Alkalinity species as HCO3, CO3, OH** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 626 | | 1.2 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 21-MAY-21 | |
| **Miscellaneous Parameters** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 514 | | 1.0 | mg/L | | 31-MAY-21 | R5475688 |
| Ammonia, Total (as N) | 3.93 | | 0.20 | mg/L | | 27-MAY-21 | R5471879 |
| Biochemical Oxygen Demand | 12.2 | | 6.0 | mg/L | | 22-MAY-21 | R5473517 |
| Chemical Oxygen Demand | 588 | | 10 | mg/L | | 28-MAY-21 | R5475058 |
| Fecal Coliforms | 60 | | 10 | MPN/100mL | | 21-MAY-21 | R5465799 |
| Phosphorus (P)-Total | 8.18 | | 0.030 | mg/L | | 29-MAY-21 | R5475476 |
| Special Request | See Attached | | | | | 06-JUN-21 | R5479586 |
| Total Suspended Solids | 44.4 | | 3.0 | mg/L | | 27-MAY-21 | R5475530 |
| **Nitrogen Total** | | | | | | | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.20 | DLM | 0.20 | mg/L | | 24-MAY-21 | R5471397 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.22 | | 0.22 | mg/L | | 27-MAY-21 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.10 | DLM | 0.10 | mg/L | | 24-MAY-21 | R5471397 |
| **Total Kjeldahl Nitrogen** | | | | | | | |
| Total Kjeldahl Nitrogen | 18.6 | | 2.0 | mg/L | 29-MAY-21 | 30-MAY-21 | R5475341 |
| **Total Nitrogen Calculated** | | | | | | | |
| Total Nitrogen | 18.6 | | 2.0 | mg/L | | 30-MAY-21 | |
| L2591293-4 MT4 ([redacted]) | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Alkalinity species as HCO3, CO3, OH** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 583 | | 1.2 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 21-MAY-21 | |
| **Miscellaneous Parameters** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 478 | | 1.0 | mg/L | | 31-MAY-21 | R5475688 |
| Ammonia, Total (as N) | 0.41 | | 0.10 | mg/L | | 27-MAY-21 | R5471879 |
| Biochemical Oxygen Demand | 45 | | 20 | mg/L | | 22-MAY-21 | R5473517 |
| Chemical Oxygen Demand | 590 | | 10 | mg/L | | 28-MAY-21 | R5475058 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2591293-4 MT4 ([redacted]) | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| Fecal Coliforms | 2140 | | 10 | MPN/100mL | | 21-MAY-21 | R5465799 |
| Phosphorus (P)-Total | 8.51 | | 0.030 | mg/L | | 29-MAY-21 | R5475476 |
| Total Suspended Solids | 440 | | 3.0 | mg/L | | 27-MAY-21 | R5475530 |
| **Nitrogen Total** | | | | | | | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.040 | DLM | 0.040 | mg/L | | 24-MAY-21 | R5471397 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 27-MAY-21 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.020 | DLM | 0.020 | mg/L | | 24-MAY-21 | R5471397 |
| **Total Kjeldahl Nitrogen** | | | | | | | |
| Total Kjeldahl Nitrogen | 16.8 | | 0.40 | mg/L | 29-MAY-21 | 30-MAY-21 | R5475341 |
| **Total Nitrogen Calculated** | | | | | | | |
| Total Nitrogen | 16.8 | | 0.40 | mg/L | | 30-MAY-21 | |
| L2591293-5 B5 ([redacted]) | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Alkalinity species as HCO3, CO3, OH** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 485 | | 1.2 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | <0.60 | | 0.60 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 21-MAY-21 | |
| **Miscellaneous Parameters** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 398 | | 1.0 | mg/L | | 31-MAY-21 | R5475688 |
| Ammonia, Total (as N) | 0.103 | | 0.020 | mg/L | | 27-MAY-21 | R5471879 |
| Biochemical Oxygen Demand | 10.5 | | 6.0 | mg/L | | 22-MAY-21 | R5473517 |
| Chemical Oxygen Demand | 138 | | 10 | mg/L | | 28-MAY-21 | R5475058 |
| Fecal Coliforms | 30 | | 1 | MPN/100mL | | 21-MAY-21 | R5464162 |
| Phosphorus (P)-Total | 1.16 | | 0.030 | mg/L | | 29-MAY-21 | R5475476 |
| Total Suspended Solids | 106 | | 3.0 | mg/L | | 27-MAY-21 | R5475530 |
| **Nitrogen Total** | | | | | | | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.040 | DLM | 0.040 | mg/L | | 24-MAY-21 | R5471397 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 27-MAY-21 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.020 | DLM | 0.020 | mg/L | | 24-MAY-21 | R5471397 |
| **Total Kjeldahl Nitrogen** | | | | | | | |
| Total Kjeldahl Nitrogen | 4.30 | | 0.40 | mg/L | 29-MAY-21 | 30-MAY-21 | R5475341 |
| **Total Nitrogen Calculated** | | | | | | | |
| Total Nitrogen | 4.30 | | 0.40 | mg/L | | 30-MAY-21 | |
| L2591293-6 WATCHORN | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Miscellaneous Parameters** | | | | | | | |
| Ammonia, Total (as N) | 0.035 | | 0.010 | mg/L | | 27-MAY-21 | R5471879 |
| Biochemical Oxygen Demand | <2.0 | | 2.0 | mg/L | | 22-MAY-21 | R5473517 |
| Chemical Oxygen Demand | 58 | | 10 | mg/L | | 28-MAY-21 | R5475058 |
| Phosphorus (P)-Total | 0.0604 | | 0.0030 | mg/L | | 29-MAY-21 | R5475476 |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2591293-6 WATCHORN | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| Total Kjeldahl Nitrogen | 1.35 | | 0.20 | mg/L | 29-MAY-21 | 30-MAY-21 | R5475341 |
| L2591293-7 S6 ([redacted]) | | | | | | | |
| Sampled By: CP on 21-MAY-21 @ 08:54 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Alkalinity species as HCO3, CO3, OH** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 453 | | 1.2 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | 13.0 | | 0.60 | mg/L | | 21-MAY-21 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 21-MAY-21 | |
| **Miscellaneous Parameters** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 393 | | 1.0 | mg/L | | 31-MAY-21 | R5475688 |
| Ammonia, Total (as N) | 0.057 | | 0.020 | mg/L | | 27-MAY-21 | R5471879 |
| Biochemical Oxygen Demand | 3.7 | | 2.0 | mg/L | | 22-MAY-21 | R5473517 |
| Chemical Oxygen Demand | 169 | | 10 | mg/L | | 28-MAY-21 | R5475058 |
| Fecal Coliforms | <10 | | 10 | MPN/100mL | | 21-MAY-21 | R5465799 |
| Phosphorus (P)-Total | 0.269 | | 0.0030 | mg/L | | 29-MAY-21 | R5475476 |
| Total Suspended Solids | 12.4 | | 3.0 | mg/L | | 27-MAY-21 | R5475530 |
| **Nitrogen Total** | | | | | | | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.020 | | 0.020 | mg/L | | 24-MAY-21 | R5471397 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.070 | | 0.070 | mg/L | | 27-MAY-21 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.010 | | 0.010 | mg/L | | 24-MAY-21 | R5471397 |
| **Total Kjeldahl Nitrogen** | | | | | | | |
| Total Kjeldahl Nitrogen | 4.33 | | 0.20 | mg/L | 29-MAY-21 | 30-MAY-21 | R5475341 |
| **Total Nitrogen Calculated** | | | | | | | |
| Total Nitrogen | 4.33 | | 0.20 | mg/L | | 30-MAY-21 | |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

## Sample Parameter Qualifier Key:

| Qualifier | Description |
|---|---|
| B | Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable. |
| DLM | Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity). |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| ALK-CO3CO3-CALC-WP | Water | Alkalinity, Carbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by carbonate is calculated and reported as mg CO3 2-/L.

| | | | |
|---|---|---|---|
| ALK-HCO3HCO3-CALC-WP | Water | Alkalinity, Bicarbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by bicarbonate is calculated and reported as mg HCO3-/L

| | | | |
|---|---|---|---|
| ALK-OHOH-CALC-WP | Water | Alkalinity, Hydroxide | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by hydroxide is calculated and reported as mg OH-/L.

| | | | |
|---|---|---|---|
| ALK-TITR-WP | Water | Alkalinity, Total (as CaCO3) | APHA 2320B |

The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. Total alkalinity is determined by titration with a strong standard mineral acid to the successive HCO3- and H2CO3 endpoints indicated electrometrically.

| | | | |
|---|---|---|---|
| BOD-WP | Water | Biochemical Oxygen Demand (BOD) | APHA 5210 B |

Samples are diluted and seeded and then incubated in airtight bottles at 20°C for 5 days. Dissolved oxygen is measured initially and after incubation, and results are computed from the difference between initial and final DO.

| | | | |
|---|---|---|---|
| COD-WP | Water | Chemical Oxygen Demand | APHA 5220 D |

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colorimetric method.

| | | | |
|---|---|---|---|
| EC-SCREEN-WP | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other test eg. IC, TDS, TSS, etc

| | | | |
|---|---|---|---|
| ETL-N-TOT-ANY-WP | Water | Total Nitrogen Calculated | Calculated |
| FC-QT97-WP | Water | Fecal Coliform by MPN QT97 | APHA 9223B QT97 |

This analysis is carried out using procedures adapted from APHA Method 9223B "Enzyme Substrate Coliform Test". The sample is mixed with a mixture of hydrolyzable substrates and then sealed in a 97-well packet. The packet is incubated at 44.5 +/- 0.2 degrees C for 18 hours and then the number of wells exhibiting a positive response are counted. The final result is obtained by comparing the number of positive responses to a probability table.

| | | | |
|---|---|---|---|
| FC10-QT97-WP | Water | Fecal coliforms, 1:10 dilution by QT97 | APHA 9223B QT97 |

Analysis is carried out using procedures adapted from APHA 9223 "Enzyme Substrate Coliform Test". Fecal (thermotolerant) coliform bacteria are determined by mixing a 1:10 dilution of sample with a product containing hydrolyzable substrates and sealing in a 97-well packet. The packet is incubated at 44.5 +/- 0.2 degrees C for 18 hours and then the number of wells exhibiting positive responses are counted. The final results are obtained by comparing the number of positive responses to a probability table.

| | | | |
|---|---|---|---|
| N-TOTKJ-WP | Water | Total Kjeldahl Nitrogen | APHA 4500 NorgD (modified) |

Aqueous samples are digested in a block digester with sulfuric acid and copper sulfate as a catalyst. Total Kjeldahl Nitrogen is then analyzed using a discrete analyzer with colorimetric detection.

| | | | |
|---|---|---|---|
| NH3-COL-WP | Water | Ammonia by colour | APHA 4500 NH3 F |

Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.

| | | | |
|---|---|---|---|
| NO2+NO3-CALC-WP | Water | Nitrate+Nitrite | CALCULATION |
| NO2-IC-N-WP | Water | Nitrite in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

# Reference Information

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| NO3-IC-N-WP | Water | Nitrate in Water by IC | EPA 300.1 (mod) |
| Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection. | | | |
| P-T-COL-WP | Water | Phosphorus, Total | APHA 4500 P PHOSPHORUS-L |
| This analysis is carried out using procedures adapted from APHA METHOD 4500-P "Phosphorus". Total Phosphorus is determined colourmetrically after persulphate digestion of the sample. | | | |
| SOLIDS-TOTSUS-WP | Water | Total Suspended Solids | APHA 2540 D (modified) |
| Total suspended solids in aquesous matrices is determined gravimetrically after drying the residue at 103 105°C. | | | |
| SPECIAL REQUEST-CI | Misc. | Special Request ALS Cincinnati | SEE SUBLET LAB RESULTS |

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| CI | ALS ENVIRONMENTAL - CINCINNATI, OHIO, USA |
| WP | ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report



Client: Dillon Consulting Engineers-Winnipeg
1558 Willson Place
Winnipeg MB R3T 0Y4

Contact: Charlie Pogue

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ALK-TITR-WP** | **Water** | | | | | | | |
| **Batch R5475688** | | | | | | | | |
| **WG3544554-18 LCS** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | 103.8 | | % | | 85-115 | 31-MAY-21 |
| **WG3544554-6 MB** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | <1.0 | | mg/L | | 1 | 31-MAY-21 |
| **BOD-WP** | **Water** | | | | | | | |
| **Batch R5473517** | | | | | | | | |
| **WG3539846-2 LCS** | | | | | | | | |
| Biochemical Oxygen Demand | | | 97.3 | | % | | 85-115 | 22-MAY-21 |
| **WG3539846-1 MB** | | | | | | | | |
| Biochemical Oxygen Demand | | | <2.0 | | mg/L | | 2 | 22-MAY-21 |
| **COD-WP** | **Water** | | | | | | | |
| **Batch R5470556** | | | | | | | | |
| **WG3541462-2 LCS** | | | | | | | | |
| Chemical Oxygen Demand | | | 102.6 | | % | | 85-115 | 26-MAY-21 |
| **WG3541462-1 MB** | | | | | | | | |
| Chemical Oxygen Demand | | | <10 | | mg/L | | 10 | 26-MAY-21 |
| **Batch R5475058** | | | | | | | | |
| **WG3543460-2 LCS** | | | | | | | | |
| Chemical Oxygen Demand | | | 105.2 | | % | | 85-115 | 28-MAY-21 |
| **WG3543460-1 MB** | | | | | | | | |
| Chemical Oxygen Demand | | | <10 | | mg/L | | 10 | 28-MAY-21 |
| **FC-QT97-WP** | **Water** | | | | | | | |
| **Batch R5464162** | | | | | | | | |
| **WG3539754-2 DUP** | | **L2591293-1** | | | | | | |
| Fecal Coliforms | | 52 | 44 | | MPN/100mL | 17 | 65 | 21-MAY-21 |
| **WG3539754-1 MB** | | | | | | | | |
| Fecal Coliforms | | | <1 | | MPN/100mL | | 1 | 21-MAY-21 |
| **FC10-QT97-WP** | **Water** | | | | | | | |
| **Batch R5465799** | | | | | | | | |
| **WG3540578-2 DUP** | | **L2591293-2** | | | | | | |
| Fecal Coliforms | | 100 | 90 | | MPN/100mL | 13 | 65 | 21-MAY-21 |
| **WG3540578-1 MB** | | | | | | | | |
| Fecal Coliforms | | | <1 | | MPN/100mL | | 1 | 21-MAY-21 |
| **N-TOTKJ-WP** | **Water** | | | | | | | |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **N-TOTKJ-WP** | **Water** | | | | | | | |
| **Batch R5475341** | | | | | | | | |
| **WG3543531-6 LCS** | | | | | | | | |
| Total Kjeldahl Nitrogen | | | 96.6 | | % | | 75-125 | 30-MAY-21 |
| **WG3543531-5 MB** | | | | | | | | |
| Total Kjeldahl Nitrogen | | | <0.20 | | mg/L | | 0.2 | 30-MAY-21 |
| **NH3-COL-WP** | **Water** | | | | | | | |
| **Batch R5471879** | | | | | | | | |
| **WG3542554-10 LCS** | | | | | | | | |
| Ammonia, Total (as N) | | | 99.96 | | % | | 85-115 | 26-MAY-21 |
| **WG3542554-9 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.010 | | mg/L | | 0.01 | 26-MAY-21 |
| **NO2-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5471397** | | | | | | | | |
| **WG3540500-2 LCS** | | | | | | | | |
| Nitrite (as N) | | | 100.0 | | % | | 90-110 | 22-MAY-21 |
| **WG3540500-6 LCS** | | | | | | | | |
| Nitrite (as N) | | | 99.2 | | % | | 90-110 | 24-MAY-21 |
| **WG3540500-1 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.010 | | mg/L | | 0.01 | 22-MAY-21 |
| **WG3540500-5 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.010 | | mg/L | | 0.01 | 24-MAY-21 |
| **NO3-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5471397** | | | | | | | | |
| **WG3540500-2 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.1 | | % | | 90-110 | 22-MAY-21 |
| **WG3540500-6 LCS** | | | | | | | | |
| Nitrate (as N) | | | 100.0 | | % | | 90-110 | 24-MAY-21 |
| **WG3540500-1 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 22-MAY-21 |
| **WG3540500-5 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 24-MAY-21 |
| **P-T-COL-WP** | **Water** | | | | | | | |
| **Batch R5475476** | | | | | | | | |
| **WG3543890-22 LCS** | | | | | | | | |
| Phosphorus (P)-Total | | | 98.8 | | % | | 80-120 | 29-MAY-21 |
| **WG3543890-21 MB** | | | | | | | | |
| Phosphorus (P)-Total | | | 0.0070 | B | mg/L | | 0.003 | 29-MAY-21 |

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **P-T-COL-WP** | **Water** | | | | | | | |
| **Batch R5477818** | | | | | | | | |
| **WG3546928-2 LCS** | | | | | | | | |
| Phosphorus (P)-Total | | | 96.9 | | % | | 80-120 | 03-JUN-21 |
| **WG3546928-1 MB** | | | | | | | | |
| Phosphorus (P)-Total | | | <0.0030 | | mg/L | | 0.003 | 03-JUN-21 |
| **SOLIDS-TOTSUS-WP** | **Water** | | | | | | | |
| **Batch R5475530** | | | | | | | | |
| **WG3542198-2 LCS** | | | | | | | | |
| Total Suspended Solids | | | 101.6 | | % | | 85-115 | 27-MAY-21 |
| **WG3542198-1 MB** | | | | | | | | |
| Total Suspended Solids | | | <3.0 | | mg/L | | 3 | 27-MAY-21 |

# Quality Control Report



**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

**Sample Parameter Qualifier Definitions:**

| Qualifier | Description |
|---|---|
| B | Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable. |

**Hold Time Exceedances:**

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Contact: Judy Dalmaijer
Company: ALS Laboratory Group
Address: Unit 12 - 1329 Niakwa Rd. E.,
Winnipeg, MB R2J 3T4

## REFERENCE DATA

Project: L2591293
PO Number: L2591293
ALS Work Order: 21051530

NARRATIVE: No standard method currently exists for characterization using microscopy. ALS combines a variety of microscopy techniques customized to individual client needs in an effort to characterize, identify, size, and/or quantify particles, fibers, and other known or unknown materials in air, water, dust, and bulk samples. Sample collection is performed outside ALS and is the responsibility of the client. Samples disposed after 60 days. TEM grids archived for 3 years. Results apply only to portions of samples analyzed. Microscopy is not suitable for examination of all types of materials. Therefore, additional testing may be required.

NOTES: Heavy concentrations of particulate may severely limit the amount of sample that can be examined. Particle characterization via optical and/or electron microscopy requires evenly dispersed particles with adequate separation allowing detection of individual particle perimeters for calculating area in microns. Samples analyzed via electron microscopy may incorporate static image analysis in which a series of representative digital photomicrographs are collected, converted to binary threshold images and analyzed for particle size by total area in square microns. By this method agglomerated masses of particles are indistinguishable from individual ones.
*NA=Not Applicable, AS=Analytical Sensitivity, MSL=Millions of Structures per Liter*

## IDENTIFICATION

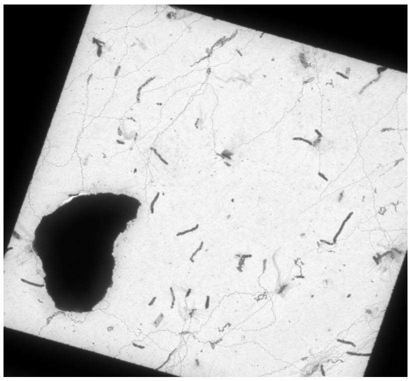
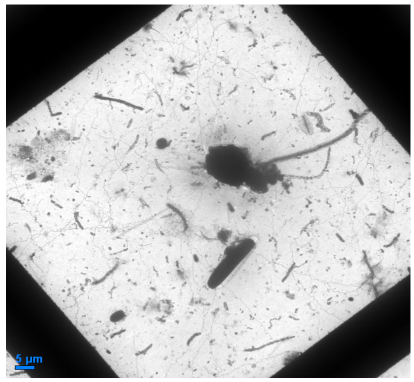
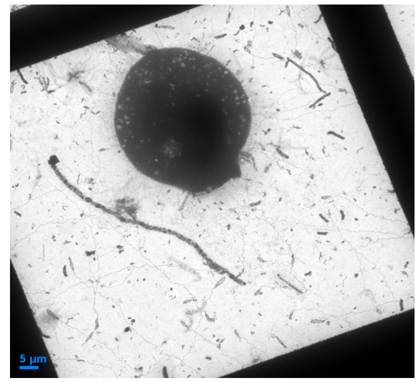
| | | | |
|---|---|---|---|
| Client ID: | L2591293-1 / W1 ([redacted]) | L2591293-2 / M2 ([redacted]) | L2591293-3 / M3 ([redacted] W3) |
| ALS ID: | 21051530-01 | 21051530-02 | 21051530-03 |
| **ANALYSIS** | | | |
| Analyst: | Pamela Hizar | Pamela Hizar | Pamela Hizar |
| Date: | 6/6/21 | 6/6/21 | 6/6/21 |
| Volume (L): | 0.0001 | 0.0001 | 0.0001 |
| AS (MSL): | 192 | 192 | 192 |
| **CONCENTRATION (MSL)** | | | |
| $>0<100\mu m^2$: | 75,933 | 182,738 | 184,848 |
| $\geq 100<200\mu m^2$: | <AS | 192 | <AS |
| $\geq 200<300\mu m^2$: | <AS | 192 | 192 |
| $\geq 300<400\mu m^2$: | <AS | 384 | <AS |
| $\geq 400<500\mu m^2$: | <AS | <AS | <AS |
| $\geq 500<600\mu m^2$: | <AS | <AS | <AS |
| $\geq 600<700\mu m^2$: | 192 | <AS | <AS |
| $\geq 700<800\mu m^2$: | <AS | <AS | <AS |
| $\geq 800<900\mu m^2$: | <AS | <AS | <AS |
| $\geq 900<1{,}000\mu m^2$: | <AS | <AS | <AS |
| $\geq 1{,}000\mu m^2$: | <AS | <AS | 192 |
| **TOTAL:** | **76,125** | **183,505** | **185,231** |

## NOTES

The vast majority of particles detected were unidentified organics (see attached images).

## PHOTOMICROGRAPHS

*Collected using Gatan Digital Micrograph.*

| L2591293-1 / W1 ([redacted]) | L2591293-2 / M2 ([redacted]) | L2591293-3 / M3 [redacted] W3) |
| --- | --- | --- |
| 21051530-01 | 21051530-02 | 21051530-03 |
|  |   |   |

ALS Environmental
www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2591293-COFC

COC Number: 17 - 876806

Page of

| Report To | Contact and company name below will appear on the final report |
|---|---|
| Company: | Dillon Consulting |
| Contact: | Charlie Pogue |
| Phone: | 204 453 2301 |
| | Company address below will appear on the final report |
| Street: | 1558 Willson Pl |
| City/Province: | Winnipeg / MB. |
| Postal Code: | R3T 0Y4 |

| Report Format / Distribution | |
|---|---|
| Select Report Format: | [X] PDF [X] EXCEL [X] EDD (DIGITAL) |
| Quality Control (QC) Report with Report | [X] YES [ ] NO |
| [ ] Compare Results to Criteria on Report - provide details below if box checked | |
| Select Distribution: | [X] EMAIL [ ] MAIL [ ] FAX |
| Email 1 or Fax | cpogue@dillon.ca |
| Email 2 | kmacintyre@dillon.ca |
| Email 3 | dbell@dillon.ca |

| Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply) | |
|---|---|
| Regular [R] [X] | Standard TAT if received by 3 pm - business days - no surcharges apply |
| PRIORITY (Business Days): 4 day [P4-20%] [ ] | EMERGENCY: 1 Business day [E - 100%] [ ] |
| 3 day [P3-25%] [ ] | Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] [ ] |
| 2 day [P2-50%] [ ] | |
| Date and Time Required for all E&P TATs: | dd-mmm-yy hh:mm |

For tests that can not be performed according to the service level selected, you will be contacted.

| Invoice To | | |
|---|---|---|
| Same as Report To | [✓] YES | [ ] NO |
| Copy of Invoice with Report | [✓] YES | [ ] NO |
| Company: | | |
| Contact: | | |

| Invoice Distribution | |
|---|---|
| Select Invoice Distribution: | [ ] EMAIL [ ] MAIL [ ] FAX |
| Email 1 or Fax | |
| Email 2 | |

| Project Information | |
|---|---|
| ALS Account # / Quote #: | |
| Job #: | 19-9041-1726 |
| PO / AFE: | |
| LSD: | |
| ALS Lab Work Order # (lab use only): | |

| Oil and Gas Required Fields (client use) | |
|---|---|
| AFE/Cost Center: | PO# |
| Major/Minor Code: | Routing Code: |
| Requisitioner: | |
| Location: | |
| ALS Contact: | Sampler: CP |

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | NUMBER OF CONTAINERS | Particle Size Dist. | BOD | Routine Chemistry | Nutrients | Bacteria | Analysis as per bottle order | | SAMPLES ON HOLD | SUSPECTED HAZARD (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W1 ([redacted]) | May.31/21 | 8:54AM | SW | 5 | X | X | X | X | X | | | | |
| | M2 ([redacted]) | " | " | " | 5 | X | X | X | X | X | | | | |
| | (W3) M3 ([redacted]) | " | " | " | 5 | X | X | X | X | X | | | | |
| | MT4 ([redacted]) | " | " | " | 4 | | X | X | X | X | | | | |
| | B5 ([redacted]) | " | " | " | 4 | | X | X | X | X | | | | |
| | Watchorn | " | " | " | 2 | | X | | X | | | | | |
| | S6 ([redacted]) | " | " | " | 4 | | X | X | X | X | | | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System? [ ] YES [ ] NO

Are samples for human consumption/ use? [ ] YES [ ] NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen [ ] SIF Observations Yes [ ] No [ ]
Ice Packs [ ] Ice Cubes [ ] Custody seal intact Yes [ ] No [ ]
Cooling Initiated [ ]

INITIAL COOLER TEMPERATURES °C | FINAL COOLER TEMPERATURES °C

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: | Time: | Received by: T.L. 7.18 | Date: 5/4 /21 | Time: 4:02 PM | Received by: | Date: | Time: |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

L2591293-COFC



# Bottle Order Request

4/26/2021 2:59 PM

ALS

**Bottle Order #:** BR311801
**Lab:** WINNIPEG
**Account #:** W984
**Order Created By:** Craig Riddell, B.Sc.Ag
**Expected Date:** 4/27/2021 9:00 AM
**Order Priority:** Regular
**Ship/Pickup Via:** Pick Up by Client
**Waybill Number:**
**Prepared Date:**
**Prepared By:**

**Company:** Dillon Consulting Engineers-Winnipeg
**Client Contact:** Charlie Pogue
**Address:** 1558 Willson Place

Winnipeg, MB, R3T 0Y4

**Phone Number:** 204-453-2301
**Fax Number:** 204-452-4412

**Client Job Number:** WASTE WATER SAMPLING - 8 SETS FOR BOD, ROUTINE , NUTRIENTS, BACTERIA AND PARTICLE SIZE DISTRIBUTION (TEM) & 2 BOD & 2 NUTRIEN

**Checked By:** ______ Date ______ Initials

**Comments:**
8 x 500 ml BOD
8 x 250 ml Routine Chemistry Bottles (TSS, Alkalinity, NO3, NO2 portion of N-TOT)
8 x 100 ml Amber Nutrient Bottles (COD, Ammonia, P-T , TKN portion of N-TOT)
8 x 250 ml Sterile Bacteria Bottles with Sodium thiosulfate (Fecal Coliform FC-QT97-WP)
8 x 1 L for Particle Size Distribution analysis in Water by TEM (Special Request-CI ( ALS Cincinnati )

2 additional sets

2 x 500 ml BOD
2 x 100 ml Amber Nutrient / COD pre-charged with sulfuric acid

| | Qty | Item (Analysis) | Container | Colour | Preservative | Instructions # |
|---|---|---|---|---|---|---|
| ☐ | 8 | 1 L HDPE Particle Size Distribution TEM | 1 L Polyethylene | | No Preservative | 3,8 |
| ☐ | 10 | BOD (500mL) | 500 mL | | No Preservative | 3,8,27 |
| ☐ | 8 | Bacteriological | 250 mL Sterilized Plastic | +Coli/coc | Sodium Thiosulfate | 3,5,9,27 |
| ☐ | 10 | NUT/TOC/COD/TKN/TN/TP /NH3/PHEN (BC) | 100mL amber glass with septa cap | Purple | H2SO4-Precharged | 3,5,11 |
| ☐ | 8 | Routine | 250 mL Polyethylene | | No Preservative | 3,8 |

**Please note the "Instructions #" above for the sample containers and items shipped to you. Find the corresponding number below and follow the instructions/guidelines.**

| Instructions # | Guideline |
|---|---|
| 3 | Keep cool (4oC). |
| 5 | CAUTION: preservative already in container. |
| 8 | No preservative. |
| 9 | Sodium Thiosulphate (Na2O3S2): irritant- in case of contact with skin, rinse affected area several times with cold water. |

Dillon Consulting Engineers-Winnipeg
ATTN: Charlie Pogue
1558 Willson Place
Winnipeg MB R3T 0Y4

Date Received: 07-JUN-21
Report Date: 17-JUN-21 15:12 (MT)
Version: FINAL

Client Phone: 204-453-2301

# Certificate of Analysis

Lab Work Order #: L2597728
Project P.O. #: NOT SUBMITTED
Job Reference: 19-9041-1726
C of C Numbers:
Legal Site Desc:

Barb Bayer, B.Sc.
General Manager, Winnipeg

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Sample Details/Parameters | Result | Qualifier* | D.L. | Units | Extracted | Analyzed | Batch |
|---|---|---|---|---|---|---|---|
| L2597728-1 W7 ([redacted]) | | | | | | | |
| Sampled By: RW on 06-JUN-21 | | | | | | | |
| Matrix: SW | | | | | | | |
| **Alkalinity species as HCO3, CO3, OH** | | | | | | | |
| **Alkalinity, Bicarbonate** | | | | | | | |
| Bicarbonate (HCO3) | 11500 | | 1.2 | mg/L | | 15-JUN-21 | |
| **Alkalinity, Carbonate** | | | | | | | |
| Carbonate (CO3) | 94.6 | | 0.60 | mg/L | | 15-JUN-21 | |
| **Alkalinity, Hydroxide** | | | | | | | |
| Hydroxide (OH) | <0.34 | | 0.34 | mg/L | | 15-JUN-21 | |
| **Alkalinity, Total (as CaCO3)** | | | | | | | |
| Alkalinity, Total (as CaCO3) | 9590 | | 1.0 | mg/L | | 14-JUN-21 | R5490425 |
| **Miscellaneous Parameters** | | | | | | | |
| Ammonia, Total (as N) | 7.70 | | 0.20 | mg/L | | 14-JUN-21 | R5491498 |
| Biochemical Oxygen Demand | <1500 | | 1500 | mg/L | | 09-JUN-21 | R5491173 |
| Chemical Oxygen Demand | 1260 | | 10 | mg/L | | 11-JUN-21 | R5487660 |
| Phosphorus (P)-Total | 29.7 | | 0.30 | mg/L | | 17-JUN-21 | R5492378 |
| Total Suspended Solids | 806 | | 30 | mg/L | | 10-JUN-21 | R5489301 |
| **Nitrogen Total** | | | | | | | |
| **Nitrate in Water by IC** | | | | | | | |
| Nitrate (as N) | <0.40 | | 0.40 | mg/L | | 09-JUN-21 | R5481042 |
| **Nitrate+Nitrite** | | | | | | | |
| Nitrate and Nitrite as N | <0.45 | | 0.45 | mg/L | | 09-JUN-21 | |
| **Nitrite in Water by IC** | | | | | | | |
| Nitrite (as N) | <0.20 | | 0.20 | mg/L | | 09-JUN-21 | R5481042 |
| **Total Kjeldahl Nitrogen** | | | | | | | |
| Total Kjeldahl Nitrogen | 380 | | 200 | mg/L | 09-JUN-21 | 10-JUN-21 | R5483162 |
| **Total Nitrogen Calculated** | | | | | | | |
| Total Nitrogen | 380 | | 200 | mg/L | | 10-JUN-21 | |

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

# Reference Information

**Test Method References:**

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| ALK-CO3CO3-CALC-WP | Water | Alkalinity, Carbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by carbonate is calculated and reported as mg CO3 2-/L.

| | | | |
|---|---|---|---|
| ALK-HCO3HCO3-CALC-WP | Water | Alkalinity, Bicarbonate | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by bicarbonate is calculated and reported as mg HCO3-/L

| | | | |
|---|---|---|---|
| ALK-OHOH-CALC-WP | Water | Alkalinity, Hydroxide | CALCULATION |

The Alkalinity of water is a measure of its acid neutralizing capacity.Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. The fraction of alkalinity contributed by hydroxide is calculated and reported as mg OH-/L.

| | | | |
|---|---|---|---|
| ALK-TITR-WP | Water | Alkalinity, Total (as CaCO3) | APHA 2320B |

The Alkalinity of water is a measure of its acid neutralizing capacity. Alkalinity is imparted by bicarbonate, carbonate and hydroxide components of water. Total alkalinity is determined by titration with a strong standard mineral acid to the successive HCO3- and H2CO3 endpoints indicated electrometrically.

| | | | |
|---|---|---|---|
| BOD-WP | Water | Biochemical Oxygen Demand (BOD) | APHA 5210 B |

Samples are diluted and seeded and then incubated in airtight bottles at 20°C for 5 days. Dissolved oxygen is measured initially and after incubation, and results are computed from the difference between initial and final DO.

| | | | |
|---|---|---|---|
| COD-WP | Water | Chemical Oxygen Demand | APHA 5220 D |

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colorimetric method.

| | | | |
|---|---|---|---|
| EC-SCREEN-WP | Water | Conductivity Screen (Internal Use Only) | APHA 2510 |

Qualitative analysis of conductivity where required during preparation of other test eg. IC, TDS, TSS, etc

| | | | |
|---|---|---|---|
| ETL-N-TOT-ANY-WP | Water | Total Nitrogen Calculated | Calculated |
| N-TOTKJ-WP | Water | Total Kjeldahl Nitrogen | APHA 4500 NorgD (modified) |

Aqueous samples are digested in a block digester with sulfuric acid and copper sulfate as a catalyst. Total Kjeldahl Nitrogen is then analyzed using a discrete analyzer with colorimetric detection.

| | | | |
|---|---|---|---|
| NH3-COL-WP | Water | Ammonia by colour | APHA 4500 NH3 F |

Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.

| | | | |
|---|---|---|---|
| NO2+NO3-CALC-WP | Water | Nitrate+Nitrite | CALCULATION |
| NO2-IC-N-WP | Water | Nitrite in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| NO3-IC-N-WP | Water | Nitrate in Water by IC | EPA 300.1 (mod) |

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

| | | | |
|---|---|---|---|
| P-T-COL-WP | Water | Phosphorus, Total | APHA 4500 P PHOSPHORUS-L |

This analysis is carried out using procedures adapted from APHA METHOD 4500-P "Phosphorus". Total Phosphorus is determined colourmetrically after persulphate digestion of the sample.

| | | | |
|---|---|---|---|
| SOLIDS-TOTSUS-WP | Water | Total Suspended Solids | APHA 2540 D (modified) |

Total suspended solids in aquesous matrices is determined gravimetrically after drying the residue at 103 105°C.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| WP | ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA |

# Reference Information

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
| --- | --- | --- | --- |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.*
*mg/kg - milligrams per kilogram based on dry weight of sample*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight*
*mg/L - unit of concentration based on volume, parts per million.*
*< - Less than.*
*D.L. - The reporting limit.*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Quality Control Report



Client: Dillon Consulting Engineers-Winnipeg
1558 Willson Place
Winnipeg MB R3T 0Y4

Contact: Charlie Pogue

| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **ALK-TITR-WP** | **Water** | | | | | | | |
| **Batch R5490425** | | | | | | | | |
| **WG3554948-4 LCS** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | 102.8 | | % | | 85-115 | 14-JUN-21 |
| **WG3554948-1 MB** | | | | | | | | |
| Alkalinity, Total (as CaCO3) | | | <1.0 | | mg/L | | 1 | 14-JUN-21 |
| **BOD-WP** | **Water** | | | | | | | |
| **Batch R5491173** | | | | | | | | |
| **WG3550351-2 LCS** | | | | | | | | |
| Biochemical Oxygen Demand | | | 101.0 | | % | | 85-115 | 09-JUN-21 |
| **WG3550351-1 MB** | | | | | | | | |
| Biochemical Oxygen Demand | | | <2.0 | | mg/L | | 2 | 09-JUN-21 |
| **COD-WP** | **Water** | | | | | | | |
| **Batch R5487660** | | | | | | | | |
| **WG3553259-6 LCS** | | | | | | | | |
| Chemical Oxygen Demand | | | 107.2 | | % | | 85-115 | 11-JUN-21 |
| **WG3553259-5 MB** | | | | | | | | |
| Chemical Oxygen Demand | | | <10 | | mg/L | | 10 | 11-JUN-21 |
| **N-TOTKJ-WP** | **Water** | | | | | | | |
| **Batch R5483162** | | | | | | | | |
| **WG3550011-10 LCS** | | | | | | | | |
| Total Kjeldahl Nitrogen | | | 96.5 | | % | | 75-125 | 10-JUN-21 |
| **WG3550011-9 MB** | | | | | | | | |
| Total Kjeldahl Nitrogen | | | <0.20 | | mg/L | | 0.2 | 10-JUN-21 |
| **NH3-COL-WP** | **Water** | | | | | | | |
| **Batch R5491498** | | | | | | | | |
| **WG3556227-2 LCS** | | | | | | | | |
| Ammonia, Total (as N) | | | 99.0 | | % | | 85-115 | 14-JUN-21 |
| **WG3556227-1 MB** | | | | | | | | |
| Ammonia, Total (as N) | | | <0.010 | | mg/L | | 0.01 | 14-JUN-21 |
| **NO2-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5481042** | | | | | | | | |
| **WG3546635-10 LCS** | | | | | | | | |
| Nitrite (as N) | | | 101.7 | | % | | 90-110 | 09-JUN-21 |
| **WG3546635-9 MB** | | | | | | | | |
| Nitrite (as N) | | | <0.010 | | mg/L | | 0.01 | 09-JUN-21 |
| **NO3-IC-N-WP** | **Water** | | | | | | | |

ALS Environmental

# Quality Control Report



| Test | Matrix | Reference | Result | Qualifier | Units | RPD | Limit | Analyzed |
|---|---|---|---|---|---|---|---|---|
| **NO3-IC-N-WP** | **Water** | | | | | | | |
| **Batch R5481042** | | | | | | | | |
| **WG3546635-10 LCS** | | | | | | | | |
| Nitrate (as N) | | | 98.9 | | % | | 90-110 | 09-JUN-21 |
| **WG3546635-9 MB** | | | | | | | | |
| Nitrate (as N) | | | <0.020 | | mg/L | | 0.02 | 09-JUN-21 |
| **P-T-COL-WP** | **Water** | | | | | | | |
| **Batch R5492378** | | | | | | | | |
| **WG3557002-6 LCS** | | | | | | | | |
| Phosphorus (P)-Total | | | 95.7 | | % | | 80-120 | 17-JUN-21 |
| **WG3557002-5 MB** | | | | | | | | |
| Phosphorus (P)-Total | | | <0.0030 | | mg/L | | 0.003 | 17-JUN-21 |
| **SOLIDS-TOTSUS-WP** | **Water** | | | | | | | |
| **Batch R5489301** | | | | | | | | |
| **WG3551524-5 LCS** | | | | | | | | |
| Total Suspended Solids | | | 107.3 | | % | | 85-115 | 10-JUN-21 |
| **WG3551524-4 MB** | | | | | | | | |
| Total Suspended Solids | | | <3.0 | | mg/L | | 3 | 10-JUN-21 |

**Legend:**

| | |
|---|---|
| Limit | ALS Control Limit (Data Quality Objectives) |
| DUP | Duplicate |
| RPD | Relative Percent Difference |
| N/A | Not Available |
| LCS | Laboratory Control Sample |
| SRM | Standard Reference Material |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| ADE | Average Desorption Efficiency |
| MB | Method Blank |
| IRM | Internal Reference Material |
| CRM | Certified Reference Material |
| CCV | Continuing Calibration Verification |
| CVS | Calibration Verification Standard |
| LCSD | Laboratory Control Sample Duplicate |

# Quality Control Report



**Hold Time Exceedances:**

| ALS Product Description | Sample ID | Sampling Date | Date Processed | Rec. HT | Actual HT | Units | Qualifier |
|---|---|---|---|---|---|---|---|
| **Aggregate Organics** | | | | | | | |
| Biochemical Oxygen Demand (BOD) | | | | | | | |
| | 1 | 06-JUN-21 | 09-JUN-21 07:00 | 48 | 67 | hours | EHTL |

**Legend & Qualifier Definitions:**

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2597728 were received on 07-JUN-21 16:20.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental

www.alsglobal.com

# Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2597728-COFC

COC Number: 17 - 876807

Page of

| Report To | Contact and company name below will appear on the final report |
|---|---|
| Company: | Dillon Consulting |
| Contact: | Charlie Pogue |
| Phone: | 204 453 2301 |
| | Company address below will appear on the final report |
| Street: | 1558 Willson Pl. |
| City/Province: | Winnipeg, MB |
| Postal Code: | R3T 0Y4 |
| Invoice To | Same as Report To [X] YES [ ] NO |
| | Copy of Invoice with Report [X] YES [ ] NO |
| Company: | |
| Contact: | |

**Report Format / Distribution**

Select Report Format: [X] PDF [X] EXCEL [X] EDD (DIGITAL)

Quality Control (QC) Report with Report [X] YES [ ] NO

[ ] Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: [X] EMAIL [ ] MAIL [ ] FAX

Email 1 or Fax: cpogue@dillon.ca

Email 2

Email 3

**Invoice Distribution**

Select Invoice Distribution: [ ] EMAIL [ ] MAIL [ ] FAX

Email 1 or Fax

Email 2

**Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)**

Regular [R] [X] Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days): 4 day [P4-20%] [ ] 3 day [P3-25%] [ ] 2 day [P2-50%] [ ]

EMERGENCY: 1 Business day [E - 100%] [ ]; Same Day, Weekend or Statutory holiday [E2 -200% (Laboratory opening fees may apply)] [ ]

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

**Project Information**

ALS Account # / Quote #:

Job #: 19-9041-1726

PO / AFE:

LSD:

**Oil and Gas Required Fields (client use)**

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only):

ALS Contact:

Sampler: RW

**Analysis Request** — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

| ALS Sample # (lab use only) | Sample Identification and/or Coordinates (This description will appear on the report) | Date (dd-mmm-yy) | Time (hh:mm) | Sample Type | Number of Containers | Alkalinity | BOD | COD | Total Nitrogen | Nitrate/Nitrite | Total Ammonia | TKN | Total Phosphorus | Total Suspended Solids | Samples on Hold | Suspected Hazard (see Special Instructions) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W7 ([redacted]) | June 6/21 | | SW | 3 | X | X | X | X | X | X | X | X | X | | |

**Drinking Water (DW) Samples[1] (client use)**

Are samples taken from a Regulated DW System? [ ] YES [ ] NO

Are samples for human consumption/ use? [ ] YES [ ] NO

**Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)**

**SAMPLE CONDITION AS RECEIVED (lab use only)**

Frozen [ ] SIF Observations Yes [ ] No [ ]

Ice Packs [ ] Ice Cubes [ ] Custody seal intact Yes [ ] No [ ]

Cooling Initiated [X]

INITIAL COOLER TEMPERATURES °C: 1.8°C

FINAL COOLER TEMPERATURES °C

| SHIPMENT RELEASE (client use) | | | INITIAL SHIPMENT RECEPTION (lab use only) | | | FINAL SHIPMENT RECEPTION (lab use only) | | |
|---|---|---|---|---|---|---|---|---|
| Released by: | Date: | Time: | Received by: 07Jun21 BW | Date: 07Jun21 | Time: 16:20 | Received by: | Date: | Time: |

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JUNE 2018 FRONT

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.