DIAVIK DIAMOND MINES (2012) INC.

AQUATIC EFFECTS MONITORING PROGRAM 2021 ANNUAL REPORT

Submitted to:

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DISTRIBUTION

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March 2022
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PO No. 3104897490

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APPENDIX II

EFFLUENT AND WATER CHEMISTRY REPORT

EFFLUENT AND WATER CHEMISTRY REPORT IN SUPPORT OF THE 2021 AEMP ANNUAL REPORT FOR THE DIAVIK DIAMOND MINE, NORTHWEST TERRITORIES

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Executive Summary

In 2021, Diavik Diamond Mines (2012) Inc. completed the field component of its Aquatic Effects Monitoring Program (AEMP) in Lac de Gras, Northwest Territories, as required by Water Licence W2015L2-0001, according to the *AEMP Design Plan Version 5.2* approved by the Wek'èezhìı Land and Water Board. This report presents the analyses of effluent and water chemistry data collected during the 2021 AEMP field sampling, and from relevant stations in the Surveillance Network Program. The objective of the water quality monitoring component of the AEMP was to assess effects of the Diavik Diamond Mine (Mine) on water quality in Lac de Gras. Initial data analyses were completed to identify substances of interest (SOIs), which are a subset of variables with potential Mine-related effects.

Concentrations of regulated effluent variables were below applicable Water Licence effluent quality criteria in the 2021 monitoring period, and effluent toxicity testing indicated that the effluent was not toxic to aquatic life. Nearly all concentrations of variables measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water. No additional variables were added to the SOI list in 2021 based on the effluent and mixing zone screening results.

During the ice-cover season, elevated conductivity was measured in the bottom two-thirds of the water column in the near-field (NF) area, indicating the depth range where the effluent plume was located. Dissolved oxygen (DO) concentrations and pH values were typically uniform throughout the water column or decreased slightly with depth. Water temperature increased gradually with depth at most stations and turbidity was typically uniform throughout the water column. During the open-water season, in situ water quality measurements for conductivity, DO, water temperature, pH, and turbidity profiles were typically uniform throughout the water column.

At AEMP sampling stations, three total manganese samples collected during the ice-cover season exceeded the AEMP drinking water Effects Benchmark. Laboratory pH values were below the Effects Benchmark in many samples; however, these occurrences were likely natural and unrelated to Mine discharge, as the effluent is slightly alkaline (median pH of 7.4) and because there is no spatial pattern in pH in relation to the diffuser. Furthermore, values of pH below 6.5 naturally occur throughout Lac de Gras, during both the ice-cover and open-water seasons, at various depths, and over time (i.e., 2002 to 2020). Concentrations of all variables in all other samples collected during the 2021 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water.

Water quality variables analyzed in 2021 were initially evaluated for inclusion as SOIs against four criteria. Twenty-three variables met the criteria for inclusion as SOIs in 2021. No variables were added to the SOI list in 2021 based on the effluent or mixing zone screening results (Criterion 1 and 2).

Water quality variables were assessed for a Mine-related effect in Lac de Gras according to Action Levels in the Response Framework. There are nine Action Levels defined in the Response Framework for water chemistry. Twenty variables demonstrated an effect equivalent to Action Level 1 and included total dissolved solids (TDS), turbidity (lab), calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, manganese, molybdenum, silicon, strontium, and uranium. With NF area median concentrations greater than two times the median concentrations in the reference dataset, these variables were identified as SOIs (Criterion 3).

Of the 20 SOIs that triggered Action Level 1, nine also triggered Action Level 2 and included TDS, chloride, sodium, sulphate, nitrate, molybdenum, silicon, strontium, and uranium. These variables had 5^{th} percentile concentrations in the NF area that were greater than two times the median concentration in the reference dataset and were greater than the normal range for Lac de Gras. None of the SOIs triggered Action Level 3.

Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for most of the 20 SOIs that triggered Action Levels 1 or 2 in 2021 based on a graphical and statistical evaluation of the data. An exception was turbidity, which had an increasing trend with distance from the Mine effluent discharge in the ice-cover season. The results of these analyses provided confirmation that the increases observed in the NF area for these variables were related to the Mine effluent discharge.

Water quality variables were assessed for effects at stations potentially affected by Mine-related dust emissions. Fifteen variables had concentrations greater than two times the median of the reference dataset at one or more of the four MF area stations located within the estimated zone of influence (ZOI) from dust deposition from the Mine; these variables were identified as SOIs (Criterion 4). Of these 15 SOIs, 12 also triggered Action Level 1 in the NF area, indicating that the exceedances at the MF stations were likely caused by dispersion of Mine effluent into the lake. The remaining three variables (i.e., boron, lithium, and zinc) did not trigger Action Level 1 in the NF area and had median concentrations at one or more of the four MF stations that were elevated compared to the median of the NF area concentrations. While there is some potential that these elevated values may be related to dust deposition, this interpretation is not supported by the absence of similar increases at the other stations within the ZOI; in addition, spatial trends within the ZOI were consistent with effects originating from the Mine effluent. Overall, analysis of the water quality results in 2021 provided no evidence to suggest that Mine-related dust is affecting the water quality of Lac de Gras. Although dust deposition has the potential to contribute to effects on water quality during certain times of the year (e.g., ice break-up, extreme wind events), several lines of evidence suggest that isolating the specific effects from dust emissions on water quality in Lac de Gras from other Mine sources (e.g., the effluent) is not possible or necessary to manage Mine-related effects in Lac de Gras.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

Acronyms and Abbreviations

AEMP	Aquatic Effects Monitoring Program
AIC	Akaike's information criterion
AICc	Akaike's information criterion, corrected for small sample size
AL	Action Level
ALS	ALS Laboratories
BV Labs	Bureau Veritas Laboratories, formerly Maxxam Analytics
$CaCO_3$	calcium carbonate
CALA	Canadian Association of Laboratory Accreditation
CFU	colony forming unit
CWQGs	Canadian Water Quality Guidelines
DDMI	Diavik Diamond Mines (2012) Inc.
DL	detection limit
DO	dissolved oxygen
DOC	dissolved organic carbon
DQO	data quality objective
EA	Environmental Assessment
e.g.	for example
et al.	and more than one additional author
EQC	effluent quality criteria
FF	far-field
Golder	Golder Associates Ltd.
IC	ice-cover
i.e.	that is
LDG	Lac de Gras
LDS	Lac du Sauvage
MF	mid-field
Mine	Diavik Diamond Mine
Mine centroid	geographic centre of the Mine
MZ	mixing zone
NF	near-field
NIWTP	North Inlet Water Treatment Plant
OW	open-water
P	probability
QA/QC	quality assurance/quality control
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
r^2	coefficient of determination
R^2	coefficient of multiple determination

RPD	relative percent difference
SD	standard deviation
SES	special effects study
SNP	Surveillance Network Program
SOI	substance of interest
SOP	Standard Operating Procedure
TDS	total dissolved solids
TSS	total suspended solids
WLWB	Wek'èezhìı Land and Water Board
ZOI	zone of influence

Symbols and Units of Measure

%	percent
>	greater than
<	less than
×	times
µg/L	micrograms per litre
µg-N/L	micrograms nitrogen per litre
µg-P/L	micrograms phosphorus per litre
µS/cm	microsiemens per centimetre
km	kilometre
km^2	square kilometre
m	metre
mg/L	milligrams per litre
mL	millilitre
NTU	nephelometric turbidity unit

1 INTRODUCTION

1.1 Background

In 2021, Diavik Diamond Mines (2012) Inc. (DDMI) completed the field component of its Aquatic Effects Monitoring Program (AEMP) for the Diavik Diamond Mine (Mine), as required by Water Licence W2015L2-0001 (WLWB 2021). This report presents the analysis of effluent and water chemistry data collected during the 2021 sampling year, which was carried out by Golder Associates Ltd. (Golder) according to the *AEMP Design Plan Version 5.2* (Golder 2020a).

While the Mine effluent discharge is the main source of Mine-related constituents to Lac de Gras and the most likely factor responsible for effects in the receiving environment, the potential influence of other Mine sources (e.g., dust deposition) on water quality in Lac de Gras are also considered herein. Water chemistry data for the Mine effluent and mixing zone boundary in Lac de Gras were obtained from the Surveillance Network Program (SNP) for the Mine, while water quality data in Lac de Gras were collected as part of AEMP field programs, which were carried out by DDMI staff according to the *AEMP Design Plan Version 5.2* (Golder 2020a) and the associated *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017b).

1.2 Objectives

The overall objective of the water quality monitoring component of the AEMP is to assess the effects of the Mine on water quality in Lac de Gras. Water chemistry data were analyzed to determine whether there were differences in water quality between areas exposed to Mine-related inputs and reference conditions for Lac de Gras (as defined in the *AEMP Reference Conditions Report Version 1.4* [Golder 2019a]) and to evaluate spatial trends in water quality in Lac de Gras.

1.3 Scope and Approach

The 2021 AEMP water quality survey in Lac de Gras was carried out according to the requirements specified in the *AEMP Design Plan Version 5.2* for an interim monitoring year (Golder 2020a). In an interim year, the effects on water quality in Lac de Gras are assessed by evaluating whether an Action Level has been triggered, and a spatial analysis of effects is completed by evaluating trends in water quality variables in relation to the diffusers in Lac de Gras. The chemistry of Mine effluent and lake water at the mixing zone boundary in Lac de Gras was also summarized, including an evaluation of seasonal variation. Temporal trends are evaluated in Aquatic Effects Re-evaluation Reports (e.g., Golder 2019b, 2020b), rather than annual reports.

Water quality variables were assessed for a Mine-related effect using gradient analysis and according to Action Levels described in the *AEMP Design Plan Version 5.2* (Golder 2020a). The magnitude, extent, and importance of effects have been defined in the Action Level criteria. Field measurements (i.e., depth profile data) are discussed qualitatively, and nutrients (i.e., phosphorus and nitrogen) are evaluated in the Eutrophication Indicators Report (Appendix XIII).

The results of the water quality Action Level screening were used in combination with an assessment of effluent and mixing zone chemistry, and potential effects from dust deposition from the Mine, to identify a subset of variables with potential Mine-related effects, referred to as substances of interest (SOIs). The intent of defining SOIs was to identify a meaningful set of variables for further analyses, while limiting analyses for variables that were less likely to be affected by the Mine.

Water quality variables were assessed for the presence of spatial trends with distance from the Mine-effluent diffusers in Lac de Gras, and in relation to stations located within the estimated zone of influence (ZOI) from dust deposition. Gradient analysis in the form of linear regressions along the three mid-field (MF) transects were completed for SOIs that triggered Action Levels. Finally, SOIs were evaluated for seasonal trends in the Mine effluent and at the mixing zone boundary in Lac de Gras.

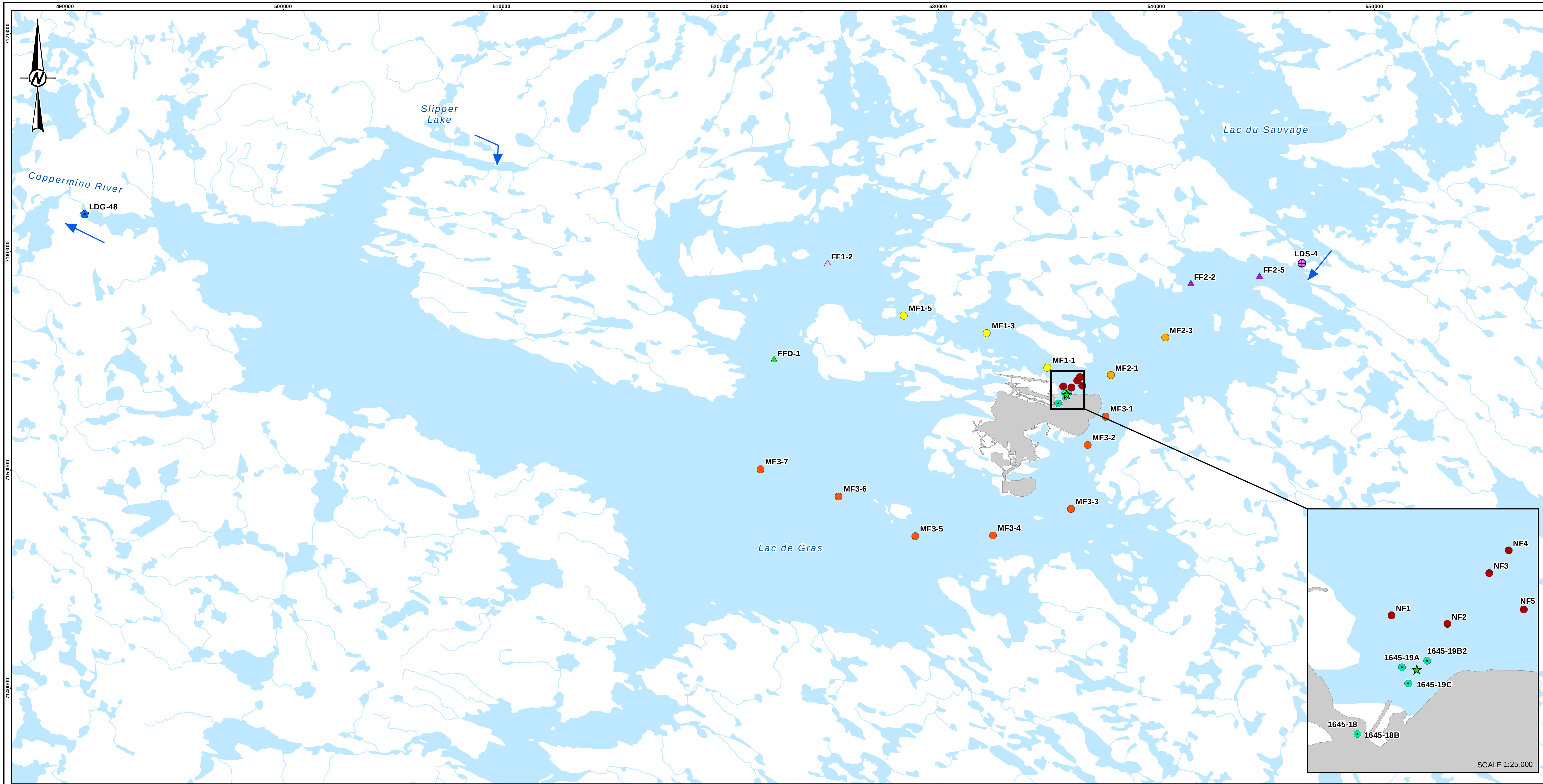
2 METHODS

2.1 Field Sampling

The 2021 water quality field sampling program included in situ water quality measurements and collection of water samples for chemical analysis. The in situ water column profile measurements were taken at AEMP stations using a multi-parameter water quality meter (YSI) following the methods described in DDMI's Standard Operating Procedure (SOP) ENVI-684-0317 "SOP YSI ProDSS". Collection of water samples followed the protocols described in ENVI-923-0119 "AEMP SOP Combined Open Water and Ice Cover". Water samples were handled according to ENVI-902-0119 "SOP Quality Assurance Quality Control" and ENVI-900-0119 "SOP Chain of Custody".

Effluent and water quality data collected in support of the Mine's SNP were incorporated herein. Data were summarized for the period of effluent discharge from 1 November 2020 to 31 October 2021. Treated effluent from the North Inlet Water Treatment Plant (NIWTP) was sampled from within the NIWTP (Figure 2-1), prior to discharge at SNP 1645-18 (the original diffuser station in Lac de Gras), and SNP 1645-18B (the second diffuser station, which became operational in September 2009). Both diffusers discharged continuously to Lac de Gras throughout the 2021 monitoring period. Sampling was completed every six days at each discharge point.

Water quality sampling at the mixing zone boundary was completed monthly at three stations (i.e., SNP 1645-19A, SNP 1645-19B2, SNP 1645-19C), which are located along a semi-circle, approximately 60 m from the effluent diffusers (Figure 2-1). These stations represent the edge of the mixing zone, which covers an area of approximately 0.01 km^2. Sampling at the mixing zone boundary occurred monthly at the water surface (2 m depth) and at 5 m depth intervals (5, 10, 15, and 20 m depth) at each station for the duration of the 2021 monitoring period. Sampling did not occur during the month of June 2021 due to unsafe ice conditions.



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD

- FLOW DIRECTION
- WATERCOURSE
- DIAVIK FOOTPRINT
- WATERBODY

0 5 10
1:175,000 KILOMETRES

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

TITLE
LOCATIONS OF AEMP WATER QUALITY SAMPLING STATIONS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
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Water quality sampling at AEMP stations in 2021 was carried out according to the sampling design for an interim year AEMP, which includes sampling in the NF and MF areas of the lake (Golder 2020a). The far-field (FF) areas in Lac de Gras are sampled every third year during the comprehensive monitoring program to allow for detailed assessment of Mine-related effects. The next comprehensive monitoring program is scheduled for 2022.

In total, water quality samples were collected at 23 stations in 2021 (Figure 2-1). Sampling occurred at a cluster of five replicate stations in the NF area (i.e., NF1 to NF5), three MF areas (i.e., MF1, MF2, and MF3), and two FF stations (i.e., FF1-2 and FFD-1). Three stations were in the MF1 area (i.e., MF1-1, MF1-3, MF1-5), four stations in the MF2 area (i.e., MF2-1, MF2-3, FF2-2, FF2-5), and seven stations in the larger MF3 area (i.e., MF3-1 to MF3-7). The NF, MF, and FF stations were approximately 20 m deep. Single stations were sampled at each of the Lac de Gras outflow to the Coppermine River (LDG-48) and the Lac du Sauvage outflow to Lac de Gras (LDS-4). Coordinates of the AEMP stations, and their approximate distance from the Mine effluent diffusers along the most direct flow path are provided in Table 2-1.

Sampling stations in the MF areas are arranged along transects that run from the NF area towards the FF areas (i.e., FF1, FFA, and FFB; the latter two FF areas and four of the five FF1 stations are not sampled in interim years and, therefore, are not shown on Figure 2-1). The MF1 transect is located northwest of the NF area and runs towards the FF1 area. The new station FFD-1, located between the FF1 and MF3 areas, provides data to assess the spatial extent of effects extending from the existing MF1/FF1 areas into the northern channel area of Lac de Gras, east of the East Island. Therefore, FFD-1 forms a part of the existing MF1 transect. The MF2 transect is located to the northeast and includes the FF2 stations near the Lac du Sauvage (LDS) inlet. The MF3 transect is located south of the NF area, and runs towards the FFB and FFA areas.

The 2021 AEMP water quality sampling occurred over two monitoring seasons: ice-cover and open-water. Ice-cover season (i.e., late winter) sampling occurred from 19 April to 9 May 2021. Open-water sampling occurred from 15 August to 15 September 2021. The same locations were sampled in each season, with the exception of LDS-4, which was sampled in the open-water season only. A detailed sampling schedule for the 2021 AEMP is provided in Attachment A, Table A-1.

Stations in the NF and MF areas were sampled at three depths (i.e., top, middle, and bottom) during each season, as these stations were likely to have vertical gradients in water quality due to the Mine discharge. Near-surface water samples (top) were collected at a depth of 2 m below the water surface, and bottom samples were collected at a depth of 2 m above the lake bottom. Mid-depth samples were collected from the mid-point of the total water column depth. Stations FF1-2, FFD-1, LDG-48, and LDS-4 were sampled at mid-depth only.

2.2 Laboratory Analysis

Water samples were shipped to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics Inc.) in Calgary, Alberta (AB), or Edmonton, AB, Canada for analysis of general parameters, major ions, nutrients and total metals[1]. In 2021, water samples were analyzed for ammonia by both BV Labs in Calgary or Edmonton, and ALS Laboratories (ALS) in Vancouver, BC, Canada. A list of the variables analyzed by BV Labs in 2021 is provided in Table 2-2.

Laboratory detection limits (DLs) represent the lowest concentration of a substance that can be reliably measured by the analytical laboratory. The target DLs for the AEMP are defined in the *AEMP Design Plan Version 5.2* (Golder 2020a) and are summarized in Table 2-2. Deviations from the target DLs and potential effects on data quality are discussed in Attachment B.

Table 2-1 Locations of the 2021 AEMP Water Quality Monitoring Stations

Area	Station	UTM Coordinates		Distance from Diffusers(a) (m)
		Easting	Northing	
NF	NF1	535740	7153854	394
	NF2	536095	7153784	501
	NF3	536369	7154092	936
	NF4	536512	7154240	1,131
	NF5	536600	7153864	968
MF1	MF1-1	535008	7154699	1,452
	MF1-3	532236	7156276	4,650
	MF1-5	528432	7157066	8,535
MF2	MF2-1	538033	7154371	2,363
	MF2-3	540365	7156045	5,386
FF2	FF2-2	541588	7158561	8,276
	FF2-5	544724	7158879	11,444
MF3	MF3-1	537645	7152432	2,730
	MF3-2	536816	7151126	4,215
	MF3-3	536094	7148215	7,245
	MF3-4	532545	7147011	11,023
	MF3-5	528956	7146972	14,578
	MF3-6	525427	7148765	18,532
	MF3-7	521859	7150039	22,330
FF1	FF1-2	524932	7159476	12,915
-(c)	FFD-1	522495	7155084	17,315
Outlet of Lac de Gras	LDG-48	490900	7161750	55,556
Outlet of Lac du Sauvage	LDS-4	547191	7160256	-(b)

a) Approximate distance from the Mine effluent diffusers along the most direct path of effluent flow.
b) Distance not shown as the station is located upstream of Lac de Gras.
c) Stations designated FFD do not represent a distinct FF sampling area.
UTM = Universal Transverse Mercator, NAD83, Zone 12V; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage; - = not applicable.

[1] The term metal is used throughout this report and includes non-metals (i.e., selenium) and metalloids (i.e., arsenic).

Table 2-2 Detection Limits for Water Quality Analysis, 2021

Variable	Unit	Detection Limit[(a)]
Conventional Parameters		
pH – lab	pH units	-
Specific conductivity – lab	µS/cm	1
Total hardness as $CaCO_3$	mg/L	0.5
Total alkalinity as $CaCO_3$	mg/L	0.5
Total dissolved solids, calculated	mg/L	-
Total dissolved solids, measured	mg/L	1
Total suspended solids	mg/L	1
Total organic carbon	mg/L	0.2
Turbidity – lab	NTU	0.1
Major Ions		
Bicarbonate	mg/L	0.5
Calcium (dissolved)	mg/L	0.01
Carbonate	mg/L	0.5
Chloride	mg/L	0.5
Fluoride	mg/L	0.01
Hydroxide	mg/L	0.5
Magnesium (dissolved)	mg/L	0.005
Potassium (dissolved)	mg/L	0.01
Sodium (dissolved)	mg/L	0.01
Sulphate	mg/L	0.5[(b)]
Nutrients		
Ammonia	µg-N/L	5
Nitrate	µg-N/L	2
Nitrite	µg-N/L	1
Nitrate + nitrite	µg-N/L	2
Total Kjeldahl nitrogen	µg-N/L	20
Total dissolved nitrogen	µg-N/L	20
Total nitrogen	µg-N/L	20
Soluble reactive phosphorus	µg-P/L	1
Total dissolved phosphorus	µg-P/L	2
Total phosphorus	µg-P/L	2
Total Metals		
Aluminum	µg/L	0.2
Antimony	µg/L	0.02
Arsenic	µg/L	0.02
Barium	µg/L	0.02
Beryllium	µg/L	0.01
Bismuth	µg/L	0.005
Boron	µg/L	5
Cadmium	µg/L	0.005
Calcium	mg/L	0.01
Chromium	µg/L	0.05
Cobalt	µg/L	0.005
Copper	µg/L	0.05
Iron	µg/L	1
Lead	µg/L	0.005
Lithium	µg/L	0.5
Magnesium	mg/L	0.005
Manganese	µg/L	0.05
Mercury	µg/L	0.0019[(c)]
Molybdenum	µg/L	0.05
Nickel	µg/L	0.02
Potassium	mg/L	0.01
Selenium	µg/L	0.04
Silicon	µg/L	50
Silver	µg/L	0.005
Sodium	mg/L	0.01
Strontium	µg/L	0.05
Sulphur	mg/L	0.5[(b)]
Thallium	µg/L	0.002
Tin	µg/L	0.01
Titanium	µg/L	0.5
Uranium	µg/L	0.002
Vanadium	µg/L	0.05
Zinc	µg/L	0.1
Zirconium	µg/L	0.05

a) Detection limits for a subset of results (n = 137; 1.1% of total results) were raised in 2021; details and a discussion of potential effects on data quality are provided in Attachment B.
b) Similar to previous years, sulphate and sulphur were analyzed at a DL of 0.5 mg/L or 0.6 mg/L (versus a requested DL of 0.05 mg/L and 0.1 mg/L, respectively) due to limitations of the current analytical method. A discussion of potential effects on data quality is provided in Attachment B.
c) Total and dissolved mercury were analyzed at a DL of 0.0019 µg/L (versus a requested DL of 0.002 µg/L) to be below the lowest guideline (i.e., 0.002 µg/L).
µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; $CaCO_3$ = calcium carbonate.

2.3 Quality Assurance/Quality Control

The *Quality Assurance Project Plan Version 3.1* (Golder 2017b) outlines the quality assurance (QA) and quality control (QC) procedures employed to support the collection of scientifically defensible and relevant data for addressing the objectives of the AEMP. A description of QA/QC practices applied to the water quality component of the 2021 AEMP and an evaluation of the QC data are provided in Attachment B. A summary of the ammonia QC issues identified during the 2021 AEMP sampling is provided herein. With the exception of the specific circumstances summarized below and in Attachment B, data collected during the 2021 AEMP were considered to be of acceptable quality.

2.3.1 Ammonia Investigation

In 2021, DDMI sent lake water quality samples to both BV Labs and ALS for analysis of ammonia. The reader is also directed to Appendix 4B of the *2014 to 2016 Aquatic Effects Re-evaluation Report Version 1.1* (Golder 2019b) and Appendix B of the 2017, 2018, 2019, and 2020 AEMP annual effluent and water chemistry reports (Golder 2018, 2019c, 2020d, 2021) for a review of the history of the data quality issues identified for ammonia and a description of recent investigations and follow-up studies.

As in the 2020 open-water season, BV Lab ammonia samples for 2021 were submitted unpreserved, due to concerns with contamination from the preservative observed in previous sampling rounds.

BV Labs completed a review of the ice-cover season ammonia data reported by both laboratories and found that the BV Labs data were affected by contamination (details are include in Appendix B), whereas the ALS data had fewer data quality issues. Therefore, the ALS ice-cover dataset were used in the 2021 data analyses.

An inter-laboratory comparison study of the open-water data conducted by BV Labs determined that the two open-water datasets were similar; however, the BV Labs open-water data were recommended for reporting. This recommendation was implemented in the 2021 AEMP data analyses.

Further details on efforts to improve ammonia data quality in 2021 are provided in Attachment B, including results of the 2021 inter-laboratory comparison studies. Although there were data quality issues for ammonia in 2021, these issues have not compromised the ability to detect Mine-related effects on ammonia that would result in adverse effects on aquatic life. Data quality issues are related to detecting ammonia at low concentrations, near the DL (5 µg-N/L), within the range of 5 to 50 µg-N/L. These low concentrations are at the absolute limit of instrument sensitivity and, as a result, are subject to high uncertainty. The AEMP Effects Benchmark for ammonia is 4,730 µg-N/L, and the lowest Action Level criterion based on the Effects Benchmark (i.e., Action Level 3: top of normal range plus 25% of Effects Benchmark) is 1,186 µg-N/L, which is well above the range where QC issues related to the low DL have been encountered. DDMI will continue to work with the analytical laboratory to determine a path forward for ammonia analysis for future monitoring.

2.4 Data Analysis

2.4.1 Overview and Substances of Interest

Initial data analyses were completed to identify SOIs (i.e., a subset of variables with the potential to show Mine-related effects). The criteria used to select SOIs are defined in the *AEMP Design Plan Version 5.2* (Golder 2020a) and are summarized as follows:

- *Criterion 1:* effluent chemistry data collected at SNP 1645-18 and SNP 1645-18B were compared to effluent quality criteria (EQC) defined in the Water Licence (Sections 2.4.4.2 and 3.2.4). Variables with concentrations in individual grab samples greater than EQC for the Maximum Average Concentration (Table 2-4) were included as SOIs.
- *Criterion 2:* variables with concentrations at the mixing zone boundary (i.e., SNP 1645-19A, SNP 1645-19B2, SNP 1645-19C) that exceeded AEMP Effects Benchmarks (Table 2-5; Sections 2.4.4.3 and 3.2.5) were included in the SOI list, provided there was not a large percentage of values below the DL (i.e., greater than 90%).
- *Criterion 3:* water quality variables were assessed according to Action Levels in the Response Framework (Sections 2.4.5.1 and 3.5). Variables that triggered Action Level 1 in the NF area were added to the SOI list. Action Level 1 is triggered if the median of the NF area data is greater than two times the median of the reference dataset, together with strong evidence of a link to the Mine.
- *Criterion 4:* variables that triggered an effect equivalent to Action Level 1 at individual MF area stations that fall within the ZOI from dust deposition in Lac de Gras (i.e., between 0.3 and 4.2 km from the boundary of the Mine footprint [Golder 2020b]: MF1-1, MF3-1, MF3-2, and MF3-3) were added to the SOI list (Sections 2.4.5.4 and 3.7).

Water quality variables analyzed in 2021 (Table 2-2) were initially evaluated for inclusion as SOIs against the above noted four criteria, with the exception of the following analytes or variables:

- dissolved oxygen (DO), temperature, pH, and specific conductivity (i.e., variables associated with in situ water column profile measurements) which are assessed in Section 3.3
- carbonate and hydroxide, which are not detected at the pH range encountered in Lac de Gras
- bicarbonate, which is redundant with total alkalinity and not a parameter of toxicological concern
- hardness, which is integrated into the calculation of Effects Benchmarks for certain parameters (e.g., copper, lead, nickel), but is not a parameter of toxicological concern itself
- nutrients that are generally not toxic to aquatic organisms (i.e., phosphorus and some forms of nitrogen), which are evaluated in the Eutrophication Indicators Report (Appendix XIII)
- nitrate+nitrite, which was evaluated separately as nitrate and nitrite

- dissolved metals; metals were evaluated in terms of the total concentrations[2], which have AEMP Effects Benchmarks (Section 2.4.4.3) and defined reference conditions for Lac de Gras (as described in the *AEMP Reference Conditions Report Version 1.4* [Golder 2019a])

Data for nitrogen parameters that may be toxic to aquatic organisms at elevated concentrations were summarized herein (i.e., ammonia, nitrate, and nitrite) and in the Eutrophication Indicators Report (Appendix XIII), because they also have the potential to result in nutrient enrichment.

Variables that triggered Action Level 1 were retained as SOIs (Section 3.5.1). In 2021, the total forms of the major ions calcium, magnesium, potassium, and sodium in the NF area also triggered Action Level 1. To avoid redundancy, and match methods from previous annual reports, graphing and statistical analyses were conducted on the dissolved fractions only. Similarly, while both total dissolved solids (TDS; calculated) and TDS (measured) triggered Action Level 1, to avoid redundancy, the analysis was focused on TDS (calculated).

Analyses completed on SOIs that met one or more of the criteria listed above, along with references to the location where the methods and results for each analysis can be found in the report, are summarized in Table 2-3.

Table 2-3 Data Analyses Completed on Substances of Interest

Analysis	SOIs	Location in Report
An examination of loads in Mine effluent and effluent chemistry (from SNP 1645-18 and 1645-18B)	SOIs that met Criteria 1 to 3	Sections 2.4.4 and 3.2
An examination of water chemistry at the edge of the mixing zone (from SNP 1645-19A, 1645-19B2, 1645-19C)	SOIs that met Criteria 1 to 3	Sections 2.4.4 and 3.2
An assessment of the magnitude and extent of effects, as defined by the Action Level criteria in the Response Framework for water quality	All SOIs	Sections 2.4.5.1 and 3.5
An evaluation of spatial trends in SOI concentrations with distance from the diffusers, including linear regression analysis of data along the MF transects	SOIs that met Criteria 1 to 3	Sections 2.4.5.2 and 3.6
An examination of potential effects from dust deposition	SOIs that met Criterion 4	Sections 2.4.5.4 and 3.7

SNP = Surveillance Network Program; SOI = substance of interest.

[2] Three metals have AEMP Effects Benchmarks for the dissolved concentrations (i.e., aluminum, manganese, and zinc). The dissolved metal concentrations for these three metals were used in the Effects Benchmark comparison. If one of these variables met Criterion 2, the total concentration would be added to the SOI list to avoid redundancy.

2.4.2 Data Screening

Initial screening of the SNP and AEMP datasets was completed prior to data analyses to identify unusually high or low values and decide whether to exclude anomalous data from further analysis. An explanation of the objectives and approach taken to complete the initial screening is provided in the *Quality Assurance Project Plan Version 3.1* (Golder 2017b), or QAPP, and in Attachment C.

Results of the initial screening for anomalous values in the SNP and AEMP datasets are presented in Attachment C, Tables C-1 to C-3. The SNP data screening identified 16 anomalous values in the effluent dataset and eight anomalous values in the mixing zone dataset, representing 0.2% and 0.06% (respectively) of the data within each dataset. In total, 23 anomalous values were identified within the AEMP water quality dataset, representing 0.2% of the data. In cases where unusual values were identified in the SNP and AEMP datasets, scatterplots were generated to allow a visual review of the excluded data (Attachment C, Figures C-1 to C-11).

2.4.3 Censored Data

For the purpose of the AEMP, censored data are concentrations reported below the analytical DL (referred to as non-detect values). Due to the location of Lac de Gras on the Canadian Shield, concentrations of many water quality variables are low and are frequently measured at or below the DL. A commonly used, simple approach to deal with censored data is the substitution of a surrogate value (e.g., the DL or some fraction of the DL) for non-detect data, which is considered acceptable in cases when a relatively small proportion of the data (less than 15%) are below the DL (US EPA 2000).

Prior to data analyses, non-detect values were substituted with half the DL (i.e., 0.5 times the DL). This approach for handling censored data (US EPA 2000) is consistent with the approved methods applied in the calculation of the normal range in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). Data measured at less than the DL are presented on plots at half the DL. The non-parametric (i.e., percentile based) methods used to assess Action Levels for water quality in this report (Section 2.4.5.1) minimized the influence of using a substitution method for handling censored data. Handling of censored data in statistical analysis of water quality data is discussed in Section 2.4.5.2.

2.4.4 Effluent and Mixing Zone Assessment

The effluent discharge from the NIWTP to Lac de Gras was assessed in terms of quantity and quality. The period of effluent discharge summarized in this report was 1 November 2020 to 31 October 2021. Concentrations of SOIs at the mixing zone boundary are also presented.

2.4.4.1 Trends in Effluent and at the Mixing Zone Boundary

Trends in effluent quantity were evaluated graphically (i.e., as bar charts) by plotting total monthly discharge volumes (cubic metres per month) and loading rates (kilograms per month) of SOIs that met selection criteria 1 to 3 as defined in Section 2.4.1. Mean daily loads for each SOI were calculated by multiplying the discharge rate by the concentration at each effluent diffuser station (SNP 1645-18, SNP 1645-18B). Linear interpolation was used to estimate the concentrations between sampling events. The total monthly load was estimated as the sum of daily loads from the two diffusers. One SOI, turbidity (Section 3.1), was excluded from this assessment because load is not a relevant measure for turbidity.

Graphs showing the concentrations of SOIs in the effluent that met criteria 1 to 3 were generated for the 2021 discharge period and are presented in Section 3.2. Results for individual grab samples were plotted separately for each station. Water sampling at the mixing zone boundary is completed monthly at surface and 5 m depth intervals at three stations (i.e., SNP 1645-19A, SNP 1645-19B2 and SNP 1645-19C). Therefore, up to 15 samples were collected each month. Results were summarized as boxplots showing 10^{th}, 25^{th}, 50^{th} (i.e., median), 75^{th}, and 90^{th} percentile concentrations; on these plots, circles represent the 5th and 95th percentile concentrations.

2.4.4.2 Comparison to Effluent Quality Criteria

The quality of the effluent discharged to Lac de Gras via the North Inlet was assessed by comparing water chemistry results at SNP 1645-18 and SNP 1645-18B with the EQC defined in the Water Licence and in Table 2-4. In addition to the criteria listed in Table 2-4, all discharges from the NIWTP to Lac de Gras must have a pH between 6.0 to 8.4 (WLWB 2021). The comparison of phosphorus to the applicable EQC is discussed in the Eutrophication Indicators Report (Appendix XIII). Maximum average and maximum grab sample concentrations in the effluent from November 2020 to October 2021 were compared to the EQC for the Mine. Variables with concentrations in effluent that exceeded the EQC were included in the SOI list.

Table 2-4 Effluent Quality Criteria for Discharge to Lac de Gras

Variable	Units	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Total ammonia	µg-N/L	6,000	12,000
Total aluminum	µg/L	1,500	3,000
Total arsenic	µg/L	50	100
Total copper	µg/L	20	40
Total cadmium	µg/L	1.5	3
Total chromium	µg/L	20	40
Total lead	µg/L	10	20
Total nickel	µg/L	50	100
Total zinc	µg/L	10	20
Nitrite	µg-N/L	1,000	2,000
Total suspended solids	mg/L	15	25
Turbidity	NTU	10	15
Biochemical oxygen demand	mg/L	15	25
Total petroleum hydrocarbons	mg/L	3	5
Fecal coliforms	CFU/100 mL	10	20

Source: WLWB (2021)

µg-N/L = micrograms nitrogen per litre; NTU = nephelometric turbidity unit; CFU = colony forming units.

2.4.4.3 Comparison to Effects Benchmarks

Water quality in Lac de Gras at the edge of the mixing zone was compared to the AEMP Effects Benchmarks presented in Table 2-5. Variables with concentrations at the mixing zone boundary that exceeded AEMP Effects Benchmarks were included in the SOI list (Section 2.4.1). Water chemistry results at the edge of the mixing zone were also evaluated as part of the Action Level screening (Section 2.4.5.1).

Effects Benchmarks represent concentrations intended to protect human health or aquatic life. They are based on the Canadian Water Quality Guidelines (CWQGs) for the protection of aquatic life (CCME 1999), the Canadian Drinking Water Quality Guidelines (Health Canada 1996, 2020), guidelines from other jurisdictions (e.g., provincial and state guidelines), adaptations of general guidelines to site-specific conditions in Lac de Gras (Appendix IV.1 in DDMI 2007), or when appropriate, values from the scientific literature.

The CWQGs are intended to provide protection of freshwater life from anthropogenic stressors such as chemical inputs or physical changes (CCME 1999). These guidelines are based on current, scientifically-defensible toxicological data and are intended to protect all forms of aquatic life, including the most sensitive life stage of the most sensitive species over the long term. The Canadian Drinking Water Quality Guidelines are based on published scientific research related to health effects, aesthetic effects and operational considerations (Health Canada 1996, 2020). Health-based guidelines are established based on comprehensive review of the known health effects associated with each chemical, exposure levels, and availability of water treatment and analytical technologies. Aesthetic effects (e.g., taste, odour) are considered when these play a role in determining whether consumers will consider the water drinkable. For variables with both aquatic life and drinking water values, the Effects Benchmark is the lower of the two.

The Effects Benchmarks used for the AEMP are generally consistent with those established during the Environmental Assessment (EA), referred to as ecological thresholds in the EA, but have incorporated a number of revisions to maintain their relevance over time for the Lac de Gras environment. Under the Response Framework for water chemistry, an Effects Benchmark must be established for water quality variables that trigger Action Level 2 if an Effects Benchmark does not already exist. As a result, DDMI has developed Effects Benchmarks for seven variables: turbidity, dissolved calcium, dissolved sodium, total aluminum, total antimony, total silicon, and total tin (Golder 2020a, WLWB 2019).

As in 2020, Effects Benchmarks for the protection of aquatic life were added for dissolved manganese and dissolved zinc based on the updated CWQG for these variables in 2021. The CWQG for dissolved zinc replaces the previous aquatic life Effects Benchmark for total zinc (30 µg/L). Seven additional variables (pH, barium, cadmium, lead, manganese, selenium, and strontium) have updated Health Canada drinking water guidelines, which are not yet reflected in the design plan but are presented in Table 2-5. These updated guidelines were used in the screening presented herein.

Table 2-5 Effects Benchmarks for Water Quality Variables

Variable	Unit	Effects Benchmarks[(a)]	
		Protection of Aquatic Life	Drinking Water
Conventional Parameters			
Dissolved oxygen	mg/L	Cold water:	-
		early life stages = 9.5	
		other life stages = 6.5	
pH	pH Units	6.5 to 9.0	7.0 to 10.5[(l)]
Total dissolved solids	mg/L	500[(b)]	500
Total alkalinity	mg/L	n/a[(c)]	-
Total suspended solids	mg/L	+5 (24 h to 30 days)[(d)]	-
		+25 (24 h period)[(d)]	
Turbidity	NTU	2.2 (long term, IC)[(e)]	-
		2.3 (long term, OW)[(e)]	
Major Ions			
Calcium (dissolved)	mg/L	60[(m)]	-
Chloride	mg/L	120	250
Fluoride	mg/L	0.12	1.5
Sodium (dissolved)	mg/L	52[(e)]	200
Sulphate	mg/L	100[(f)]	500
Nutrients			
Ammonia	µg-N/L	4,730[(g)]	-
Nitrate	µg-N/L	3,000	10,000
Nitrite	µg-N/L	60	1,000
Total Metals			
Aluminum (total)	µg/L	87[(e)]	100/200[(h)]
Aluminum (dissolved)	µg/L	Variable with pH[(g,i)]	-
Antimony	µg/L	33[(e)]	6
Arsenic	µg/L	5	10
Barium	µg/L	1,000[(f)]	2,000[(l)]
Boron	µg/L	1,500	5,000
Cadmium	µg/L	0.1[(g)]	7[(l)]
Chromium	µg/L	1 (Cr VI)[(j)]	50
Copper	µg/L	2	1,000
Iron	µg/L	300	300
Lead	µg/L	1	5[(l)]
Manganese (total)	µg/L	-	20[(l)]
Manganese (dissolved)	µg/L	Variable with pH and Hardness[(n)]	-
Mercury	µg/L	0.026 (inorganic); 0.004 (methyl)	1
Molybdenum	µg/L	73	-
Nickel	µg/L	25	-
Selenium	µg/L	1	50[(l)]
Silicon	µg/L	2,100[(e)]	-
Silver	µg/L	0.25	-
Strontium	µg/L	30,000[(k)]	7,000[(l)]
Thallium	µg/L	0.8	-
Tin	µg/L	73[(e)]	-
Uranium	µg/L	15	20
Zinc (total)	µg/L	-	5,000
Zinc (dissolved)	µg/L	Variable with pH, Hardness, and DOC[(o)]	-

Source: Golder (2020a)

a) Unless noted, benchmarks are derived from current Canadian Water Quality Guidelines and Canadian Drinking Water Quality Guidelines; the Effects Benchmark is selected as the lesser of the two values.

b) Adopted from Alaska DEC (2012) and as directed by the WLWB (2013).

c) Alkalinity should not be less than 25% of natural background level. There is no maximum guideline (US EPA 1998); because this benchmark involves a decrease in alkalinity and the Mine effluent is slightly alkaline, this benchmark is not applicable.

d) Average increase of 5 mg/L (over a period of 24 hours to 30 days) or maximum increase of 25 mg/L in a 24 h-period.

e) See Appendix B of the *AEMP Design Plan Version 4.1* (Golder 2017a) for description.

f) BC MOE (2013).

g) See Appendix IV.1 in DDMI (2007) and BC MOE (2001) for description.

h) 100 µg/L for conventional treatment and 200 µg/L for other treatment types.

i) Benchmark value (mg/L) = $e[1.6-3.327(\text{median pH})+0.402(\text{median pH})^2]$ when median pH is less than 6.5 and is 50 µg/L when median pH is greater than or equal to 6.5 (BC MOE 2017).

j) Total chromium concentrations will be compared to the benchmark for chromium VI.

k) Based on results from HydroQual (2009) and Pacholski (2009).

l) Updated CCME or Health Canada drinking water guideline, which are not reflected in *AEMP Design Plan Version 5.2* (Golder 2020a).

m) See *AEMP Response Plan for Diavik Diamond Mine – Proposed Calcium Effects Benchmark* (Golder 2019d).

n) The CWQG for manganese (i.e., long-term guideline) is found using the CWQG calculator in Appendix B of the Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life: Manganese (CCME 2019).

o) Benchmark value (µg/L) = $e(0.947[\ln(\text{hardness mg}\cdot L^{-1})] - 0.815[\text{pH}] + 0.398[\ln(\text{DOC mg}\cdot L^{-1})] + 4.625)$ (CCME 2018).

- = benchmark not available; IC = ice-cover; OW = open-water; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; n/a = not applicable; DOC = dissolved organic carbon

2.4.4.4 Effluent Toxicity

Part G, Condition 36 and Annex 1 of the Water Licence requires toxicity testing of effluent discharged to Lac de Gras, as follows:

- acute lethality to Rainbow Trout, *Oncorhynchus mykiss*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/13
- acute lethality to the crustacean, *Daphnia magna*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/14
- chronic toxicity to the amphipod, *Hyalella azteca*, per a water-only protocol approved by the WLWB, if the maximum average concentration of total ammonia exceeds 3 mg/L at either SNP Station 1645-18 or 1645-18B
- chronic toxicity to early life stages of salmonid fish, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/28
- chronic toxicity to the crustacean, *Ceriodaphnia dubia*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/21
- chronic toxicity to the freshwater alga, *Pseudokirchneriella subcapitata*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/25

These toxicity tests are completed on a quarterly basis, with the exception of *Hyalella azteca* testing, which is only required if elevated levels of ammonia are observed in the treated effluent (see the Revision History Table in Annex 1 of the Water Licence).

Effluent samples were submitted to BV Labs in Burnaby, BC, or Edmonton, AB, Canada and Nautilus Environmental in Burnaby for toxicity testing. The effluent toxicity data collected during the 2021 reporting period were used to evaluate whether Mine effluent had the potential to cause toxic responses in biota in Lac de Gras.

The results of lethal and sublethal toxicity testing carried out on effluent samples from SNP 1645-18 and SNP 1645-18B were summarized for the 2021 reporting period. Results for lethal tests are presented as a "pass" or "fail" to be consistent with laboratory procedures and standards. A lethal test was considered a fail if a result of equal to or greater than 50% mortality in 100% effluent was obtained. Although not a requirement under the Water Licence, a sublethal test was considered a fail if the test results demonstrated sublethal effects equal to or greater than 50%, relative to the control.

2.4.5 AEMP Water Quality Assessment

2.4.5.1 Action Level Evaluation

Water quality variables were assessed for a Mine-related effect as described in the *AEMP Design Plan Version 5.2* (Golder 2020a). The main goal of the Response Framework is to ensure that significant adverse Mine-related effects never occur. This is accomplished by requiring proponents to take action at pre-defined Action Levels, which are triggered well before significant adverse effects could occur (Table 2-6). A significant adverse effect, as it pertains to water quality, was defined in the EA as a concentration of a variable that exceeds an established guideline for the protection of aquatic life and drinking water quality by more than 20% (Golder 2020a). This effect must have a high probability of being permanent or long-term in nature and must occur throughout Lac de Gras.

Water quality is assessed annually relative to Action Levels for water chemistry (Table 2-6). Magnitude of effects on water chemistry variables were determined by comparing concentrations between NF, MF, and FF sampling areas, reference conditions, and benchmark values. Reference conditions for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range. The normal ranges used in the Action Level screening for water quality are described in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a) and are summarized in Table 2-7. The water quality benchmark values used in the Action Level assessment (referred to herein as Effects Benchmarks), are discussed in Section 2.4.4.3 and are presented in Table 2-5. The magnitude of effect was classified according to the appropriate Action Level (Table 2-6).

Action Levels were assessed separately for the ice-cover and open-water seasons. The ice-cover season was defined as November to June, and the open-water season was defined as July to October. The results for all depths and stations sampled, both at the mixing zone boundary and at AEMP stations, were included in the calculation of the 2021 exposure values considered at each Action Level (Table 2-6).

Box and whisker plots were generated for SOIs that triggered an Action Level, to illustrate spatial variation in water quality in Lac de Gras and to show the 2021 results relative to the Action Levels. On these plots the box is bound by the 25th and 75th quantiles, with a thick line showing the median value. The whiskers depict the 10th and 90th quantiles, and points are used to show the 5th and 95th quantiles. Non-detect values were plotted at half the DL, to be consistent with data handling procedures used in the evaluation of Action Levels and estimation of the normal range (Golder 2019a).

Table 2-6 Action Levels for Water Chemistry, Excluding Indicators of Eutrophication

Action Level	Magnitude of Effect[a]	Extent of Effect	Action/Note
1	Median of NF greater than two times the median of reference dataset[b] (open-water or ice-cover) and strong evidence of link to Mine	NF	Early warning.
2	5th percentile of NF values greater than two times the median of reference areas AND normal range[b]	NF	Establish Effects Benchmark if one does not exist.
3	75th percentile of MZ values greater than normal range plus 25% of Effects Benchmark[c]	MZ	Confirm site-specific relevance of Effects Benchmark. Establish Effects Threshold. Define the Significance Threshold if it does not exist. The WLWB to consider developing an EQC if one does not exist
4	75th percentile of MZ values greater than normal range plus 50% of Effects Threshold[c]	MZ	Investigate mitigation options.
5	95th percentile of MZ values greater than Effects Threshold	MZ	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
6	95th percentile of NF values greater than Effects Threshold + 20%	NF	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
7	95th percentile of MF values greater than Effects Threshold + 20%	MF	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
8	95th percentile of FFB values greater than Effects Threshold + 20%	FFB	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
9	95th percentile of FFA values greater than Effects Threshold + 20%	FFA	Significance Threshold.[d]

a) Calculations were based on pooled data from all depths.

b) Normal ranges and reference datasets were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a); the normal range for open-water was based on the 15 August to 15 September period. In cases where the reference area median value reported in Golder (2019a) was equal to the DL, half the DL was used to calculate the 2× reference area median criterion, to be consistent with data handling methods used for the AEMP.

c) Indicates 25% or 50% of the difference between the Effects Benchmark/Threshold and the top of the normal range.

d) Although the Significance Threshold is not an Action Level, it is presented as the highest Action Level to show escalation of effects towards the Significance Threshold.

NF = near-field; MZ = mixing zone; MF = mid-field; FF = far-field; WLWB = Wek'èezhìı Land and Water Board; EQC = Effluent Quality Criteria.

Table 2-7 Normal Ranges for Water Chemistry Variables

Variable	Unit	Normal Range			
		Ice-cover		Open-water	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
Conventional Parameters					
Total alkalinity	mg/L	3.2	6.0	3.1	4.7
Total hardness	mg/L	5.0	7.0	4.0	6.0
Total dissolved solids, calculated	mg/L	2.9	6.5	3.8	5.8
Total dissolved solids, measured	mg/L	0	24	0	20
Total suspended solids	mg/L	0	1.0	0	1.0
Total organic carbon	mg/L	2.0	3.1	1.9	3.0
Turbidity – lab	NTU	0	0.18	0.13	0.29
Major Ions					
Calcium (dissolved)	mg/L	0.9	1.3	0.8	1.1
Chloride	mg/L	0	1.0	0	1.0
Fluoride	mg/L	0.02	0.03	0.019	0.03
Magnesium (dissolved)	mg/L	0.6	0.8	0.6	0.8
Potassium (dissolved)	mg/L	0.5	0.8	0.4	0.7
Sodium (dissolved)	mg/L	0	1.0	0	1.0
Sulphate	mg/L	1.9	2.5	1.7	2.1
Nutrients					
Ammonia	µg-N/L	14.3	23	0	5.0
Nitrate	µg-N/L	0	15.2	0	2.0
Nitrite	µg-N/L	0	2.0	0	2.0
Total Metals					
Aluminum	µg/L	2.3	3.9	3.4	6.2
Antimony	µg/L	0	0.02	0	0.02
Arsenic	µg/L	0.15	0.22	0.16	0.19
Barium	µg/L	1.74	2.18	1.61	1.94
Beryllium	µg/L	0	0.01	0	0.01
Bismuth	µg/L	0	0.005	0	0.005
Boron	µg/L	0	5.0	0	5.0
Cadmium	µg/L	0	0.005	0	0.005
Calcium	mg/L	0.94	1.15	0.87	1.00
Chromium	µg/L	0	0.06	0	0.06
Cobalt	µg/L	0.01	0.02	0.01	0.04
Copper	µg/L	0	0.8	0	0.6
Iron	µg/L	0	5.0	0	7.6
Lead	µg/L	0	0.007	0	0.006
Lithium	µg/L	1.2	1.5	1.2	1.3
Magnesium	mg/L	0.59	0.79	0.58	0.66
Manganese	µg/L	0.60	1.95	1.54	4.67
Mercury	µg/L	0	0.01	0	0.01
Molybdenum	µg/L	0.06	0.09	0.07	0.13
Nickel	µg/L	0.83	1.10	0.72	1.12
Potassium	mg/L	0.53	0.67	0.50	0.57
Selenium	µg/L	0	0.04	0	0.04
Silicon	µg/L	0	50	0	50
Silver	µg/L	0	0.005	0	0.005
Sodium	mg/L	0.56	0.75	0.55	0.68
Strontium	µg/L	6.70	8.78	6.51	8.01
Sulphur	mg/L	0.84	1.07	0.83	1.32
Thallium	µg/L	0	0.002	0	0.002
Tin	µg/L	0	0.01	0	0.01
Titanium	µg/L	0	0.5	0	0.5
Uranium	µg/L	0.027	0.030	0.024	0.029
Vanadium	µg/L	0	0.1	0	0.1
Zinc	µg/L	0.37	1.53	0.29	2.04
Zirconium	µg/L	0	0.05	0	0.05

Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a)
NTU = nephelometric turbidity unit; µg-N/L micrograms nitrogen per litre.

2.4.5.2 Gradient Analysis

Spatial gradients in water quality SOIs along the three MF transects were analyzed using linear regression, per the *AEMP Design Plan Version 5.2* (Golder 2020a). The NF area data were included in the linear regression for each of the three MF transects. The stations included in each MF transect are described in Section 2.1. The maximum values of top, middle and bottom depth samples for the three MF transects were used in the regression analysis. Regression results were considered significant at $\alpha = 0.05$.

Due to the spatial span of the MF3 transect, variables often had non-linear patterns with distance from the diffusers. Therefore, the analysis method allowed for piecewise regression (also referred to as segmented, or broken stick regression). Two approaches were used:

- Model 1: a linear multiplicative model, with main effects of distance from diffusers, gradient (MF1, MF2, and MF3 transects), and their interaction
- Piecewise modeling to account for changes in spatial gradients, where individual transects were analyzed separately from one another:
  - Model 2: a linear multiplicative model, with main effects of distance from diffusers, gradient (only MF1 and MF2 transects), and their interaction
  - Model 3: a linear piecewise (broken stick) model with distance (MF3 transect only)

For each variable in each season, Model 1 was used to test for presence of a significant (P<0.05) breakpoint (i.e., where the slopes of the linear regressions changed) using the Davies test (Davies 1987, 2002). If a significant breakpoint was identified, Models 2 and 3 were used for that variable in that season. If no significant breakpoint was identified, Model 1 was used for that variable in that season.

Following the initial fit of the model, the residuals (of either Model 1 or Model 2, as applicable) were examined for normality. Model 3 was not considered for transformations since the addition of a breakpoint was expected to resolve non-linear patterns. Box-Cox transformations were applied to the datasets for each variable (Box and Cox 1964). The Box-Cox transformations are a family of transformations that include the commonly used log and square root transformations. The Box-Cox transformation process tests a series of power values, usually between -2 and +2, and records the log-likelihood of the relationship between the response and the predictor variables under each transformation. The transformation that maximizes the log-likelihood is the one that will best normalize the data. Therefore, the data are transformed using a power value (λ) identified by the transformation process. For a λ of zero, the data are natural log transformed. The transformation rules can be described using the following definitions:

$$\text{Transformed value} = \frac{\text{value}^{\lambda} - 1}{\lambda} \quad \text{if } \lambda \neq 0$$

$$\text{Transformed value} = \ln(\text{value}) \quad \text{if } \lambda = 0$$

The selected transformation was applied to all data (i.e., a transformation selected based on Model 2 was also applied to MF3 data).

Following data transformation (if required), the selected models were fitted to the data. Statistical outliers were identified using studentized residuals with absolute values of 3.5 or greater, or due to consideration of leverage (where a single point could strongly influence the overall fit of the model). All values removed from the analysis were retained for plots of model predictions, where they were presented using a different symbol from the rest of the data.

Following removal of outliers, breakpoint significance and data transformation were re-examined. Residuals from the refitted models were examined for normality, heteroscedasticity, and evidence of non-linear patterns. If non-linearity was evident, the analysis was terminated and data were presented qualitatively. If normality was evident, three models were constructed to assess the effect of heteroscedasticity for each response variable in each season:

- heteroscedasticity by gradient (applied only to Models 1 and 2)
- heteroscedasticity by predicted value (accounting for the classic trumpet shape of heteroscedastic data)
- heteroscedasticity by distance from the diffuser

These three models were compared to the original model that did not account for heteroscedasticity, using Akaike's information criterion (AIC), corrected for small sample size (AICc). The model with the lowest AIC score among a set of candidate models was interpreted to have the strongest support, given the set of examined models and the collected data (Burnham and Anderson 2002), and thus was selected for interpretation. When using AIC not corrected for small sample size, models with AIC scores within two units of each other are considered to have similar levels of support (Arnold 2010). Since the small sample size correction was used in the analysis, the cut-off value was adjusted to reflect the higher penalization of model parameters (the adjustment depended on the number of data points and model parameters).

The constructed models were used to produce the following outputs:

- estimates and significance of slopes (i.e., distance effects) for each gradient; in the case of MF3 data analyzed using piecewise regression, the significance of the first slope, extending from the NF to the breakpoint, was calculated
- the r^2 or R^2 value of each model, to examine explained variability
- fitted prediction lines and 95% confidence intervals (back-transformed to original scale of the variable)

Analyses were performed using the R statistical environment and "segmented" package (Muggeo 2008).

Based on US EPA guidance, a screening value of greater than 15% censoring was used to flag datasets that may not be amenable to the linear regression analysis (US EPA 2000). The decision of whether to analyze the data using linear regression was based on review of the number of values less than the DL (<DL) according to variable and season. Because of large numbers of values <DL, linear regression analysis was not performed for:

- antimony: ice-cover (55% <DL) and open-water (69% <DL)
- chromium: ice-cover (33% <DL) and open-water (39% <DL)
- silicon: ice-cover (30% <DL) and open-water (93% <DL)

Scatterplots of concentrations according to distance from the effluent discharge were prepared for variables that had large numbers of values below the DL.

2.4.5.3 Comparison to Effects Benchmarks

The field and analytical data obtained from the AEMP water quality sampling programs were compared to Effects Benchmarks presented in the *AEMP Design Plan Version 5.2* (Golder 2020a) and in Table 2-5. These water quality benchmark values were also used in the Action Level screening at Action Level 3 (Section 2.4.5.1).

2.4.5.4 Effects from Dust Deposition

The AEMP water quality data analysis included an evaluation of effects on water quality at stations potentially affected by Mine-related dust emissions. Based on the analysis conducted for the last re-evaluation (Golder 2020b), the dust ZOI is estimated to extend between 3.7 and 4.8 km from the geographic centre of the Mine (Mine centroid), or between 0.3 and 4.2 km from the boundary of the Mine footprint. These distances were estimated based on gradient analysis of dust deposition relative to distance from the Mine site and encompass the area of the lake where potential effects would be expected to be measurable (Golder 2020b). Beyond this estimated zone, dust deposition levels are similar to background levels. The AEMP sampling stations that fall within the expected ZOI from dust deposition include the five stations in the NF area, and stations MF1-1, MF3-1, MF3-2, and MF3-3[3]. Among the stations sampled in the ZOI, the estimated dust deposition rate is higher in the NF area compared to the four MF stations, which is similar to the spatial trend in concentrations of water quality parameters resulting from effluent discharge (i.e., the two effects are spatially confounded).

The combined effects from discharge of Mine effluent, and potentially dust deposition, on water quality in the NF area were assessed according to the water quality Action Level 1 criteria (Section 2.4.5.1). A similar analysis was used to evaluate effects from dust deposition at the potentially affected stations in the MF area. Water quality variables at the aforementioned four MF stations with median concentrations (i.e., of top, middle, and bottom samples) that exceeded 2× the median of reference area data (i.e., the same criterion used in the assessment of Action Level 1 in the NF area) were considered potentially affected by dust emissions, in addition to effluent effects. The comparison to Action Level 1 criteria was only done for the open-water season data, because dust that is deposited on the ice during winter does not enter lake water until ice-off. If a variable triggered an effect equivalent to Action Level 1 at the MF stations identified above, but not the NF area (i.e., where the concentration of effluent is greatest), it was considered possible that water quality at these stations may have been influenced by a combination of dust deposition and effluent discharge.

However, the scenario described above is unlikely to provide clear evidence of a dust effect, because of the spatial overlap of effluent discharge and dust deposition, which suggests that separating the effluent effect from the potential dust effect may not be possible based on a field monitoring approach.

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[3] The list of stations included in the dust ZOI is based on the revised ZOI delineated in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b). Station MF2-1 was previously considered to be within in the ZOI, but is no longer expected to be measurably affected by dust. Station MF3-3 now falls within the revised dust ZOI.

3 RESULTS

3.1 Substances of Interest

Twenty-three variables met the criteria for inclusion as SOIs in 2021 (Table 3-1) based on the selection procedure described in Section 2.4.1:

- *Criterion 1:* None of the effluent chemistry variables with EQC were added to the SOI list because concentrations in individual grab samples were less than EQC for the maximum average concentration (Section 3.2.4) in all samples analyzed during the 2021 reporting period.
- *Criterion 2:* None of the mixing zone water chemistry variables with Effects Benchmarks were added to the SOI list because concentrations in all samples analyzed during the 2021 reporting period were below the relevant Effects Benchmarks (Section 3.2.5).
- *Criterion 3:* Twenty variables were added to the list of SOIs because they triggered Action Level 1 in the NF area (Section 3.5.1): TDS, turbidity, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, manganese, molybdenum, silicon, strontium, and uranium.
- *Criterion 4:* Three additional variables were added as SOIs as a result of applying this criterion: boron, lithium, and zinc. Twelve of the SOIs selected under Criterion 3 also triggered an effect equivalent to Action Level 1 at one or more of the four MF area stations located within the estimated ZOI from dust deposition from the Mine site (Section 3.7): TDS, turbidity, calcium, chloride, sodium, sulphate, ammonia, nitrate, chromium, molybdenum, strontium, and uranium. The triggers at the MF stations for these variables were most likely caused by dispersion of Mine effluent within the lake.

Table 3-1 Water Quality Substances of Interest, 2021

Substance of Interest	Substances of Interest Criteria			
	1 Effluent Screening	2 Mixing Zone Screening	3 Action Level 1	4 Potential Dust Effects
Conventional Parameters				
Total dissolved solids, calculated	-	-	X	X
Turbidity – lab	-	-	X	X
Major Ions				
Calcium (dissolved)	-	-	X[(a)]	X[(a)]
Chloride	-	-	X	X
Magnesium (dissolved)	-	-	X[(a)]	-
Potassium (dissolved)	-	-	X[(a)]	-
Sodium (dissolved)	-	-	X[(a)]	X[(a)]
Sulphate	-	-	X	X
Nutrients				
Ammonia	-	-	X	X
Nitrate	-	-	X	X
Total Metals				
Aluminum	-	-	X	-
Antimony	-	-	X	-
Barium	-	-	X	-
Boron	-	-	-	X
Chromium	-	-	X	X
Copper	-	-	X	-
Lithium	-	-	-	X
Manganese	-	-	X	-
Molybdenum	-	-	X	X
Silicon	-	-	X	-
Strontium	-	-	X	X
Uranium	-	-	X	X
Zinc	-	-	-	X

a) Both the total and dissolved fractions triggered Action Level 1. To avoid redundancy and match methods from previous annual reports, the analysis was conducted on the dissolved fractions only.

X = criterion met; - = criterion not met.

3.2 Trends in Effluent and at the Mixing Zone Boundary

3.2.1 Conventional Variables, Total Dissolved Solids, and Associated Ions

The conventional variables and major ions that met Criterion 3 of the SOI selection process (Section 2.4.1) included turbidity, TDS, calcium, chloride, magnesium, potassium, sodium, and sulphate. Loads of these variables, together with their concentrations in effluent and at the mixing zone, are presented in Figure 3-1 to Figure 3-8.

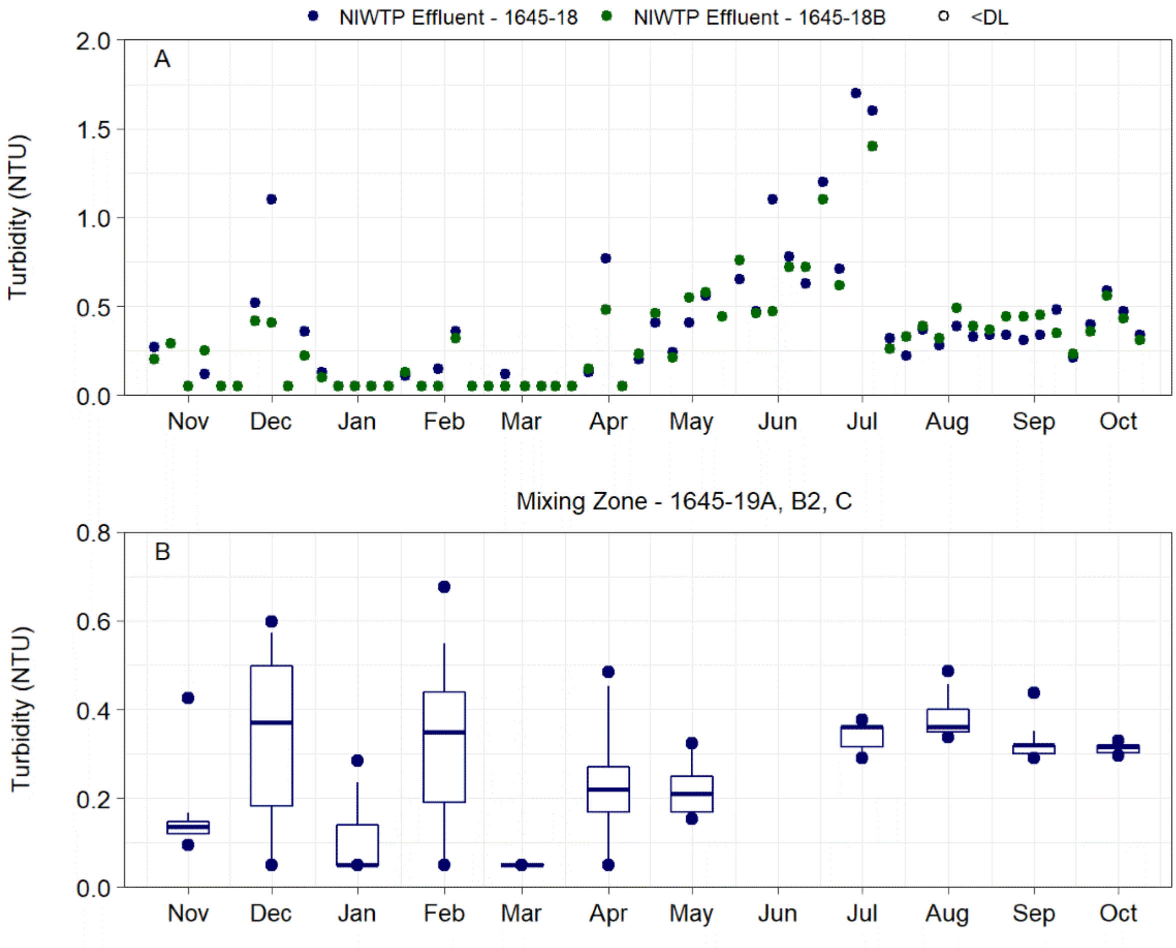
The turbidity of the effluent discharged from the NIWTP was generally higher and more variable during the open-water season compared to ice-cover (Figure 3-1A). Median turbidity values at the mixing zone boundary were lowest in January and March, with the highest values occurring in December, February, and August (Figure 3-1B). Turbidity at the mixing zone boundary was less variable and higher during the open-water season compared to ice-cover.

The monthly loads of TDS and associated ions from the NIWTP remained within a similar range (calcium and chloride) or generally decreased (TDS, magnesium, potassium, sodium, sulphate) through April, reflecting the variation in the monthly volume of effluent discharged (Figure 3-2A to Figure 3-8A). The loads of these SOIs increased during the late ice-cover season, peaking in May (calcium and chloride) or June (TDS, magnesium, potassium, sodium, and sulphate), before decreasing in July, increasing again in August, and then decreasing through the remainder of the open-water season as flow rates from the NIWTP decreased.

The concentrations of TDS, magnesium, potassium, and sulphate in the effluent decreased from November to the late ice-cover season and generally increased from the late ice-cover season until August, before decreasing or remaining within a similar range through the end of the reporting period (Figure 3-2B, Figure 3-5B, Figure 3-6B, and Figure 3-8B). Calcium concentrations remained in a similar range from November to March before decreasing in the late ice-cover season, increasing through August, and then remained within a similar range through October (Figure 3-3B). Chloride concentrations increased from November to February, decreased from February to June, before increasing again between June and August, and then remained within a similar range through the remainder of the open-water season (Figure 3-4B). Sodium concentrations generally decreased during the reporting period (Figure 3-7B).

The median concentrations of TDS and associated ions at the mixing zone boundary decreased from November to December and then generally increased during the rest of the ice-cover season, with the exception of potassium and sulphate (Figure 3-2C to Figure 3-5C, and Figure 3-7C). Median concentrations were lower during the open-water season for these SOIs. Median concentrations of potassium varied without a distinct pattern (Figure 3-6C), while median concentrations of sulphate remained within a similar range throughout the year (Figure 3-8C). Concentrations of most of these SOIs at the mixing zone boundary were more variable during ice-cover compared to the open-water season.

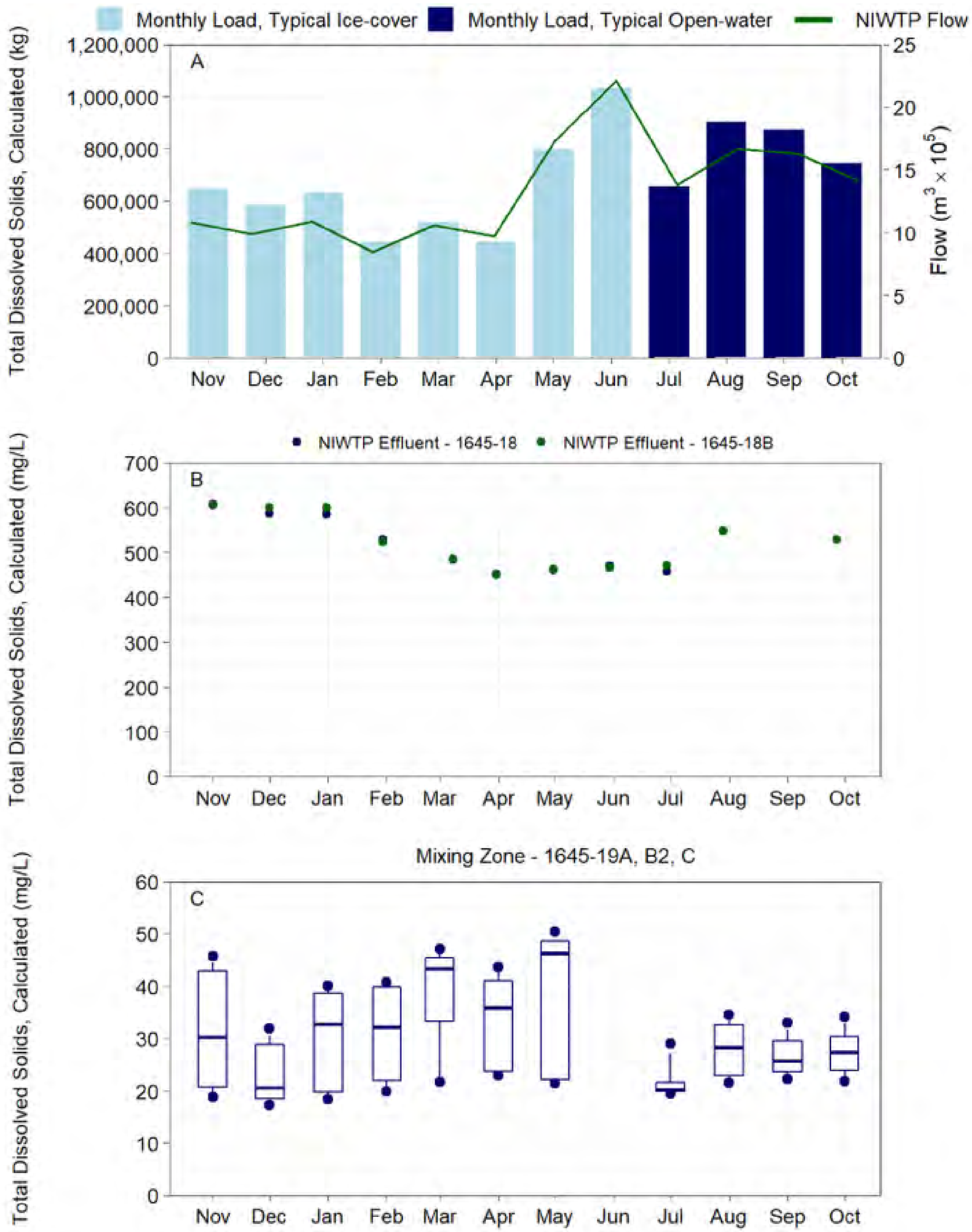
Figure 3-1 Turbidity: A) North Inlet Water Treatment Plant Effluent (SNP 1645-18 and SNP 1645-18B) and B) Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

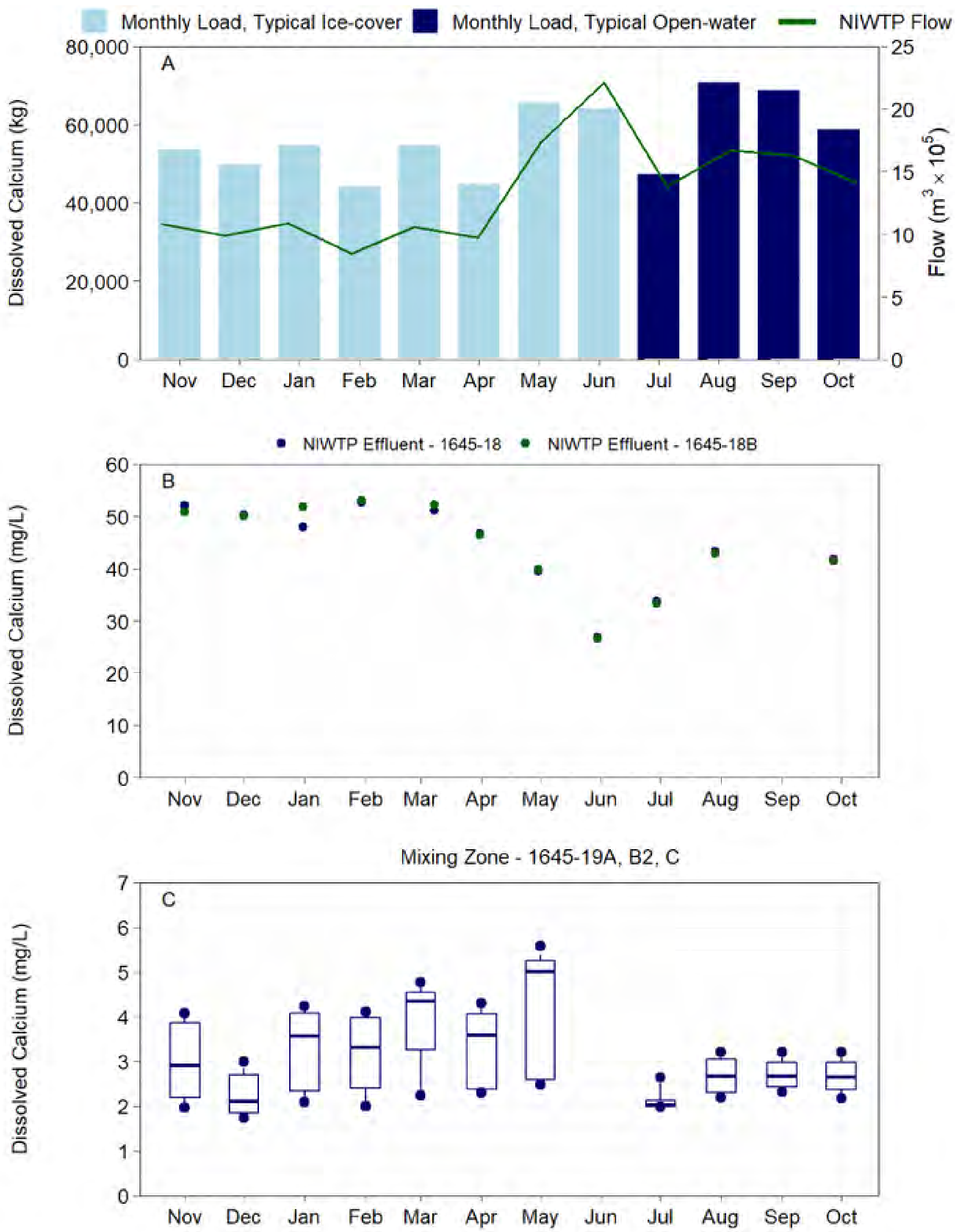
Figure 3-2 Total Dissolved Solids, Calculated: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

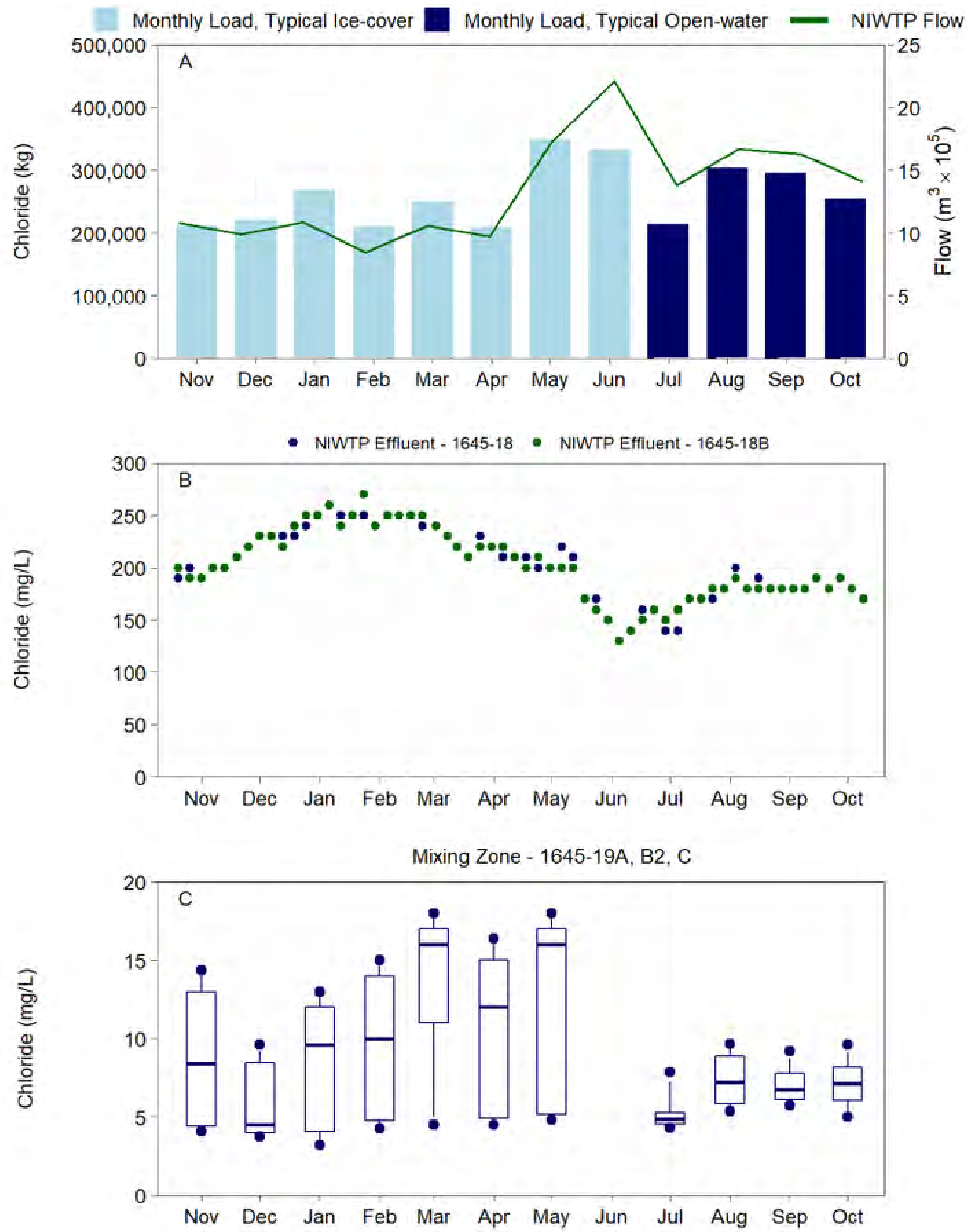
Figure 3-3 Calcium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

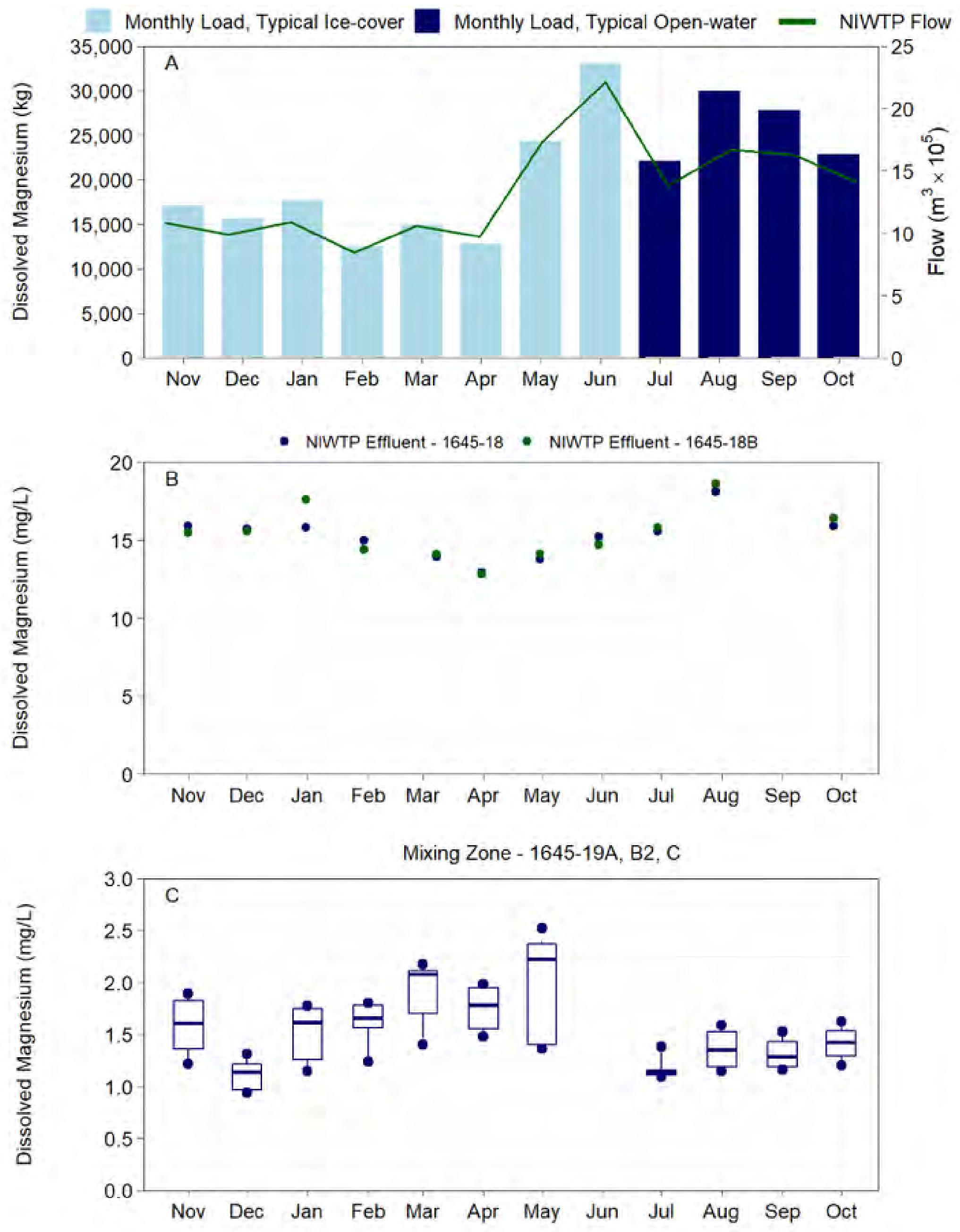
Figure 3-4 Chloride: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

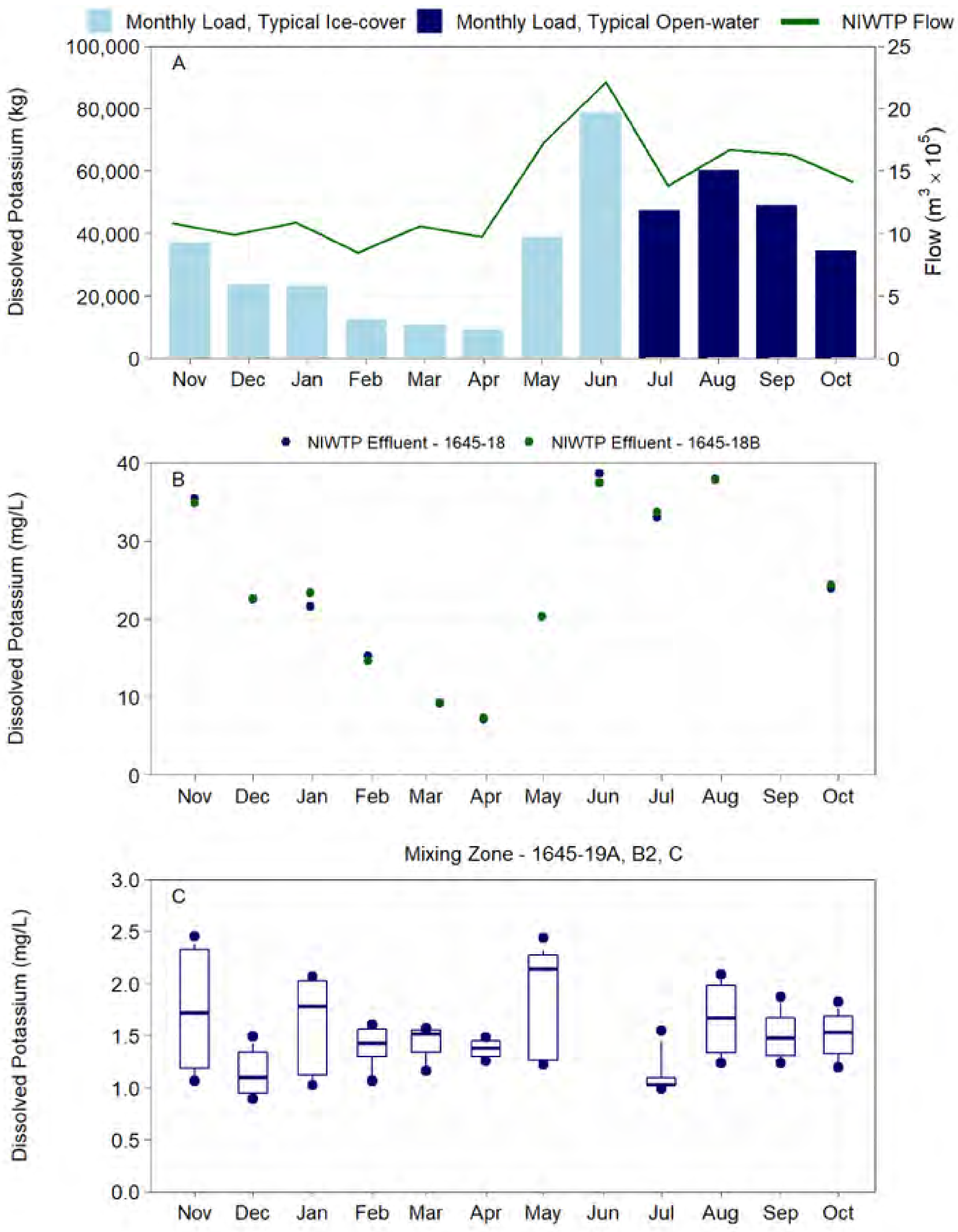
Figure 3-5 Magnesium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

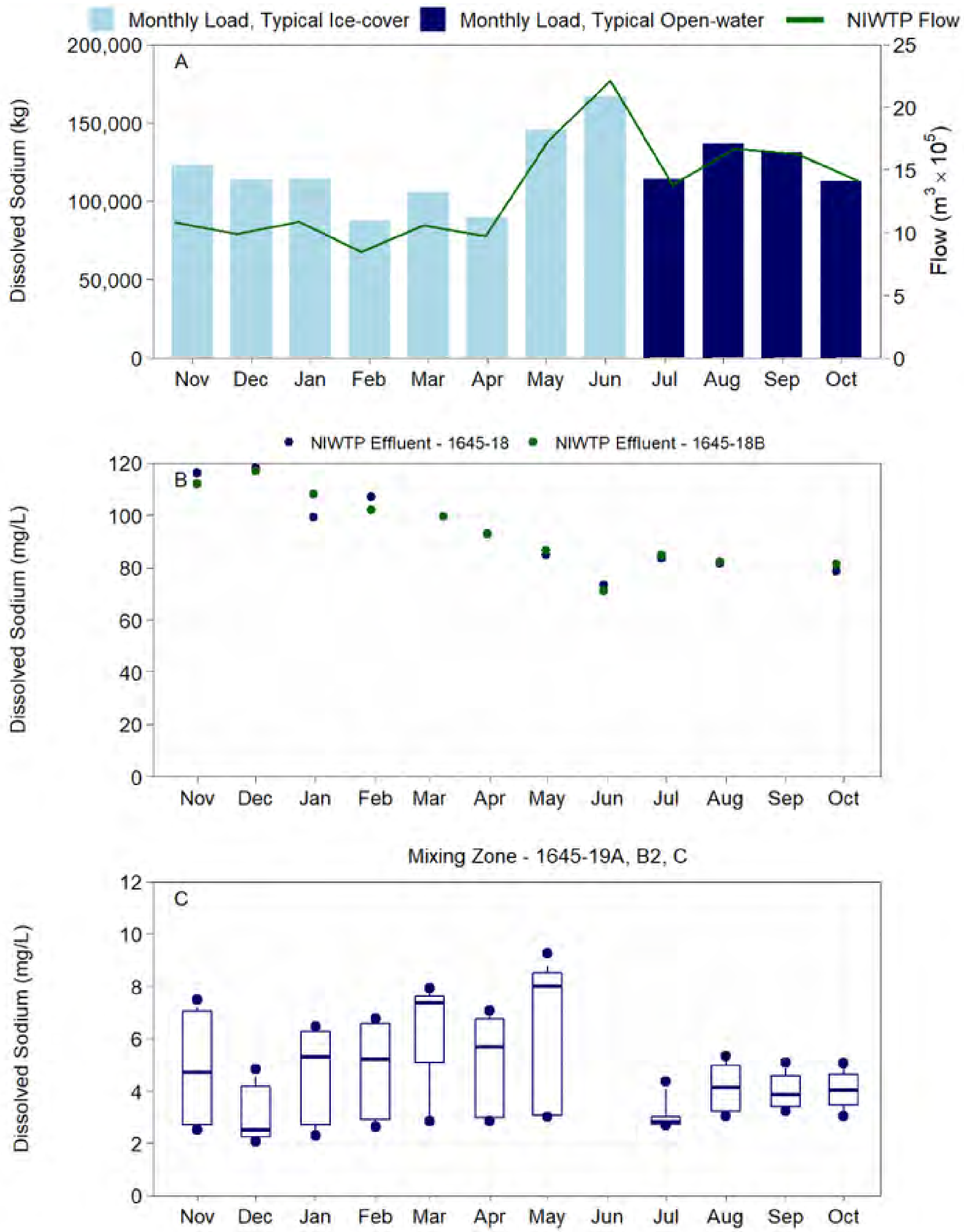
Figure 3-6 Potassium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

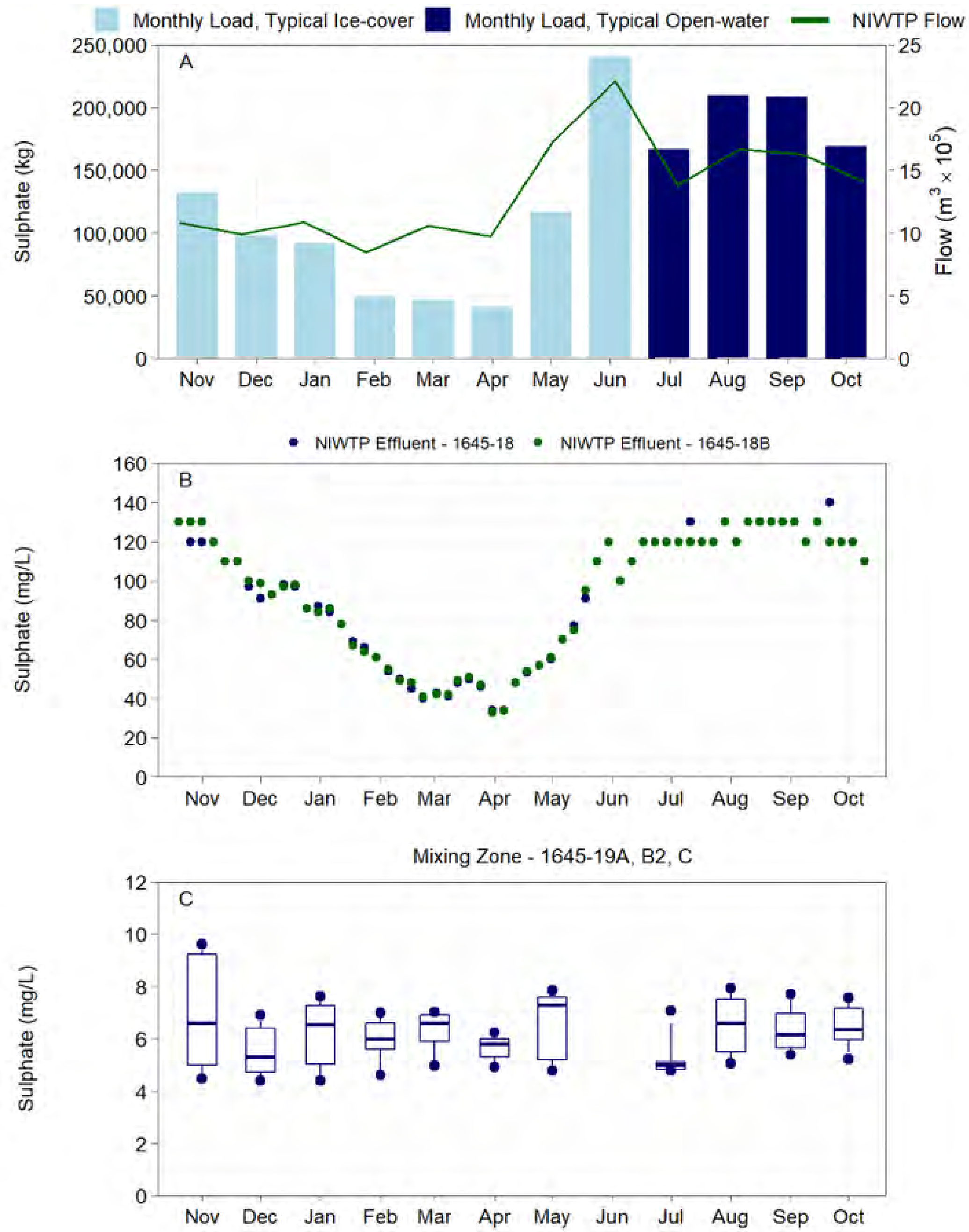
Figure 3-7 Sodium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-8 Sulphate: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

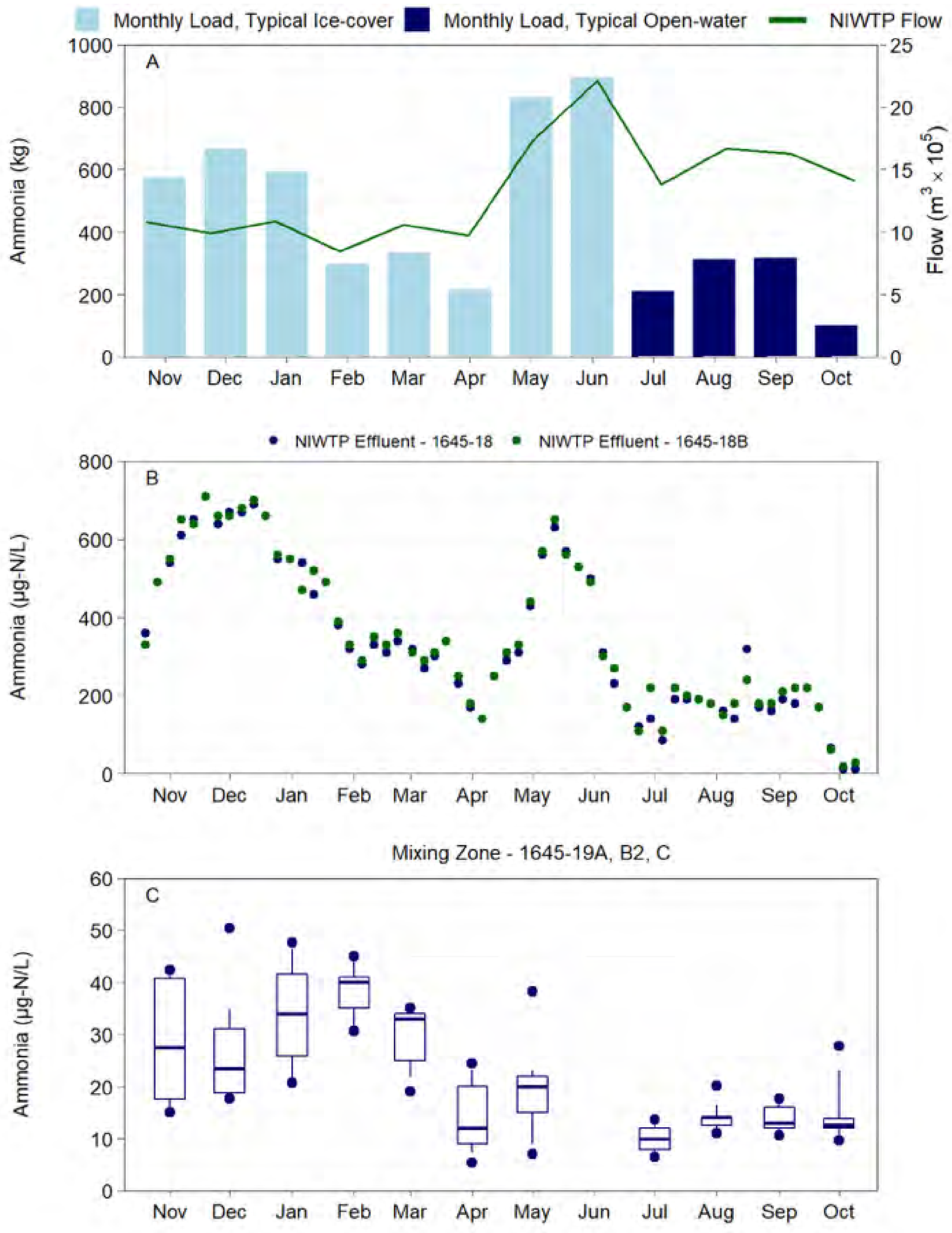
3.2.2 Nitrogen Variables

The nitrogen variables that met Criterion 3 in the SOI selection process (Section 2.4.1) were ammonia and nitrate. Loads of these variables, together with their concentrations in effluent and at the mixing zone boundary, are presented in Figure 3-9 and Figure 3-10.

The monthly loading rate of ammonia increased from November to December, decreased through April, and then increased again through late ice-cover, before subsequently decreasing to a lower level throughout the open-water season (Figure 3-9A/B). The seasonal trend in the loading rate of nitrate reflected trends both in the effluent flow rate and concentration in effluent. The load and concentration of nitrate generally declined from November to April, and then increased through late ice-cover season, peaked in June, decreased in July, increased again in August, before decreasing again in the late open-water season (Figure 3-10A/B).

The median concentrations of ammonia at the mixing zone boundary during the ice-cover season generally reflected trends in effluent concentration (Figure 3-9C). Concentrations of ammonia at the mixing zone boundary were lower and less variable in the open-water season compared to the ice-cover season. The median concentrations of nitrate varied without a distinct pattern from November to January, increased from February to May, decreased in July, and then increased during the rest of the reporting period (Figure 3-10C).

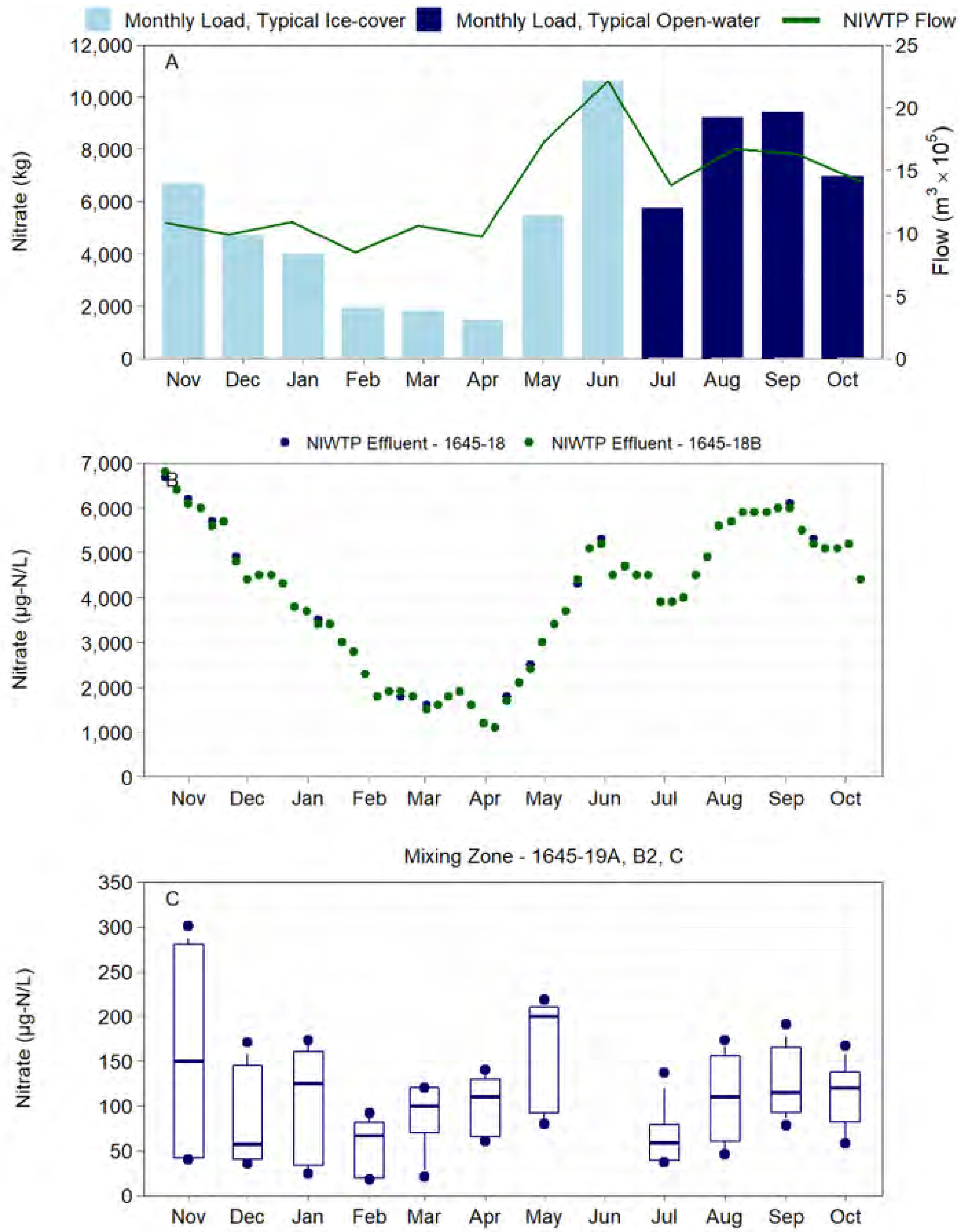
Figure 3-9 Ammonia: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-10 Nitrate: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

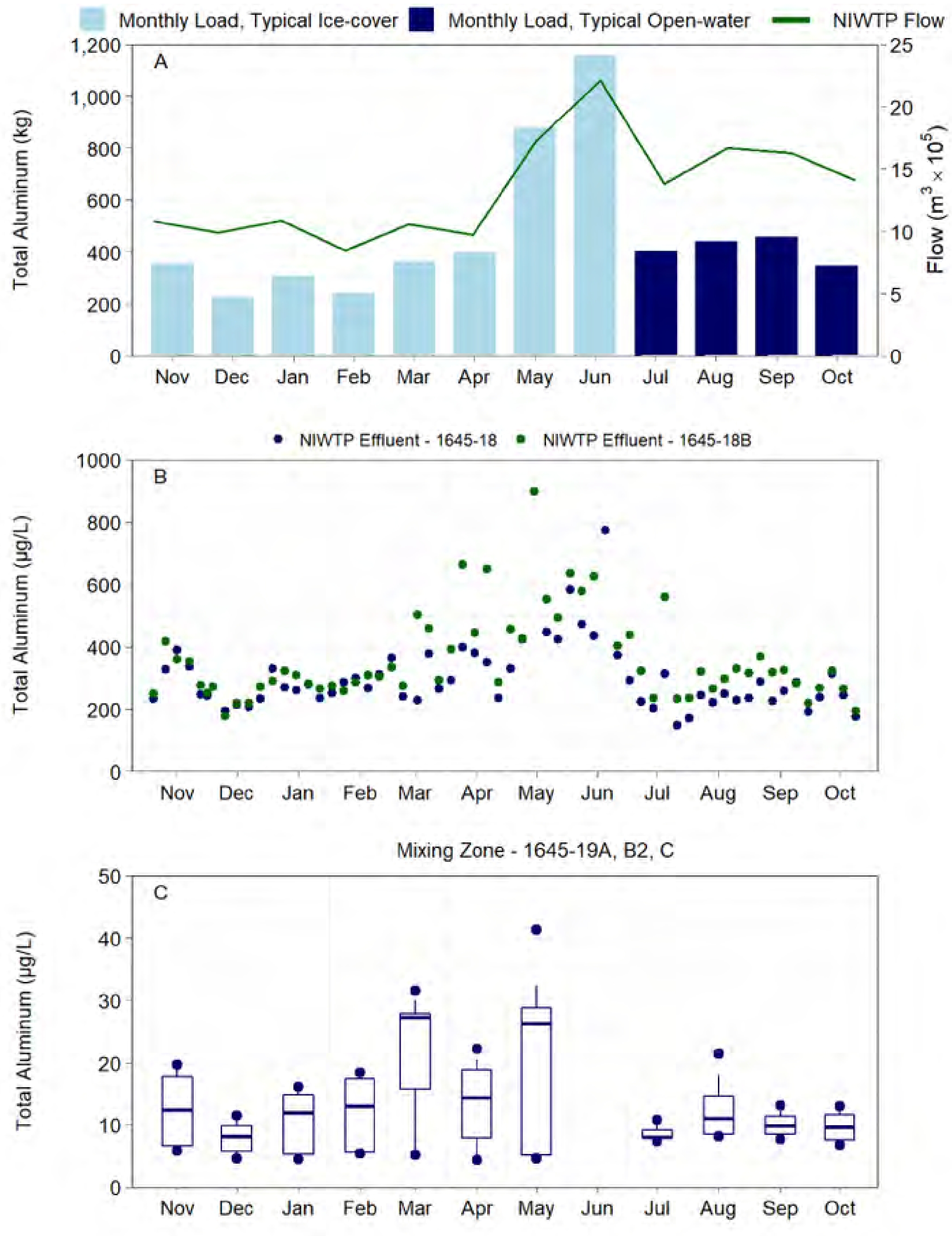
3.2.3 Total Metals

The total metal SOIs that met Criterion 3 in the SOI selection process (Section 2.4.1) were aluminum, antimony, barium, chromium, copper, manganese, molybdenum, silicon, strontium, and uranium. Loads of these variables, together with their concentrations in effluent and at the mixing zone boundary, are presented in Figure 3-11 to Figure 3-20. The monthly loading rates of total metal SOIs either reflected trends in the effluent flow rate or chemistry, or were influenced by a combination of the two. The seasonal pattern in the concentrations of variables in the effluent over the reporting period were variable-specific:

- The concentration of aluminum generally remained within a similar range throughout the reporting period, with the exception of April to June, when concentrations increased (Figure 3-11B).
- The concentration of antimony decreased from November to April, increased from April to July, and then remained within a similar range through the rest of the reporting period (Figure 3-12B).
- The concentration of barium in effluent generally stayed within a similar range throughout the reporting period (Figure 3-13B). Concentrations were slightly higher from January to May, and a peak concentration was observed in May.
- The concentration of chromium in effluent generally remained in a similar range through April and subsequently decreased through the remainder of the reporting period (Figure 3-14B).
- The concentration of copper gradually decreased from November to February, increased through the late ice-cover and early open-water season, peaking in August and September, before subsequently decreasing through the remainder of the reporting period (Figure 3-15B).
- The concentrations of manganese in effluent increased from November to April, decreased sharply through May, and then gradually increased and became less variable through the remainder of the reporting period (Figure 3-16B).
- The concentrations of molybdenum in effluent decreased gradually from November to April, then increased through August, and gradually decreased through the remainder of the reporting period (Figure 3-17B). Concentrations were most variable from mid-November to February.
- The concentration of silicon in effluent increased gradually from November to April, decreased during late ice-cover season, and subsequently remained within a similar range for the remainder of the reporting period (Figure 3-18B).
- The concentration of strontium remained within a similar range from November to April, decreased through June, increased through July, and then remained within a similar range for the remainder of the reporting period (Figure 3-19B).
- The concentration of uranium in effluent generally decreased from November to May and then increased from June to the end of the open-water season (Figure 3-20B). Concentrations were most variable from November to January.

Concentrations of most total metal SOIs in the effluent were greater than the concentrations measured at the mixing zone boundary in 2021, indicating that the Mine effluent is a source of these constituents to Lac de Gras. One exception was copper, which had generally lower concentrations in the effluent than those recorded at the mixing zone boundary (Figure 3-15B/C). The concentrations of most of these SOIs at the mixing zone boundary were more variable during the ice-cover season than during the open-water season (Figure 3-11C to Figure 3-20C).

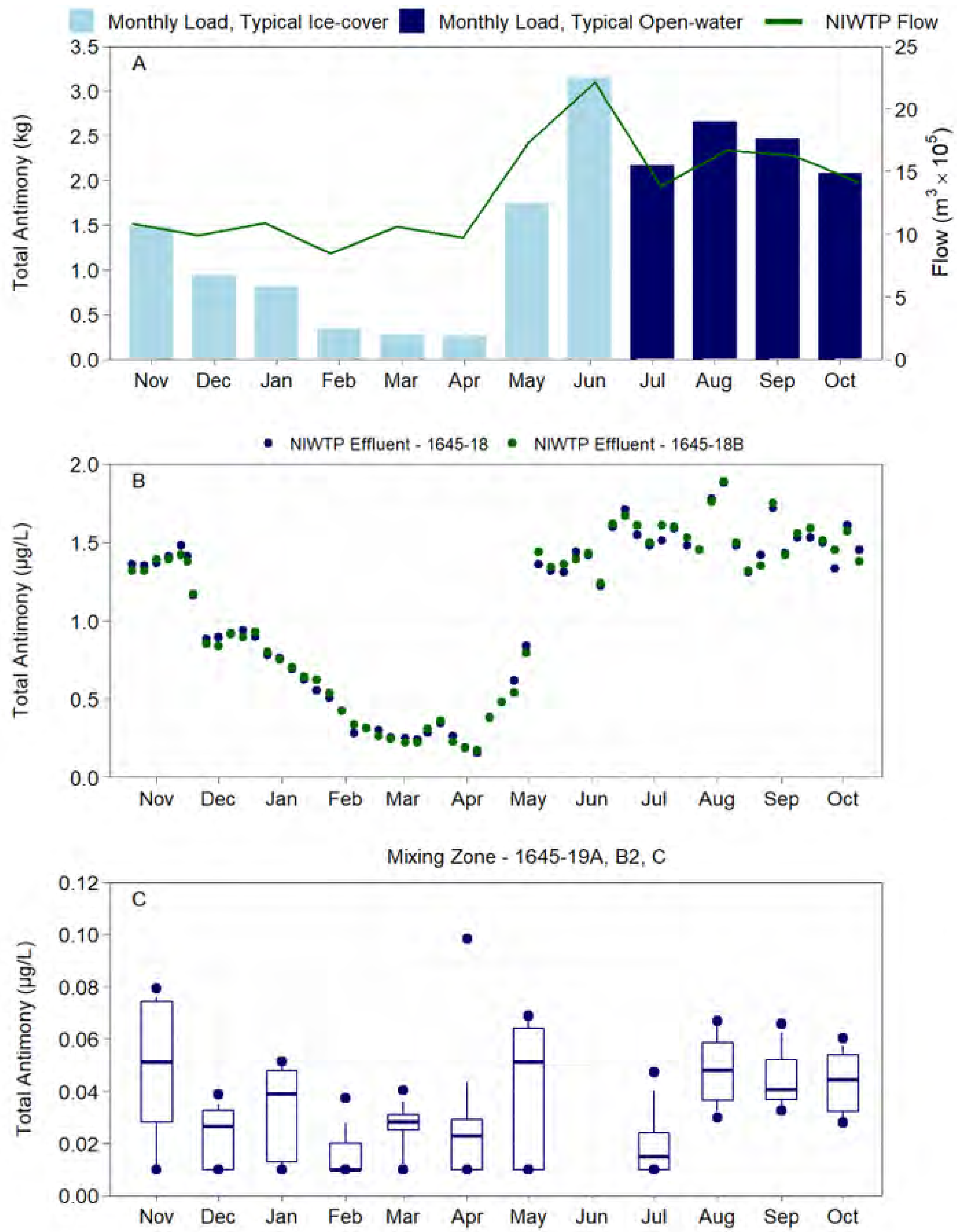
Figure 3-11 Aluminum: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

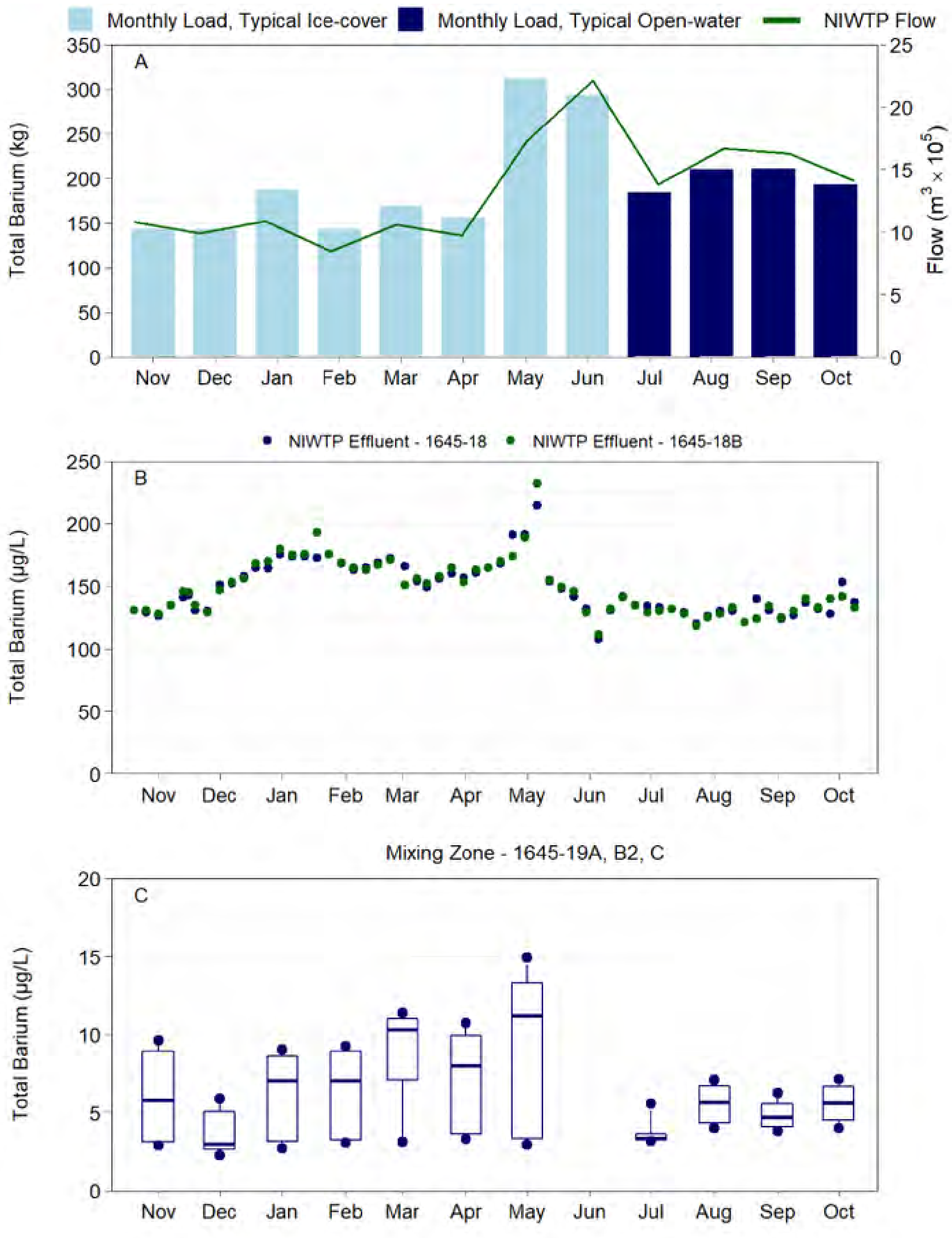
Figure 3-12 Antimony: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

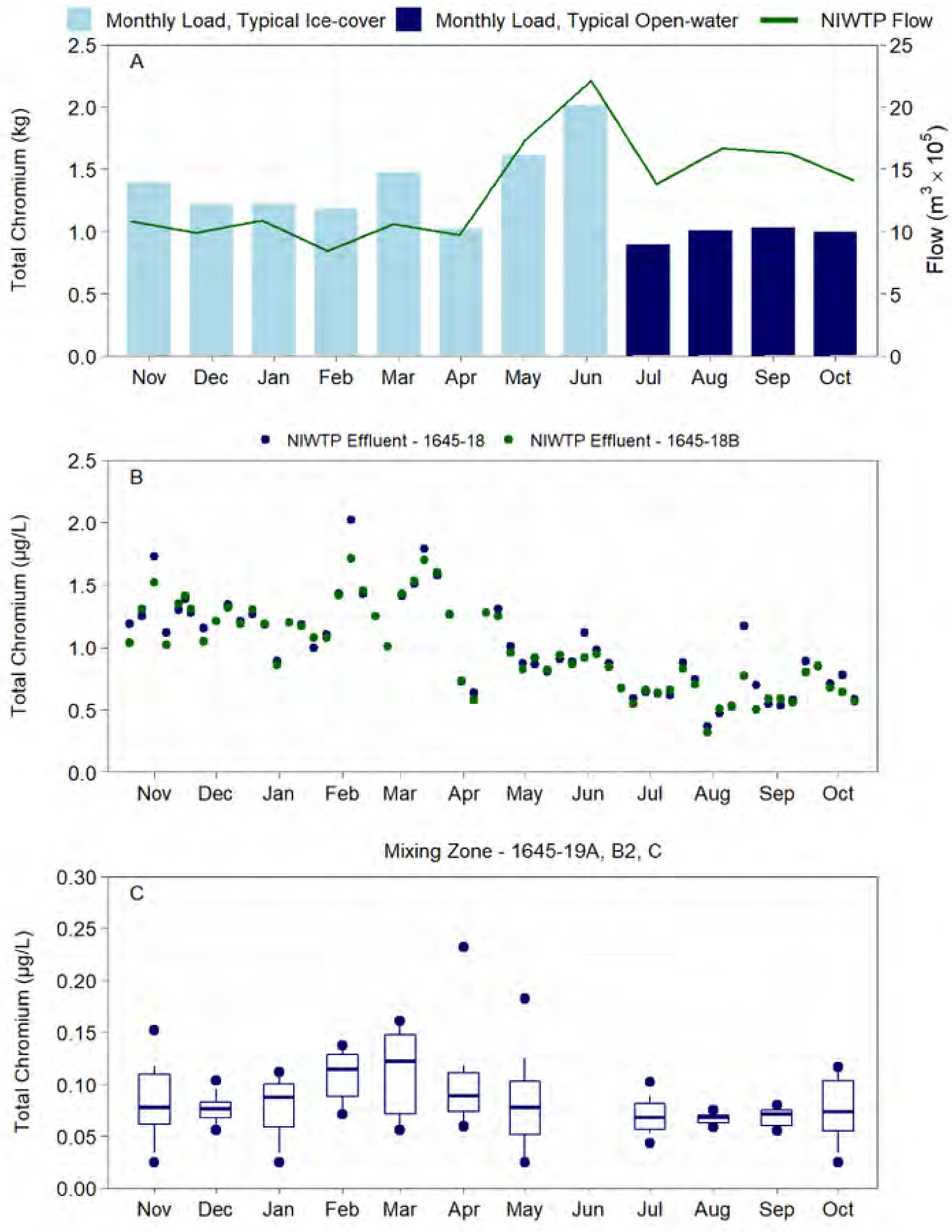
Figure 3-13 Barium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

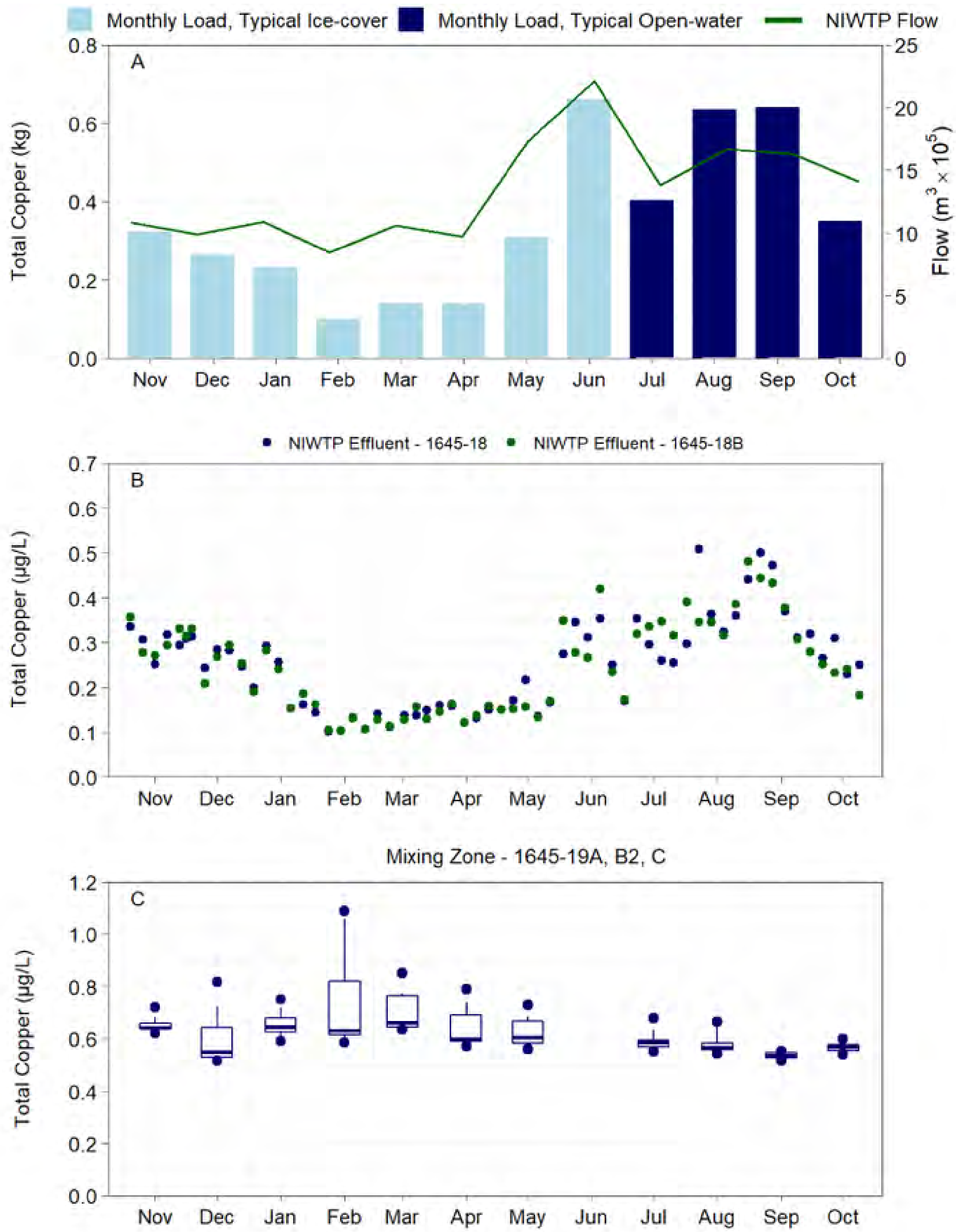
Figure 3-14 Chromium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

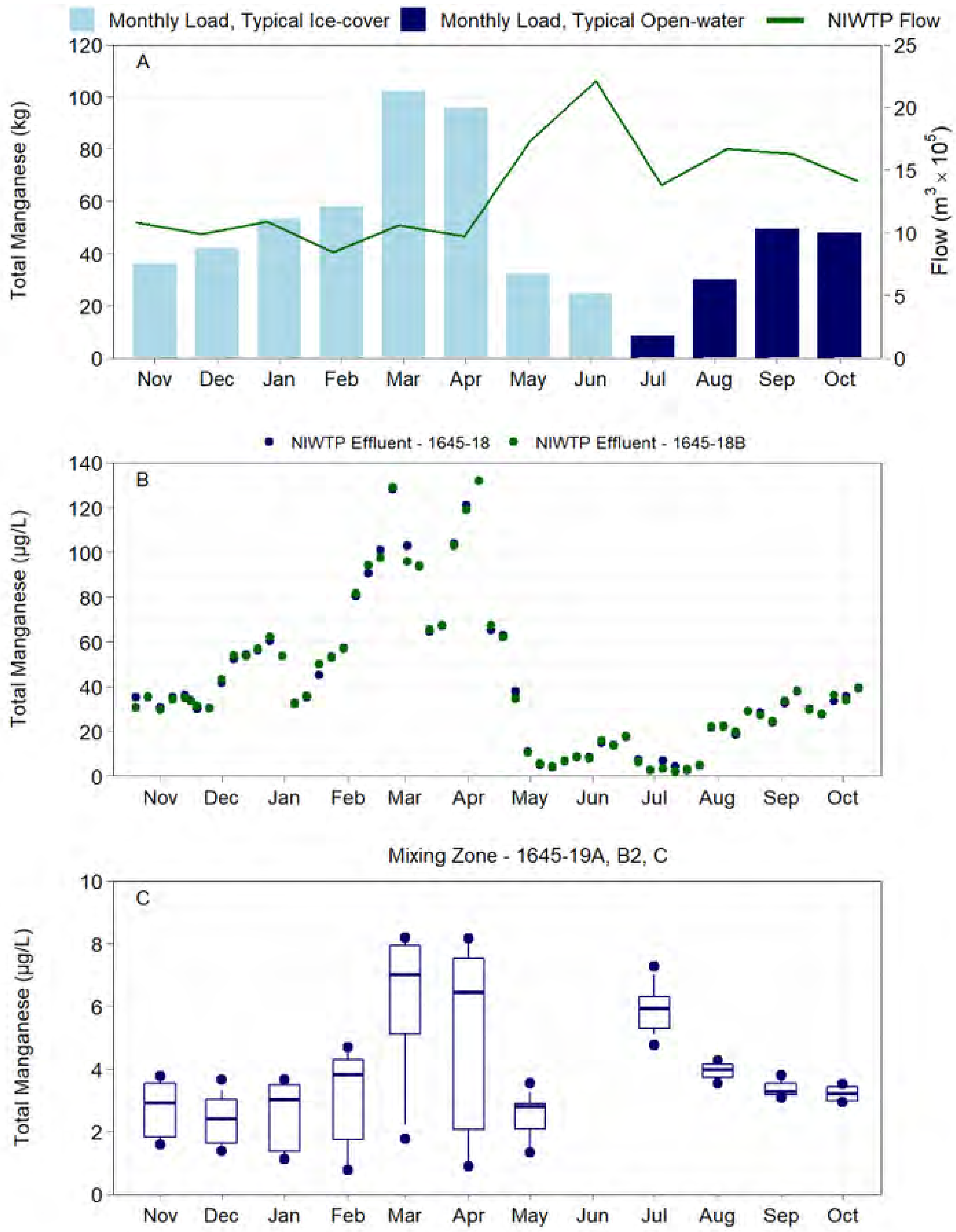
Figure 3-15 Copper: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

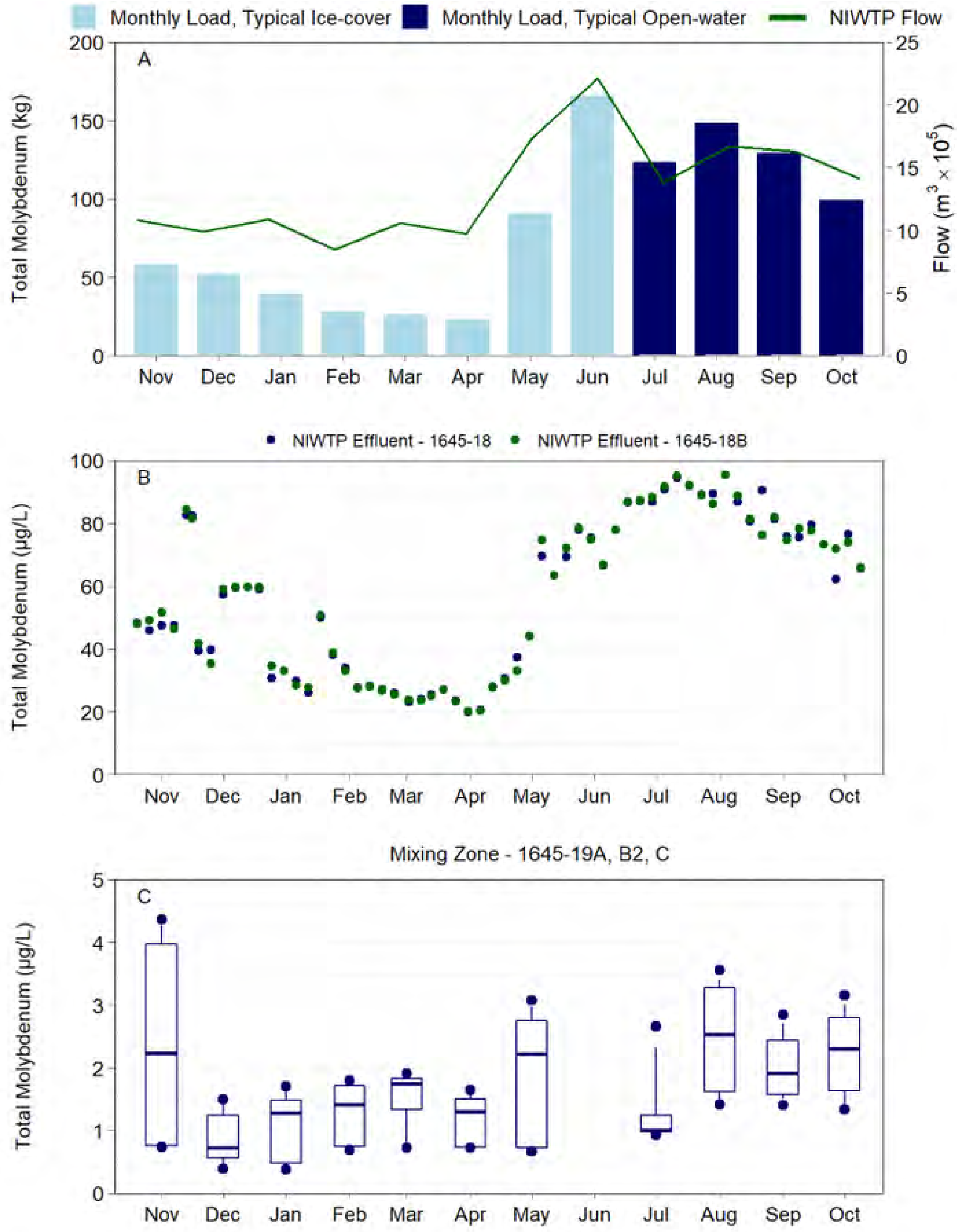
NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-16 Manganese: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.
NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

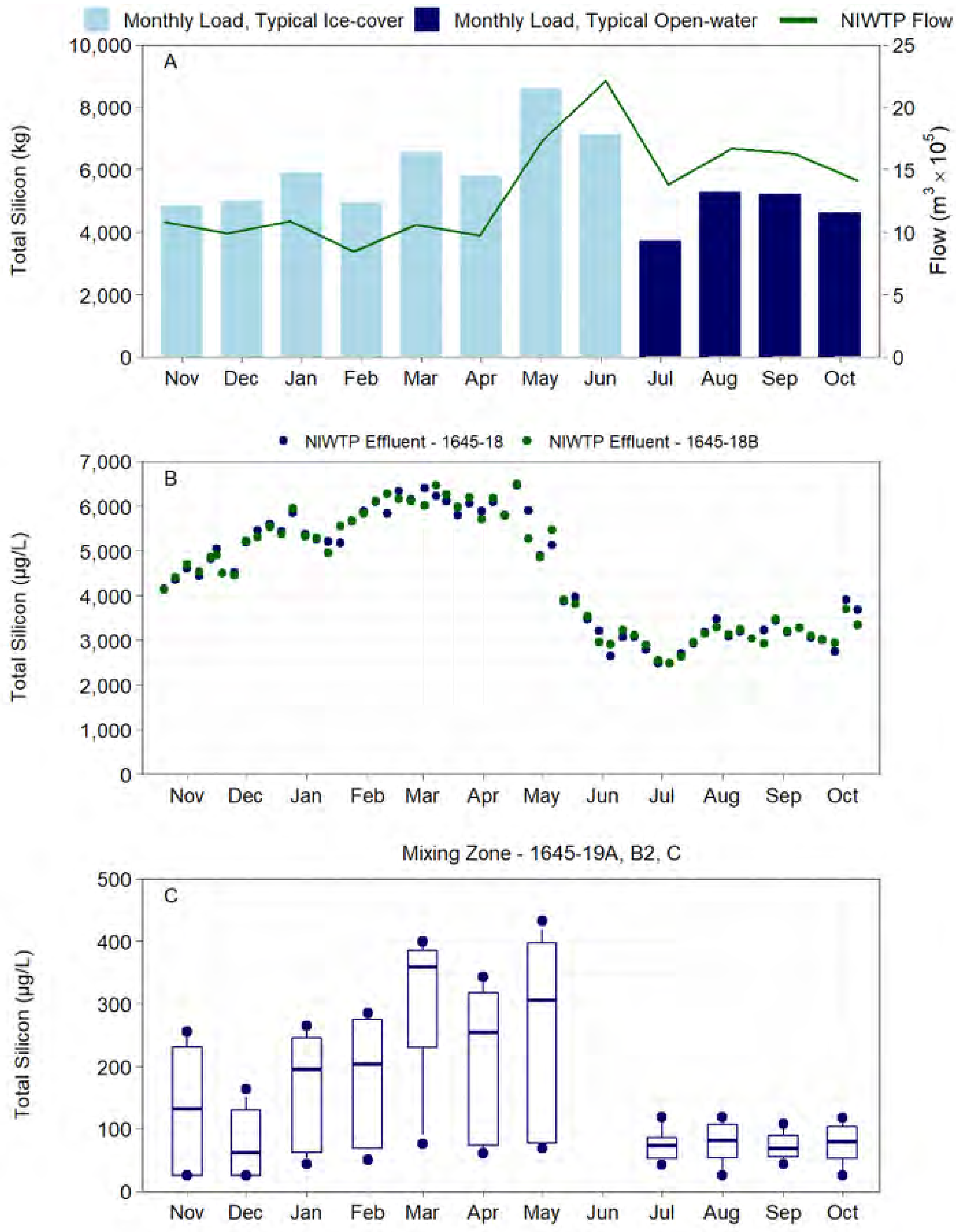
Figure 3-17 Molybdenum: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

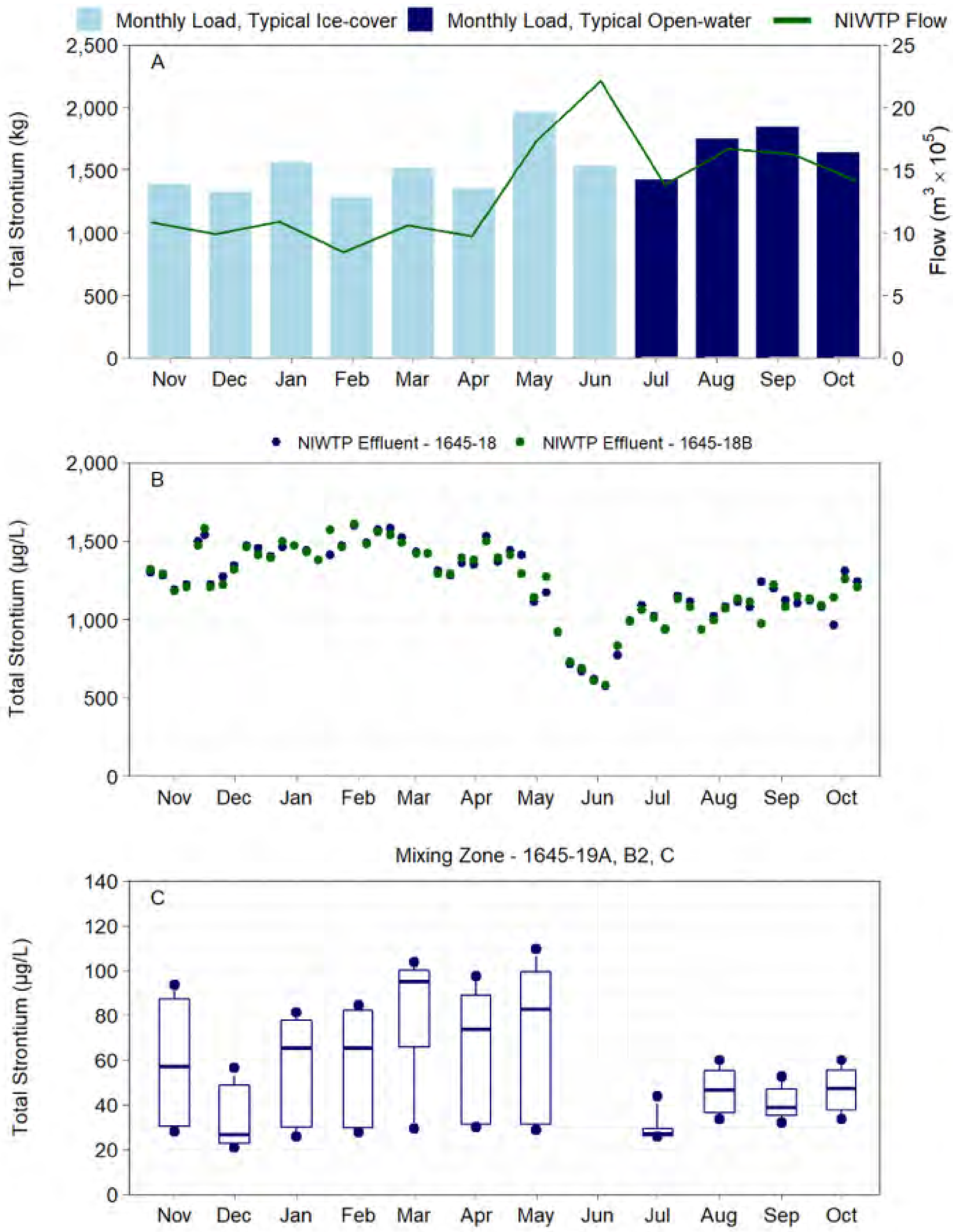
Figure 3-18 Silicon: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

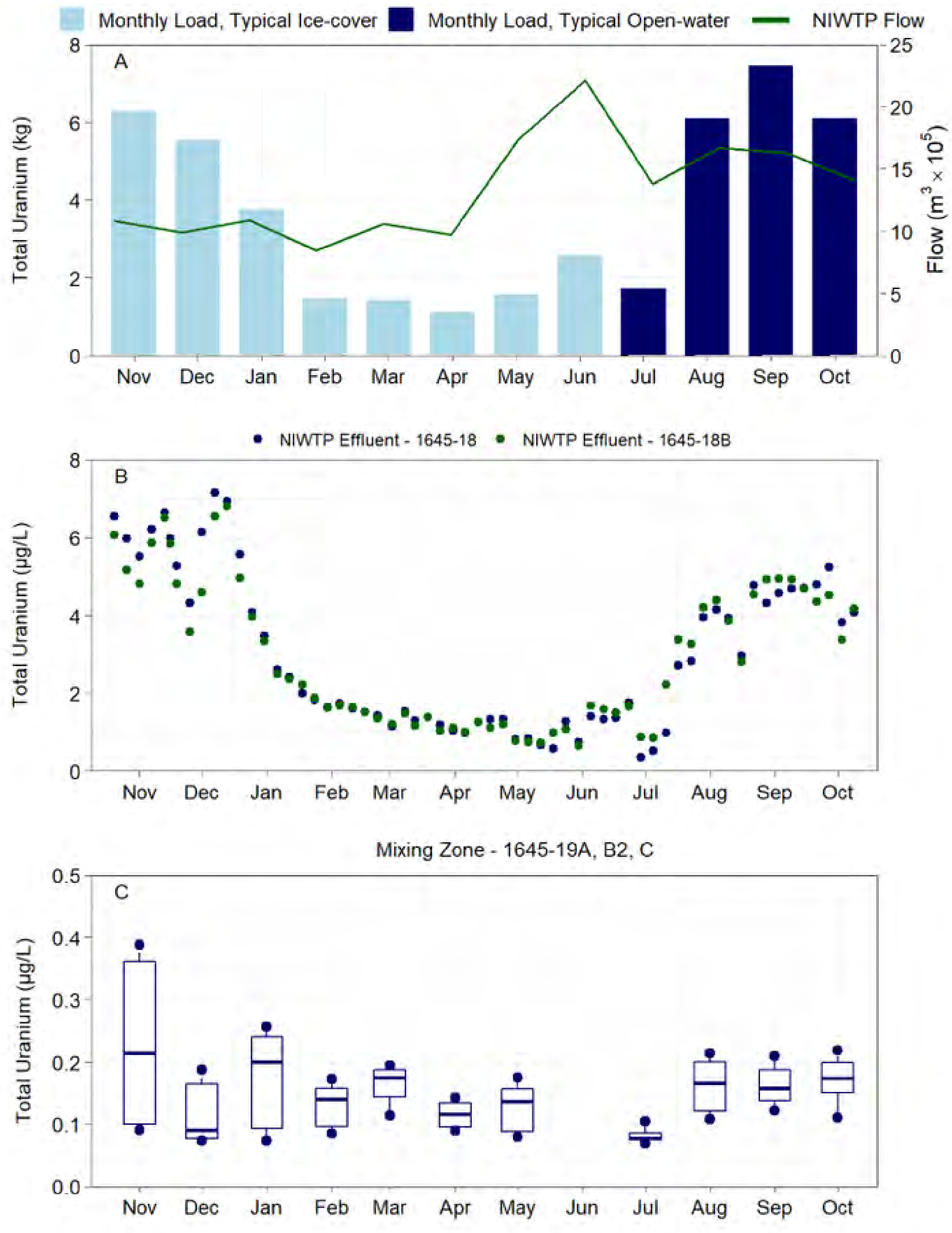
Figure 3-19 Strontium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-20 Uranium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2020 to 31 October 2021



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); filled symbols represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2021 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

3.2.4 Comparison to Effluent Quality Criteria

During the 2021 sampling period, concentrations of variables in effluent with EQC were below the maximum allowable concentration in any grab sample. Similarly, the average concentrations were below EQC for the Maximum Average Concentration at both diffusers (Table 3-2). Therefore, no variables triggered Criterion 1 in the SOI selection process (Section 2.4.1).

In addition to the criteria listed in Table 3-2, all discharges from the NIWTP in 2021 to Lac de Gras had pH values between 6.0 to 8.4 (range: 6.3 to 8.0; median: 7.4), consistent with Water Licence requirements. The monthly SNP reports submitted to the WLWB provide graphs demonstrating compliance of effluent chemistry with EQCs. These reports are accessible on the WLWB public registry.

3.2.5 Comparison of Mixing Zone Data to Effects Benchmarks

During the 2021 sampling period, nearly all concentrations measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water (Table 3-3). The total lead (67.8 µg/L) and total tin (93.2 µg/L) samples at SNP 1645-19B2 collected on 20 February 2021 exceeded the Effects Benchmarks of 1 µg/L and 73 µg/L, respectively. The dissolved lead and dissolved tin concentrations associated with the same sample were well below the Effects Benchmarks (<0.005 µg/L and <0.01 µg/L, respectively), indicating that the total lead and total tin values were likely erroneous. Both the total lead and total tin values were identified as anomalous values during the initial data screening (Section 2.4.2), indicating that they were extreme values compared to other samples collected at the mixing zone boundary. All other total lead and total tin values were below the Effects Benchmarks. Consequently, total lead and total tin did not trigger Criterion 2 in the SOI selection process (Section 2.4.1).

None of the pH values measured at the mixing zone boundary in 2021 exceeded the upper limits of the aquatic life and drinking water Effects Benchmarks (i.e., 8.5 and 10.5, respectively). However, pH values measured at the mixing zone boundary in 2021, were below the drinking water Effects Benchmark value of 7.0 in 95% of samples and below the aquatic life Effects Benchmark value of 6.5 in 49% of samples (Table 3-3). Because the pH of the Mine effluent was slightly alkaline (i.e., median pH of 7.4) and the pH throughout Lac de Gras was often below the aquatic life Effects Benchmark of 6.5, during both ice-cover and open-water conditions at various depths, and over time (i.e., 2002 to 2020; Golder 2020b, 2021), these exceedances were attributed to natural conditions and unrelated to the Mine discharge. Therefore, pH did not trigger Criterion 2 in the SOI selection process (Section 2.4.1) and was not considered an SOI.

Table 3-2 Comparison of Effluent Chemistry to Effluent Quality Criteria, 1 November 2020 to 31 October 2021

Variable	Units	Effluent Quality Criteria		Effluent Concentration		
		Maximum Average Concentration	Maximum Concentration of Any Grab Sample	Minimum	Maximum	Median
Total ammonia	µg-N/L	6,000	12,000	12	710	310
Total aluminum	µg/L	1,500	3,000	149	1,500[(a)]	292
Total arsenic	µg/L	50	100	0.88	2.6	1.3
Total copper	µg/L	20	40	0.10	0.51	0.25
Total cadmium	µg/L	1.5	3	<0.005	0.059[(a)]	0.0025
Total chromium	µg/L	20	40	0.32	2.0	0.99
Total lead	µg/L	10	20	<0.005	0.033	0.005
Total nickel	µg/L	50	100	1.9	7.5	4.6
Total zinc	µg/L	10	20	<0.1	7.5[(a)]	0.11
Nitrite	µg-N/L	1,000	2,000	<1.0	370	210
Total suspended solids	mg/L	15	25	<1.0	10.3	1.0
Turbidity	NTU	10	15	<0.1	2.4	0.4
Biochemical oxygen demand	mg/L	15	25	<2.0	<2.0	1.0
Total petroleum hydrocarbons	mg/L	3	5	<0.26	0.14	0.13
Fecal coliforms	CFU/100 mL	10	20	<1.0	<1.0	0.5

a) This value was identified as anomalous during data screening.

µg-N/L = micrograms nitrogen per litre; NTU = nephelometric turbidity unit; CFU = colony forming units.

Table 3-3 Comparison of Mixing Zone Water Chemistry to AEMP Effects Benchmarks, 1 November 2020 to 31 October 2021

Variable	Unit	Effects Benchmarks		Mixing Zone Concentration		
		Protection of Aquatic Life	Drinking Water	Minimum	Maximum	Median
Conventional Parameters						
Dissolved oxygen – field	mg/L	6.5[(a)]	-	11.4	19.3	14.3
pH – BV Labs	pH Units	6.5 to 9.0	7.0 to 10.5	**5.8**	7.6	**6.3**
pH – DDMI Labs	pH Units	6.5 to 9.0	7.0 to 10.5	**6.2**	7.5	**6.7**
Total dissolved solids, calculated	mg/L	500	500	17	53	28
Total dissolved solids, measured	mg/L	500	500	6.4	70	33
Total suspended solids	mg/L	+5 (24 h to 30 days) +25 (24 h period)	-	<1.0	2.3	0.5
Turbidity – lab	NTU	2.2 (long term, IC) 2.3 (long term, OW)	-	<0.1	1.2	0.32
Major Ions						
Calcium (dissolved)	mg/L	60	-	1.7	5.9	2.7
Chloride	mg/L	120	250	3.1	18	7.4
Fluoride	mg/L	0.12	1.5	0.013	0.053	0.034
Sodium (dissolved)	mg/L	52	200	2.1	10.0	4.1
Sulphate	mg/L	100	500	4.2	10.0	6.1
Nutrients						
Ammonia	µg/L	4,730	-	<5	77	19
Nitrate	µg/L	3,000	10,000	12	320	93
Nitrite	µg/L	60	1,000	<1	13	2
Total Metals						
Aluminum (total)	µg/L	87	100/200	4.2	53.9	10.0
Aluminum (dissolved)	µg/L	50[(b)]	-	2.9	26.0	8.5
Antimony	µg/L	33	6	<0.02	0.177	0.032
Arsenic	µg/L	5	10	0.23	0.40	0.29
Barium	µg/L	1,000	2,000	2.2	15.4	5.2
Boron	µg/L	1,500	5,000	<5	7.6	2.5
Cadmium	µg/L	0.1	7	<0.005	0.018	0.003
Chromium	µg/L	1 (Cr VI)	50	<0.05	0.68[(c)]	0.075
Copper	µg/L	2	1,000	0.5	1.10	0.60
Iron	µg/L	300	300	1.9	49.4[(c)]	6.5
Lead	µg/L	1	5	<0.005	**67.8[(c)]**	0.003
Manganese (total)	µg/L	-	20	0.76	8.3	3.5
Manganese (dissolved)	µg/L	Variable[(d)]	-	0.37	7.2	2.1
Mercury	µg/L	0.026 (inorganic); 0.004 (methyl)	1	<0.0019	0.0024	0.001
Molybdenum	µg/L	73	-	0.35	4.5	1.5
Nickel	µg/L	25	-	0.09	3.5[(c)]	0.80
Selenium	µg/L	1	50	<0.04	<0.04	0.02
Silicon	µg/L	2,100	-	<50	449	89
Silver	µg/L	0.25	-	<0.005	0.0118	0.003
Strontium	µg/L	30,000	7000	20.9	113	44.5
Thallium	µg/L	0.8	-	<0.002	0.0038	0.001
Tin	µg/L	73	-	<0.01	**93.2[(c)]**	0.005
Uranium	µg/L	15	20	0.07	0.41	0.14
Zinc (total)	µg/L	-	5,000	<0.1	17.0[(c)]	0.37
Zinc (dissolved)	µg/L	Variable[(e)]	-	<0.1	7.8	0.3

Note: **Bold** indicates a value exceeds the relevant Effects Benchmark.
a) The focus of the comparison was on dissolved oxygen concentrations less than 6.5 mg/L.
b) Variable with pH. Benchmark of 50 µg/L based on the median lab pH of 6.5.
c) This value was identified as anomalous during data screening.
d) Variable with pH and hardness. Benchmark value was calculated on a sample-by-sample basis.
e) Variable with pH, hardness, and DOC. Benchmark value was calculated on a sample-by-sample basis.
- = not available; IC = ice-cover; OW = open-water.

3.2.6 Effluent Toxicity

Results of toxicity testing in 2021 indicated that effluent samples were not toxic to aquatic test organisms (Table 3-4 and Table 3-5). A total of 24 acute and chronic lethal toxicity tests and 24 sublethal toxicity tests were successfully conducted using ten effluent samples collected during the 2021 reporting period.

There were no toxic effects to aquatic test organisms in samples submitted for lethal testing.

There were no test failures in the sublethal toxicity tests, and few effects were reported:

- Results of the sublethal early life stage Rainbow Trout embryo toxicity test indicated reduced embryo viability in both samples collected in September 2021, but the relative percent difference compared to control was less than 50% and considered a pass.
- Results of the sublethal *P. subcapitata* growth inhibition tests indicated that the effluent stimulated algal growth in all samples, which is not considered a toxic response.
- Results of the sublethal *C. dubia* reproduction test indicated that the effluent reduced reproduction in both samples collected in October 2020, but the reduction in reproduction compared to control was less than 50% and was considered a pass.

All other sublethal toxicity testing showed no effects. The raw toxicity test results for October 2020, November 2020, February 2021, June 2021, and September 2021 are provided in Attachment E.

Table 3-4 Acute and Chronic Lethality Toxicity Testing Results, North Inlet Water Treatment Plant Effluent, 2021

Test Organism[a]	Month and year	Station	
		SNP 1645-18	SNP 1645-18B
		100% effluent	100% effluent
Rainbow Trout	October 2020	Pass	Pass
	February 2021	Pass	Pass
	June 2021	Pass	Pass
	September 2021	Pass	Pass
Daphnia magna	October 2020	Pass	Pass
	February 2021	Pass	Pass
	June 2021	Pass	Pass
	September 2021	Pass	Pass
Ceriodaphnia dubia	October 2020	Pass	Pass
	February 2021	Pass	Pass
	June 2021	Pass	Pass
	September 2021	Pass	Pass

a) Toxicity test is considered a fail if mortality of test organisms is greater than or equal to 50%.

Table 3-5 Sublethal Toxicity Testing Results, North Inlet Water Treatment Plant Effluent, 2021

Test Organism	Month and year	Station	
		SNP 1645-18	SNP 1645-18B
		100% effluent	100% effluent
Early life stage Rainbow Trout[a]	November 2020[d]	Pass	Pass
	February 2021	Pass	Pass
	June 2021	Pass	Pass
	September 2021	Pass	Pass
Pseudokirchneriella subcapitata[b]	October 2020	Pass[e]	Pass[e]
	February 2021	Pass[e]	Pass[e]
	June 2021	Pass[e]	Pass[e]
	September 2021	Pass[e]	Pass[e]
Ceriodaphnia dubia[c]	October 2020	Pass	Pass
	February 2021	Pass	Pass
	June 2021	Pass	Pass
	September 2021	Pass	Pass

a) The early life stage Rainbow Trout embryo toxicity test is considered a fail if the relative percent difference in embryo viability between the two treatments (i.e., control and 100% v/v concentration) is equal to or greater than 50%.

b) Toxicity test is considered a fail if reduction in growth compared to control is equal to or greater than 50%.

c) Toxicity test is considered a fail if the reduction in reproduction compared to control is equal to or greater than 50%.

d) Effluent samples collected in October 2020 for the early life stage Rainbow Trout toxicity test exceeded holding time due to shipping delays and effluent was re-sampled in November 2020.

e) Laboratory results indicate algal growth stimulation compared to control.

3.3 Depth Profiles

This section describes the in situ (i.e., field-measured) water quality measurements for conductivity, DO, temperature, pH, and turbidity recorded at AEMP stations (Attachment D).

Specific conductivity generally increased with depth in the NF area during the ice-cover season to approximately 14 to 16 m depth and then declined slightly near the lake bottom (Figure 3-21). The greater specific gravity of the effluent, combined with the absence of wind and wave-driven mixing during ice-cover conditions, resulted in elevated conductivity in the bottom two-thirds of the water column in the NF area. The greater conductivity at this depth indicated the depth range where the effluent plume was located. Complete vertical mixing of the effluent was observed during ice-cover at all stations along the MF1 transect (Figure 3-22), and at most stations along the MF2 and the MF3 transects. Exceptions were noted at MF2-1, MF2-3, MF3-1, and MF3-2 (Figure 3-23 and Figure 3-24), which are located closest to the NF area and the diffusers along the MF2 and MF3 transects. Specific conductivity at MF2-1 and MF2-3 was generally uniform in the upper two-thirds of the water column and increased in the bottom third. At MF3-1, specific conductivity increased until approximately 16 m depth and then remained uniform throughout the increasing water depth. Specific conductivity at MF3-2 increased slightly until approximately 14 m depth and then declined with increasing water depth. During the open-water season, specific conductivity was typically uniform throughout the water column (Figure 3-21 to Figure 3-24).

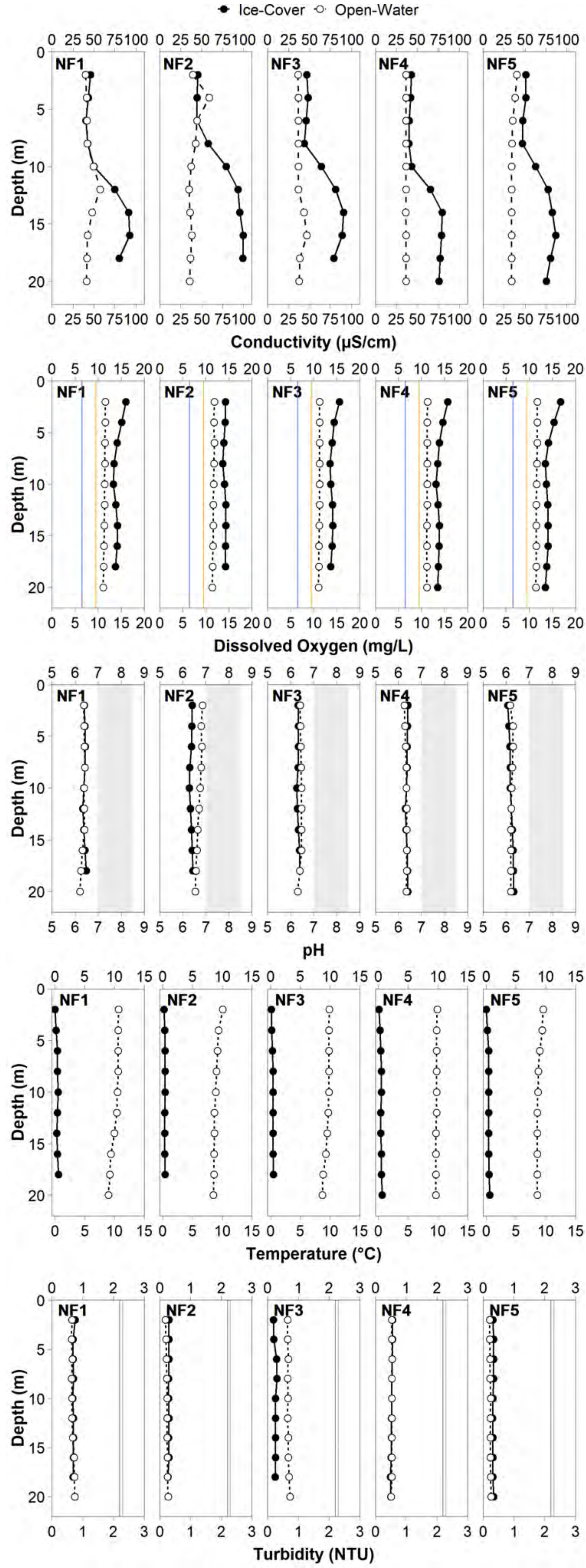
During the ice-cover season, DO concentrations were typically highest just below the ice and declined slightly with increasing depth. The greatest decline in DO near the lake bottom was measured at MF1-5, where near-bottom DO concentrations were at or below the Effects Benchmark of 9.5 mg/L for the protection of aquatic life for early life stages. In addition, some concentrations measured at MF1-5 during ice-cover season were also below the Effects Benchmark of 6.5 mg/L for the protection of aquatic life for "other" life stages (i.e., non-early life stages). The lower DO values at these stations were unlikely to be Mine-related, as the reduction in DO near the lake bottom was not present in the NF area where the effect would be expected to be greatest, and because the measured values were within the range of concentrations observed during the *Winter Dissolved Oxygen Baseline Survey*, which occurred in 2000 prior to initiation of Mine discharge (DDMI 2000). During the open-water season, DO concentrations were typically uniform throughout the water column (Figure 3-21 to Figure 3-24).

During the ice-cover season, pH values were typically uniform throughout the water column or decreased slightly with depth (Figure 3-21 to Figure 3-24). Slightly greater pH values closer to the water surface likely reflect the removal of dissolved carbon dioxide through photosynthesis. The pH values measured in Lac de Gras during the open-water season were typically uniform throughout the water column and greater than or similar to values measured during the ice-cover season (Figure 3-21 to Figure 3-24). Field pH values were frequently below the drinking water Effects Benchmark value of 7.0 as well as the aquatic life Effects Benchmark value of 6.5 (median = 6.4; range = 5.3 to 6.9). These occurrences were likely natural and unrelated to Mine discharge, as the effluent is slightly alkaline (median pH of 7.4) and because there is no spatial pattern in pH in relation to the diffuser. Furthermore, values of pH below 6.5 naturally occur throughout Lac de Gras, during both the ice-cover and open-water seasons, at various depths, and over time (i.e., 2002 to 2019; Golder 2020b).

Water temperature in Lac de Gras increased gradually with depth at most stations during the ice-cover season (Figure 3-21 to Figure 3-24). During the open-water season, temperature profiles were vertically homogeneous or temperature decreased with depth.

Turbidity was typically uniform throughout the water column during both the ice-cover and open-water seasons (Figure 3-21 to Figure 3-24). The exception was at MF1-3 during the open-water season, where turbidity increased with depth. Field turbidity values were within the respective Effects Benchmarks for ice-cover (2.2 NTU) and open-water (2.3 NTU) conditions, for all measurements.

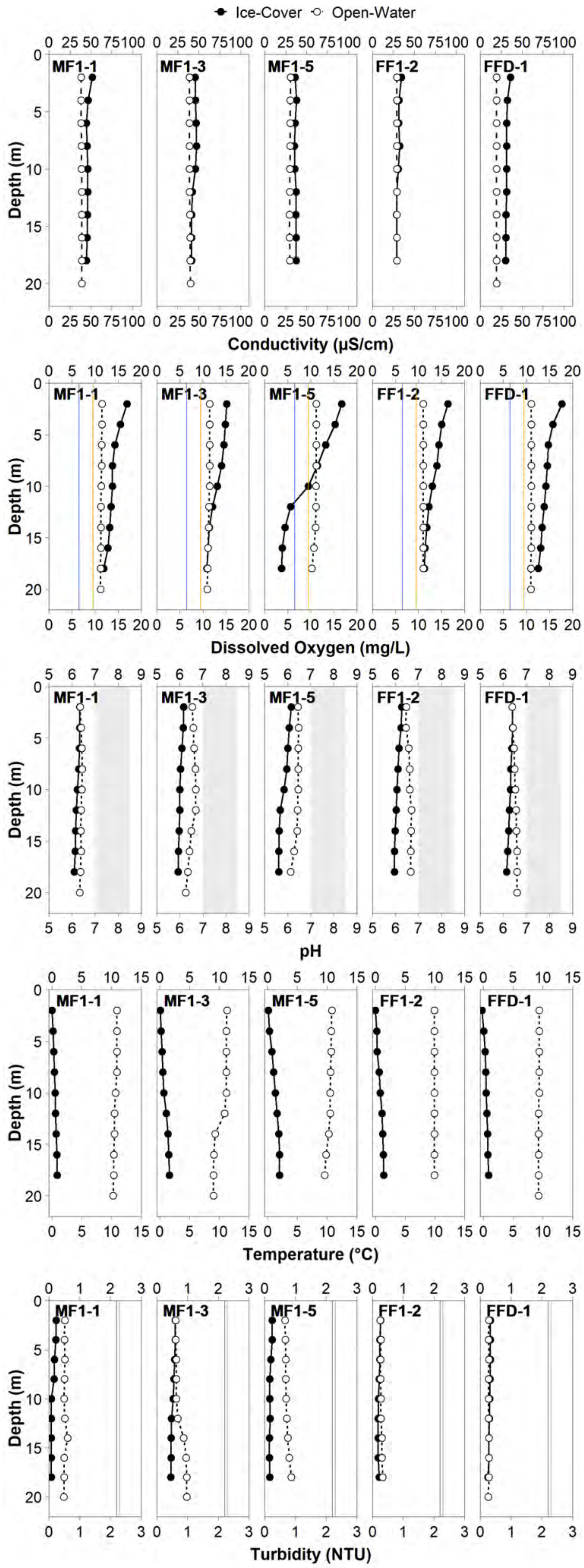
Figure 3-21 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at NF Stations, 2021



Note: The yellow and blue lines shown on the dissolved oxygen profiles, the grey lines shown on the turbidity profiles, and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

NF = near-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

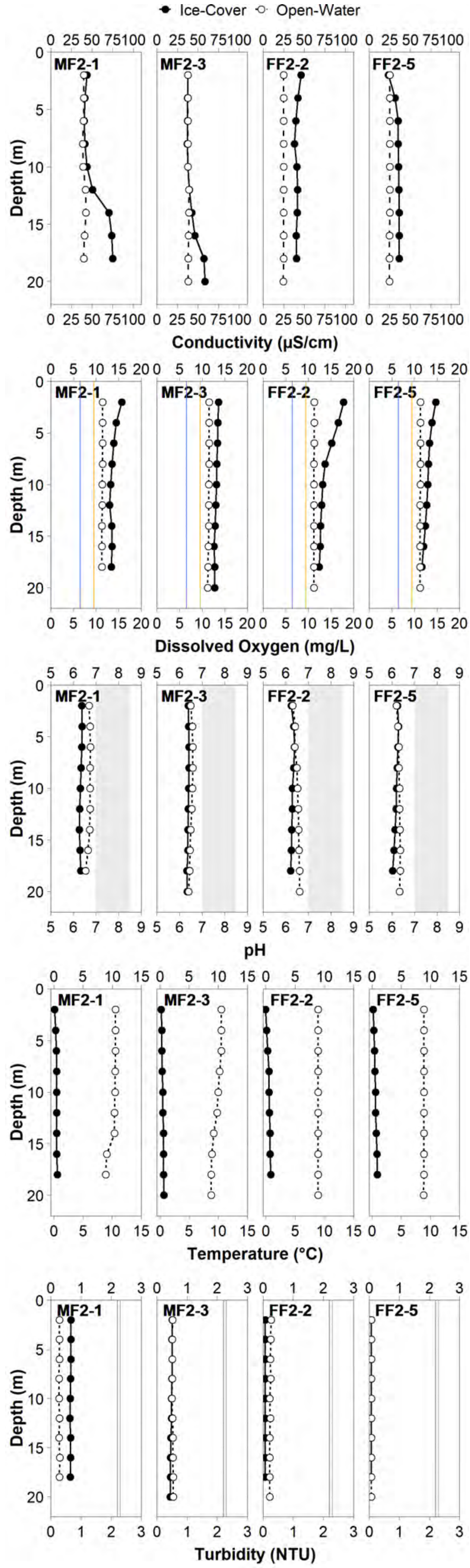
Figure 3-22 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF1 Transect Stations, 2021



Note: The yellow and blue lines shown on the dissolved oxygen profiles, the grey lines shown on the turbidity profiles, and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

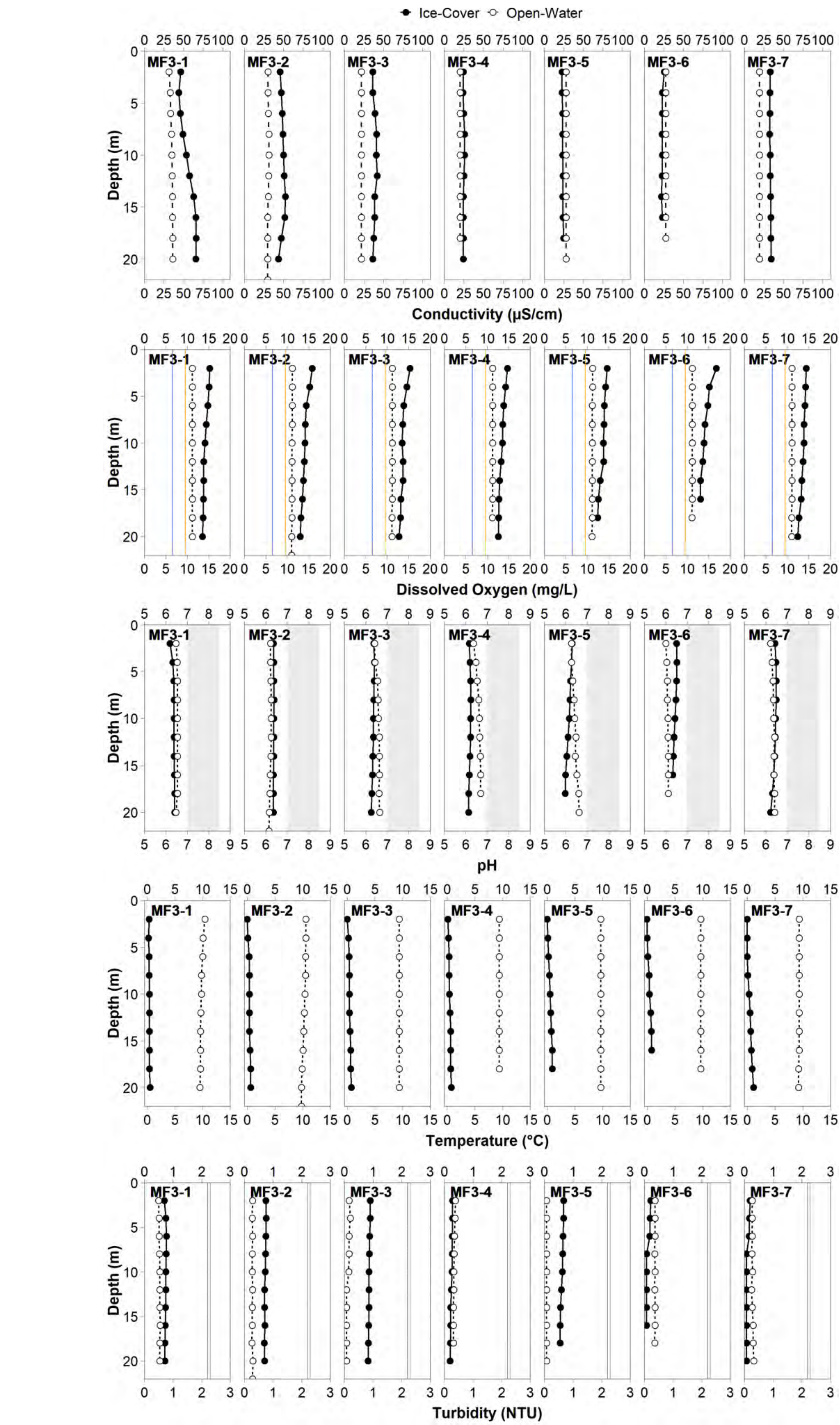
Figure 3-23 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF2 Transect Stations, 2021



Note: The yellow and blue lines shown on the dissolved oxygen profiles, the grey lines shown on the turbidity profiles and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

Figure 3-24 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF3 Transect Stations, 2021



Note: The yellow and blue lines shown on the dissolved oxygen profiles, the grey lines shown on the turbidity profiles and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

3.4 Comparison of AEMP Data to Effects Benchmarks

Concentrations of water quality variables at AEMP stations (Attachment D) were compared to the AEMP Effects Benchmarks listed in Table 2-5. This section provides a summary of benchmark exceedances noted for discrete water quality samples. A comparison of field-measured depth profile data to benchmarks is provided in Section 3.3.

- Three total manganese samples collected during the ice-cover season exceeded the drinking water Effects Benchmark of 20 µg/L, which is an aesthetic guideline applied to prevent undesirable tastes in beverages and staining of plumbing fixtures and laundry (Health Canada 2019). No dissolved manganese sample collected exceeded the aquatic life Effects Benchmark (which varies with pH, dissolved organic carbon [DOC], and hardness). Samples with exceedances of the Effects Benchmark were:
    - MF1-5B (178 µg/L): the corresponding dissolved sample (145 µg/L) also exceeded the drinking water Effects Benchmark; however, the dissolved sample was below the aquatic life Effects Benchmark (200 µg/L). Samples collected at nearby stations were generally well below the Effects Benchmarks. The elevated concentrations of total and dissolved manganese (and iron, although below the Effects Benchmark) at this station were likely related to the hypoxic or potentially anoxic conditions at the lake bottom, as indicated by DO profile data. Both the total and dissolved samples were flagged as anomalous in the initial data screening (Section 2.4.2); indicating that the value was extreme compared to other samples collected in Lac de Gras.
    - MF1-5M (28.5 µg/L): the corresponding dissolved sample (19 µg/L) did not exceed the drinking water Effects Benchmark or the aquatic life Effects Benchmark (200 µg/L). Samples collected at nearby stations were generally well below the Effects Benchmark. As in the case of the bottom sample from this station, low bottom DO concentration may account for the elevated manganese concentration. The sample was not flagged as anomalous in the initial data screening (Section 2.4.2), indicating that the value was not unusual compared to other samples collected in Lac de Gras.
    - MF3-5B (51.4 µg/L): the corresponding dissolved sample (48 µg/L) also exceeded the drinking water Effects Benchmark; however, the dissolved sample was below the aquatic life Effects Benchmark (230 µg/L). Samples collected at nearby stations were generally well below the Effects Benchmark, and the ice-cover DO profile did not suggest low bottom DO concentrations. Neither of the samples were flagged as anomalous in the initial data screening (Section 2.4.2), however, the concentration in the sample was elevated relative to other nearby stations indicating that the value was unusual compared to other samples collected in Lac de Gras.
- Laboratory pH values were at or below the drinking Effects Benchmark of 7 in all AEMP samples. In addition, laboratory pH values (median = 6.6; range = 5.9 to 7.0) were below the aquatic life Effects Benchmark of 6.5 in 12 samples collected during the ice-cover season and in 31 samples collected during the open-water season. However, as noted in Section 3.3 for field pH values that were below the Effects Benchmark, these occurrences were natural and unrelated to the Mine discharge.

Concentrations of all variables in all other samples collected during the 2021 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water (Attachment D).

3.5 Action Level Evaluation

Mine-related effects on water quality were categorized according to Action Levels (Table 2-6). Results of the Action Level screening are organized sequentially for each Action Level. Spatial variation in the concentrations of water quality variables that were identified as SOIs in 2021 are presented relative to Action Level values in Figure 3-26 to Figure 3-31.

3.5.1 Action Level 1

Action Level 1 was triggered for variables that had NF area median concentrations that were two times greater than the reference condition dataset median concentration defined in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In addition, the increase in concentration in the NF area had to be linked to the Mine (i.e., constituent detected in the Mine effluent at a higher concentration than in lake water, or in another Mine source such as dust) to trigger Action Level 1.

In total, 20 of the water quality variables assessed in 2021 triggered Action Level 1 (Table 3-7). Most of these variables were measured in the NIWTP effluent at concentrations greater than the concentration in Lac de Gras. Exceptions were copper, which generally had similar to lower concentrations in the effluent than in Lac de Gras, turbidity, which had similar values in the effluent as in Lac de Gras, as well as ammonia and manganese, which at times in the open-water season had similar concentrations in the effluent to those in Lac de Gras. Variables that triggered Action Level 1, with the exception of copper and sulphate, were also detected in dust near the Mine at concentrations above those measured at the control stations (Dust Deposition Report [Appendix I]). This provides evidence of a link to the Mine, which is required for an Action Level 1 to be triggered. No management action is required under the Response Framework (Table 2-6) when a water quality variable triggers Action Level 1.

Variables that triggered Action Level 1 were retained as SOIs according to Criterion 3 (Section 2.4.1). For some variables that were analyzed in more than one form or as different fractions (e.g., total and dissolved), the most representative of these was included as an SOI to avoid duplication. For example, while both calculated and measured TDS triggered Action Level 1, to avoid redundancy, the analysis was focused on calculated TDS. Total and dissolved calcium, magnesium, potassium, and sodium in the NF area triggered Action Level 1. To avoid redundancy and match methods from previous annual reports, graphing and analyses have been conducted on the dissolved fractions of these four variables.

Of the 20 variables that triggered Action Level 1, nine (i.e., TDS, calcium, chloride, sodium, sulphate, nitrate, molybdenum, strontium, and uranium) had NF area median concentrations that exceeded two times the reference dataset median concentration during both the ice-cover and open-water seasons. One variable (i.e., ammonia) triggered Action Level 1 during the open-water season only. The remaining ten variables (i.e., turbidity, magnesium, potassium, aluminum, antimony, barium, chromium, copper, manganese, and silicon) triggered Action Level 1 during the ice-cover season only.

3.5.2 Action Level 2

All SOIs that triggered Action Level 1 were evaluated against Action Level 2. Action Level 2 was triggered if the 5th percentile concentration in the NF area was greater than two times the median concentration in the reference condition dataset, and greater than the normal range for Lac de Gras. Of the 20 SOIs that triggered Action Level 1, nine (i.e., TDS, chloride, sodium, sulphate, nitrate, molybdenum, silicon, strontium, and uranium) triggered Action Level 2 in one or both sampling seasons (Table 3-8). In most cases, Action Level 2 was triggered during both the ice-cover and open-water seasons. The exception was silicon, which triggered Action Level 2 only during the ice-cover season.

Under the Response Framework, when a water quality variable triggers Action Level 2, the required management action is to establish an AEMP Effects Benchmark for that variable, if one does not already exist. Each of the nine variables that triggered Action Level 2 in 2021 have existing Effects Benchmarks (Table 2-5).

3.5.3 Action Level 3

Variables that triggered Action Level 2 were evaluated for an effect at Action Level 3. Action Level 3 was triggered if the 75th percentile concentration at the mixing zone boundary was greater than the normal range plus 25% of the distance between the top of the normal range and the AEMP Effects Benchmark. None of the water quality variables triggered Action Level 3 (Table 3-9). The 75th percentile concentrations of TDS, the major ions and nitrate at the mixing zone were two to five times lower than the Action Level 3 criterion in both seasons. The 75th percentile concentrations of the total metals were seven to 36 times lower than the Action Level 3 criterion in both seasons. Therefore, Action Level 3 was not triggered for any water quality parameter in 2021.

Table 3-6 Comparison of 2021 Water Quality Data to Action Level 1

Variable	Unit	2021 Detection Limit	Action Level 1 Criteria and 2021 AEMP Results					
			Action Level 1 Criterion		2021 AEMP		Action Level 1 Triggered? (Yes/No)	
			2× Median of Reference Datasets[(a)]		Median of NF values[(b)]			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters								
Total alkalinity	mg/L	0.5	8.8	8.0	6.8	6.0	No	No
Total dissolved solids, calculated	mg/L	-	10.7	10.0	**24.7**	**19.5**	**Yes**	**Yes**
Total dissolved solids, measured	mg/L	1	30	20	**37**	**26**	[(c)]	[(c)]
Total suspended solids	mg/L	1	1	1	<1	<1	No	No
Total organic carbon	mg/L	0.2	5.2	4.4	2.2	2.4	No	No
Turbidity – lab	NTU	0.1	0.10	0.42	**0.14**	0.36	**Yes**	No
Major Ions								
Calcium (dissolved)	mg/L	0.01	2.20	2.00	**2.69**	**2.17**	**Yes**	**Yes**
Chloride	mg/L	0.5	1.6	2.0	**6.5**	**4.6**	**Yes**	**Yes**
Fluoride	mg/L	0.01	0.048	0.044	0.040	0.028	No	No
Magnesium (dissolved)	mg/L	0.005	1.38	1.40	**1.52**	0.99	**Yes**	No
Potassium (dissolved)	mg/L	0.01	1.26	1.20	**1.27**	0.97	**Yes**	No
Sodium (dissolved)	mg/L	0.01	1.0	1.0	**3.14**	**2.63**	**Yes**	**Yes**
Sulphate	mg/L	0.5	4.4	3.8	**5.7**	**4.9**	**Yes**	**Yes**
Nutrients								
Ammonia	µg/L	5	36	5.0	10.7	**9.5**	No	**Yes**
Nitrate	µg-N/L	2	6.8	2.0	**95**	**34**	**Yes**	**Yes**
Nitrite	µg-N/L	1	2	2	<1	1.8	No	No
Total Metals								
Aluminum	µg/L	0.2	5.8	8.8	**8.0**	6.9	**Yes**	No
Antimony	µg/L	0.02	0.02	0.02	**0.026**	<0.02	**Yes**	No
Arsenic	µg/L	0.02	0.38	0.34	0.32	0.24	No	No
Barium	µg/L	0.02	3.86	3.62	**5.32**	3.20	**Yes**	No
Beryllium	µg/L	0.01	0.01	0.01	<0.01	<0.01	No	No
Bismuth	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Boron	µg/L	5	5	5	<5	<5	No	No
Cadmium	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Calcium	mg/L	0.01	2.04	1.92	**3.17**	**2.20**	[(c)]	[(c)]
Chromium	µg/L	0.05	0.06	0.06	**0.08**	<0.05	**Yes**	No
Cobalt	µg/L	0.005	0.022	0.040	0.018	0.018	No	No
Copper	µg/L	0.05	0.60	0.60	**0.66**	0.49	**Yes**	No
Iron	µg/L	1	5.0	10	3.4	7.1	No	No
Lead	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Lithium	µg/L	0.5	2.8	2.4	2.3	1.9	No	No
Magnesium	mg/L	0.005	1.32	1.26	**1.69**	1.00	[(c)]	No
Manganese	µg/L	0.05	2.42	4.88	**3.79**	3.00	**Yes**	No
Mercury	µg/L	0.0019	0.01	0.01	<0.0019	<0.0019	No	No
Molybdenum	µg/L	0.05	0.14	0.18	**1.02**	**0.85**	**Yes**	**Yes**

Table 3-6 Comparison of 2021 Water Quality Data to Action Level 1 (continued)

Variable	Unit	2021 Detection Limit	Action Level 1 Criteria and 2021 AEMP Results					
			Action Level 1 Criterion		2021 AEMP		Action Level 1 Triggered? (Yes/No)	
			2× Median of Reference Datasets[(a)]		Median of NF values[(b)]			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Nickel	µg/L	0.02	1.94	1.90	0.86	0.65	No	No
Potassium	mg/L	0.01	1.16	1.08	**1.36**	1.01	[(c)]	No
Selenium	µg/L	0.04	0.04	0.04	<0.04	<0.04	No	No
Silicon	µg/L	50	50	50	**143**	<50	**Yes**	No
Silver	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Sodium	mg/L	0.01	1.28	1.26	**4.17**	**2.66**	[(c)]	[(c)]
Strontium	µg/L	0.05	15.2	14.6	**47.4**	**25.1**	**Yes**	**Yes**
Sulphur	mg/L	0.5	1.96	1.82	1.40	<0.5	No	No
Thallium	µg/L	0.002	0.002	0.002	<0.002	<0.002	No	No
Tin	µg/L	0.01	0.01	0.01	<0.01	<0.01	No	No
Titanium	µg/L	0.5	0.5	0.5	<0.5	<0.5	No	No
Uranium	µg/L	0.002	0.056	0.056	**0.108**	**0.086**	**Yes**	**Yes**
Vanadium	µg/L	0.05	0.1	0.1	<0.05	<0.05	No	No
Zinc	µg/L	0.1	1.8	1.5	0.28	0.91	No	No
Zirconium	µg/L	0.05	0.05	0.05	<0.05	<0.05	No	No

a) The 2× median value was based on the reference condition dataset median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference condition median value was considered to be equal to 0.5 of the DL.

b) The median of NF area values was calculated from data pooled across all sample depths, dates and stations (n = 15 samples).

c) Action Level 1 comparison was applied to an alternate form or fraction of this substance (e.g., dissolved rather than total; calculated rather than measured) to avoid duplication.

Note: **Bold** indicates a value exceeds the Action Level 1 criterion.

- = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; 2× = two times; NF = near-field.

Table 3-7 Comparison of 2021 Water Quality Data to Action Level 2

Variable	Unit	2021 Detection Limit	Action Level 2 Criteria and 2021 AEMP Results							
			Action Level 2 Criteria				2021 AEMP Result		Action Level 2 Triggered? (Yes/No)	
			2× Median of Reference Areas[a]		Top of Normal Range		5th Percentile of NF values[b]			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters										
Total dissolved solids, calculated	mg/L	-	10.7	10.0	6.5	5.8	**19.5**	**18.7**	**Yes**	**Yes**
Turbidity – lab	NTU	0.1	0.10	0.42	0.18	0.29	0.13	0.29	No	No
Major Ions										
Calcium (dissolved)	mg/L	0.01	2.20	2.00	1.30	1.10	2.07	1.91	No	No
Chloride	mg/L	0.5	1.6	2.0	1.0	1.0	**3.9**	**4.3**	**Yes**	**Yes**
Magnesium (dissolved)	mg/L	0.005	1.4	1.4	0.8	0.8	1.2	0.92	No	No
Potassium (dissolved)	mg/L	0.01	1.3	1.2	0.8	0.7	1.0	0.91	No	No
Sodium (dissolved)	mg/L	0.01	1	1	1	1	**2.5**	**2.3**	**Yes**	**Yes**
Sulphate	mg/L	0.5	4.4	3.8	2.5	2.1	**5.0**	**4.4**	**Yes**	**Yes**
Nutrients										
Ammonia	µg-N/L	5	36	5	23	5	<5	<5	No	No
Nitrate	µg-N/L	2	6.8	2.0	15.2	2.0	**52.4**	**17.7**	**Yes**	**Yes**
Total Metals										
Aluminum	µg/L	0.2	5.8	8.8	3.9	6.2	4.0	5.2	No	No
Antimony	µg/L	0.02	0.02	0.02	0.02	0.02	<0.02	<0.02	No	No
Barium	µg/L	0.02	3.86	3.62	2.18	1.94	3.06	2.72	No	No
Chromium	µg/L	0.05	0.06	0.06	0.06	0.06	0.055	<0.05	No	No
Copper	µg/L	0.05	0.6	0.6	0.8	0.6	0.62	0.44	No	No
Manganese	µg/L	0.05	2.42	4.88	1.95	4.67	0.82	2.70	No	No
Molybdenum	µg/L	0.05	0.14	0.18	0.09	0.13	**0.71**	**0.75**	**Yes**	**Yes**
Silicon	µg/L	50	50	50	50	50	**57.7**	<50	**Yes**	No
Strontium	µg/L	0.05	15.2	14.6	8.8	8.0	**28.4**	**21.9**	**Yes**	**Yes**
Uranium	µg/L	0.002	0.056	0.056	0.030	0.029	**0.083**	**0.065**	**Yes**	**Yes**

a) The 2× median value was based on the reference condition dataset median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference condition median value was considered to be equal to 0.5 of the DL. Normal ranges are those presented in the *AEMP Reference Conditions Report, Version 1.4* (Golder 2019a).

b) The 5th percentile concentration of NF area values was calculated from data pooled across all sample depths, dates and stations (n = 15 samples).

Note: **Bold** indicates a value exceeds the Action Level 2 Criteria.

- = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; 2× = two times; NF = near-field.

Table 3-8 Comparison of 2021 Water Quality Data to Action Level 3

Variable	Unit	2021 Detection Limit	AEMP Effects Benchmark[(a)]	Action Level 3 Criteria and 2021 AEMP Results					
				Action Level 3 Criterion		2021 AEMP Results		Action Level 3 Triggered (Yes/No)	
				Normal Range[(b)] + 25% of Effects Benchmark		75th Percentile of Mixing Zone Values[(c)]			
				Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters									
Total dissolved solids, calculated	mg/L	-	500	129.9	129.4	41.6	29.8	No	No
Major Ions									
Chloride	mg/L	0.5	120	30.8	30.8	14.8	8.0	No	No
Sodium (dissolved)[(d)]	mg/L	0.01	52	13.8	13.8	6.8	4.5	No	No
Sulphate	mg/L	0.5	100	26.9	26.6	6.9	7.0	No	No
Nutrients									
Nitrate	µg-N/L	2	3,000	761	752	148	150	No	No
Total Metals									
Molybdenum	µg/L	0.05	73	18.3	18.3	1.75	2.60	No	No
Silicon	µg/L	50	2,100	563	563	277	101	No	No
Strontium	µg/L	0.05	7,000	1,757	1,756	86.5	48.8	No	No
Uranium	µg/L	0.002	15	3.8	3.8	0.18	0.18	No	No

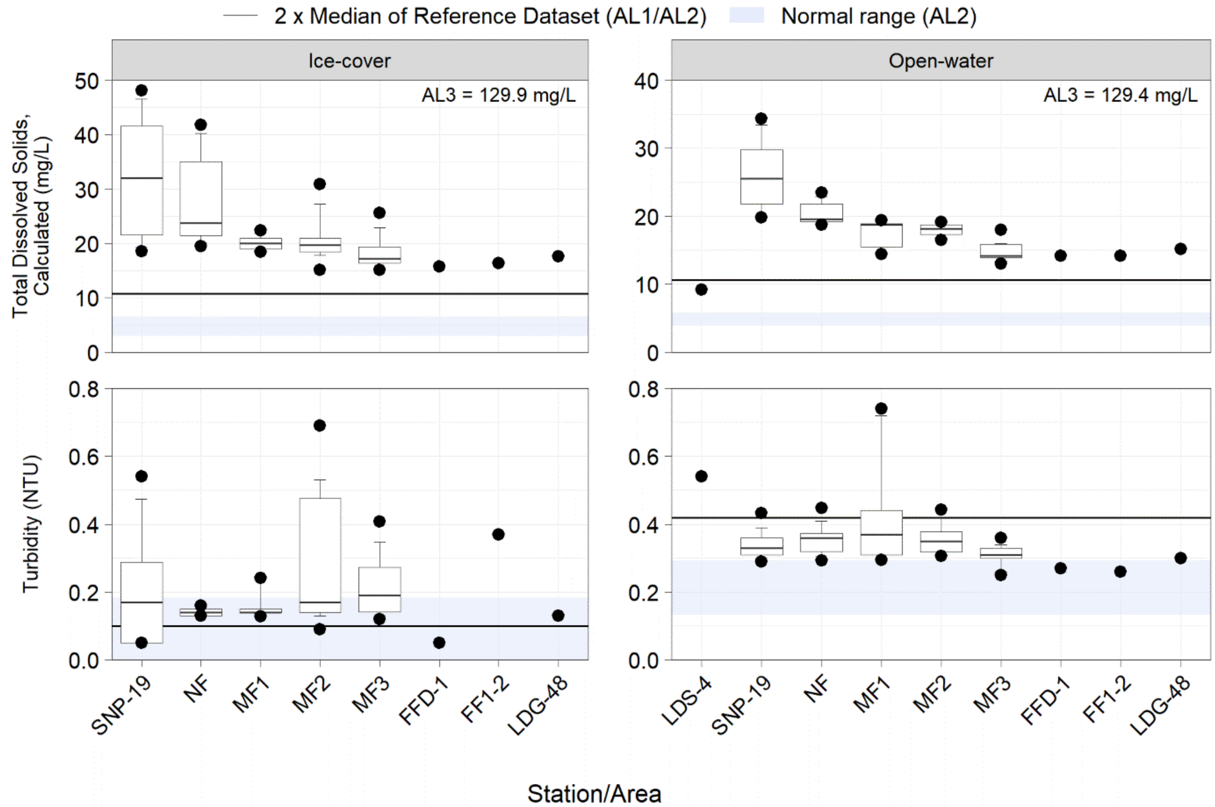
a) The AEMP Effects Benchmarks are described in the *AEMP Design Plan Version 5.2* (Golder 2020a) and in Section 2.4.4.3.

b) Normal ranges are those presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

c) The 75th percentile of mixing zone values were calculated from data pooled across all sample depths, dates and stations.

\- = not applicable; µg-N/L = micrograms nitrogen per litre.

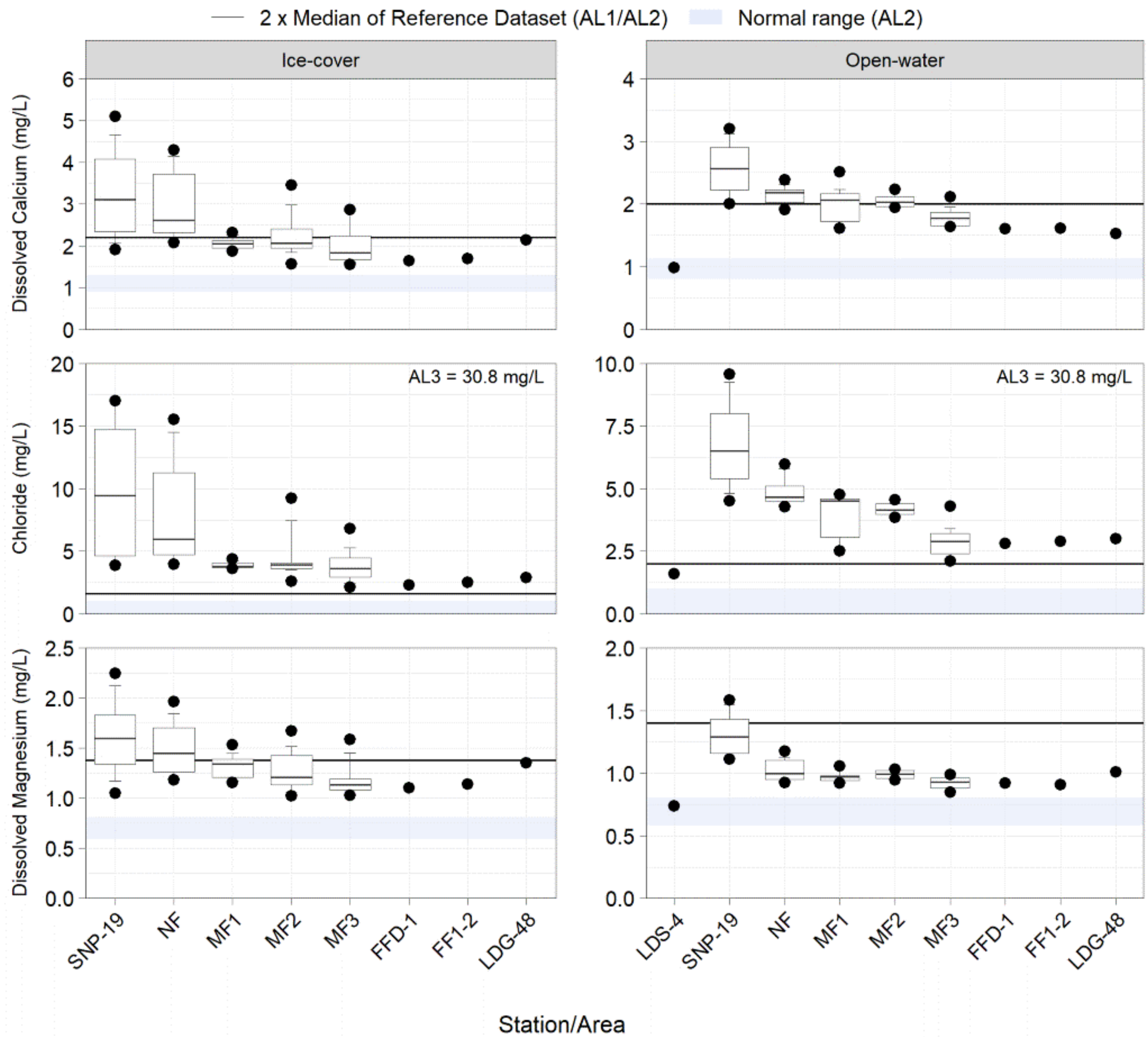
Figure 3-25 Total Dissolved Solids, Calculated and Turbidity at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2021



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Filled symbols represent the 5th and 95th percentile concentrations, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

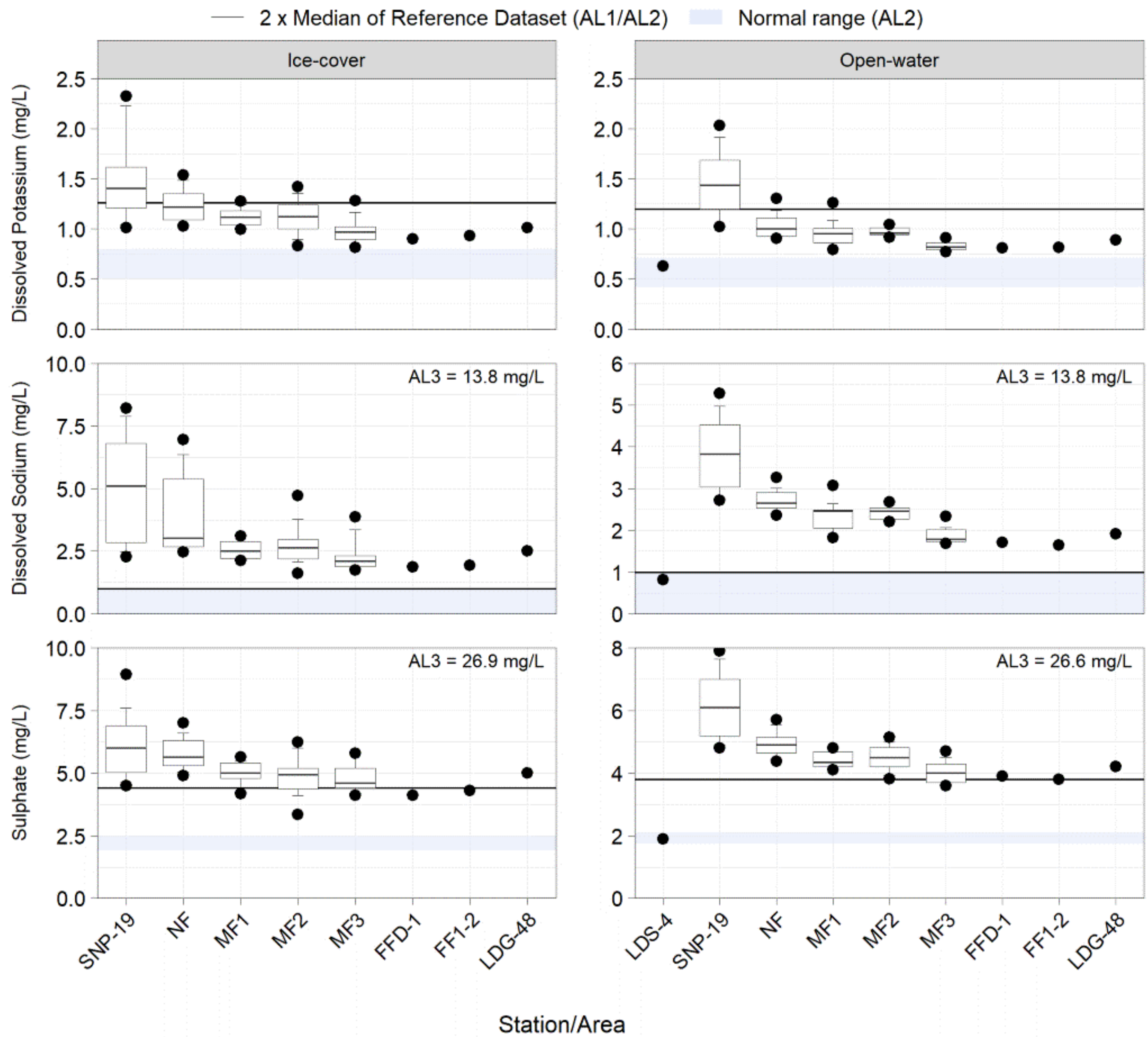
Figure 3-26 Concentration of Dissolved Calcium, Chloride, and Dissolved Magnesium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2021



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Filled symbols represent the 5th and 95th percentile concentrations, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

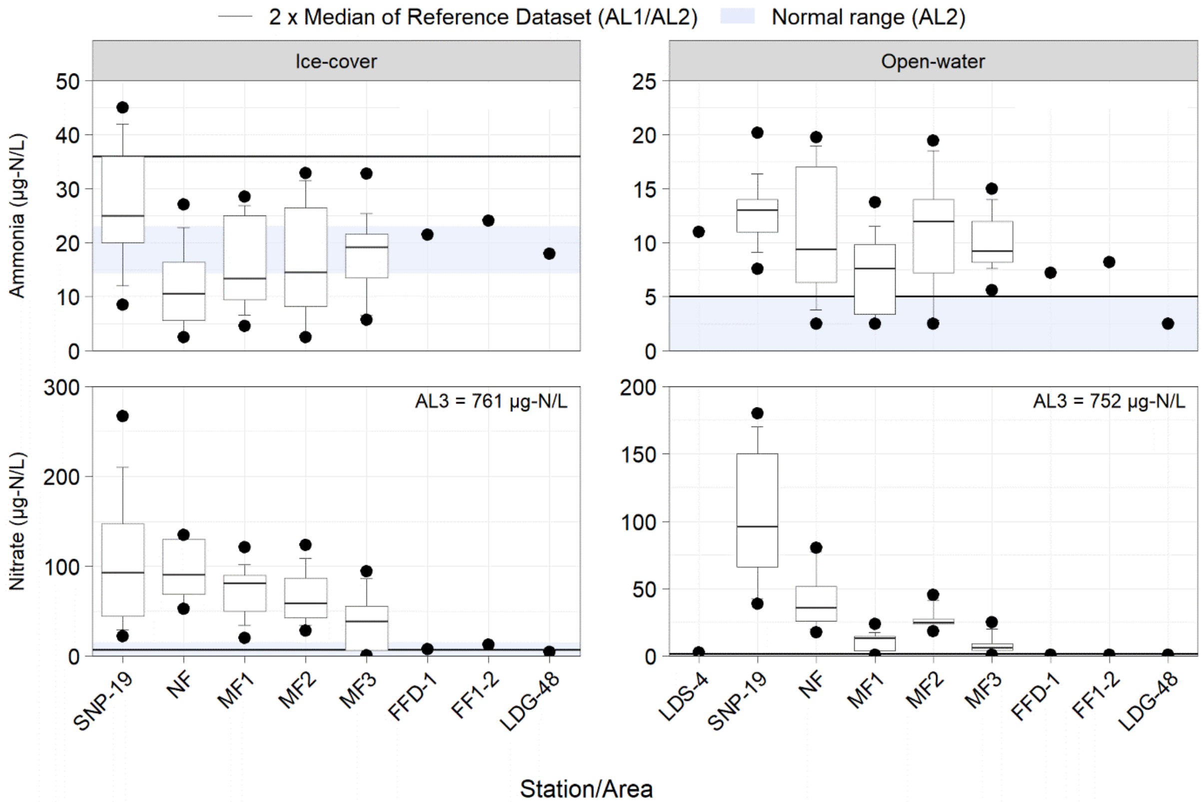
Figure 3-27 Concentration of Dissolved Potassium, Dissolved Sodium, and Sulphate at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2021



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Filled symbols represent the 5th and 95th percentile concentrations, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-28 Concentration of Ammonia and Nitrate at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2021

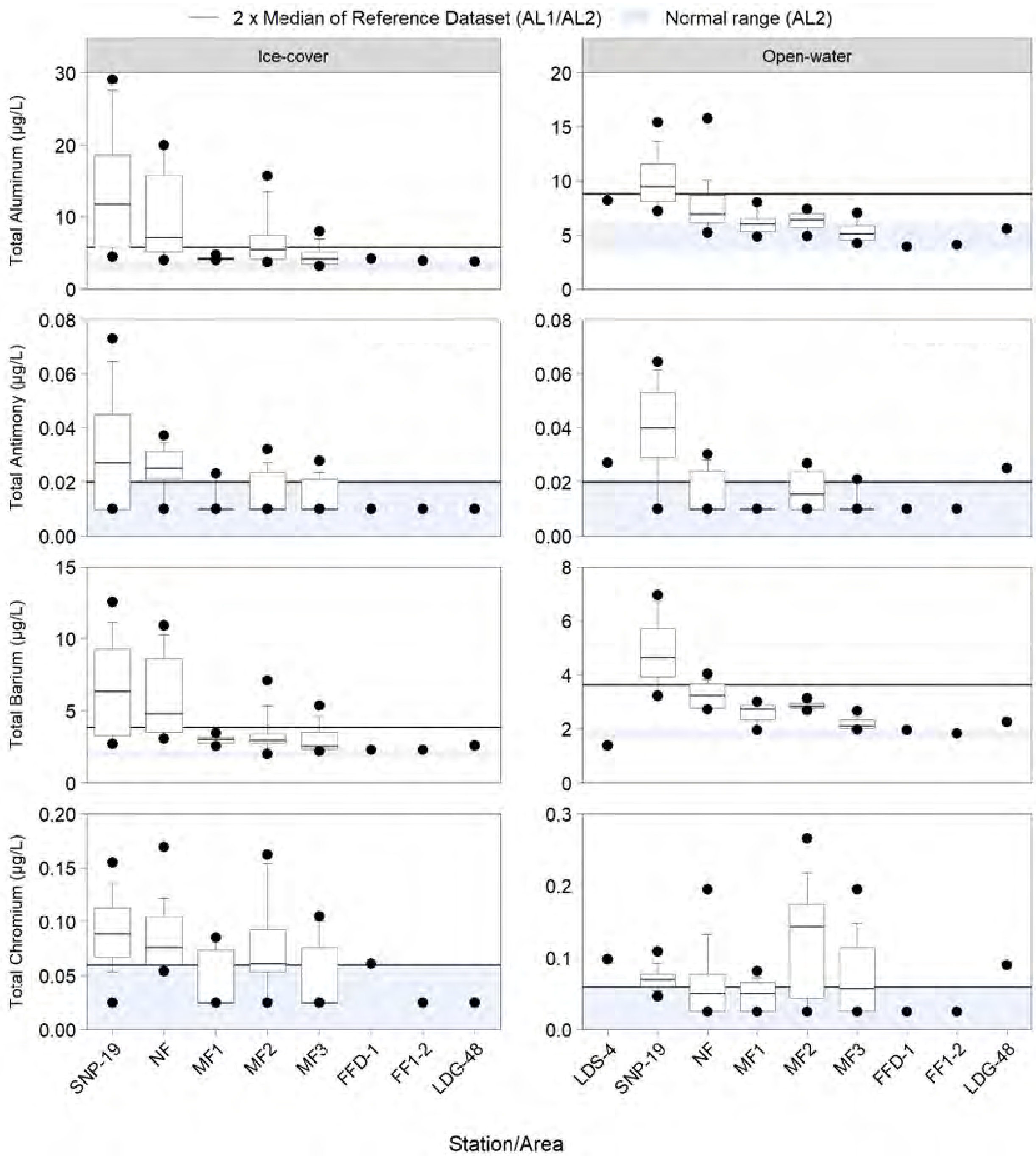


Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Filled symbols represent the 5th and 95th percentile concentrations, except in cases with three or less data points, where the reported values are shown.

Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.3.1, Attachment B).

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

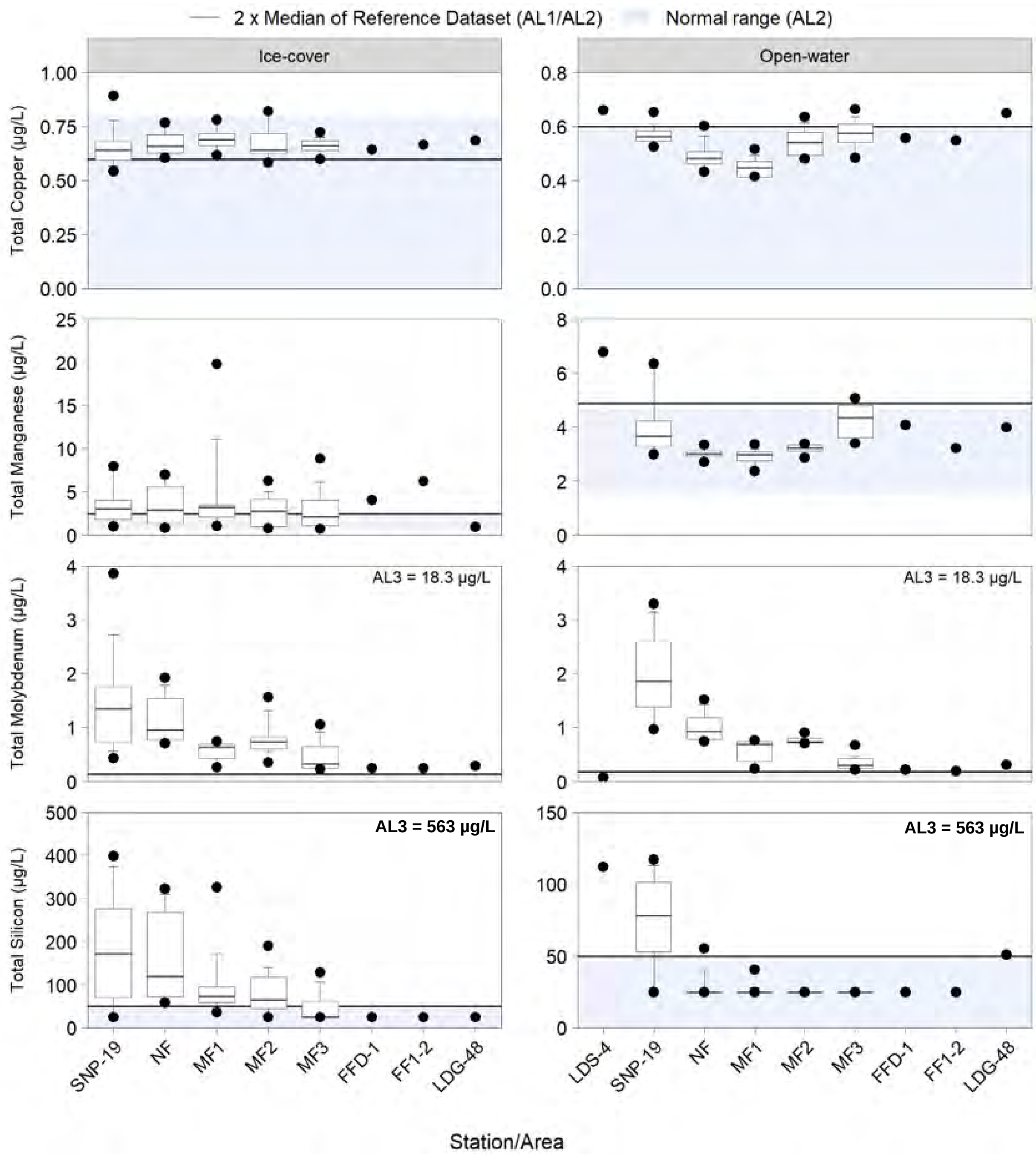
Figure 3-29 Concentration of Total Aluminum, Total Antimony, Total Barium, and Total Chromium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2021



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Filled symbols represent the 5th and 95th percentile concentrations, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

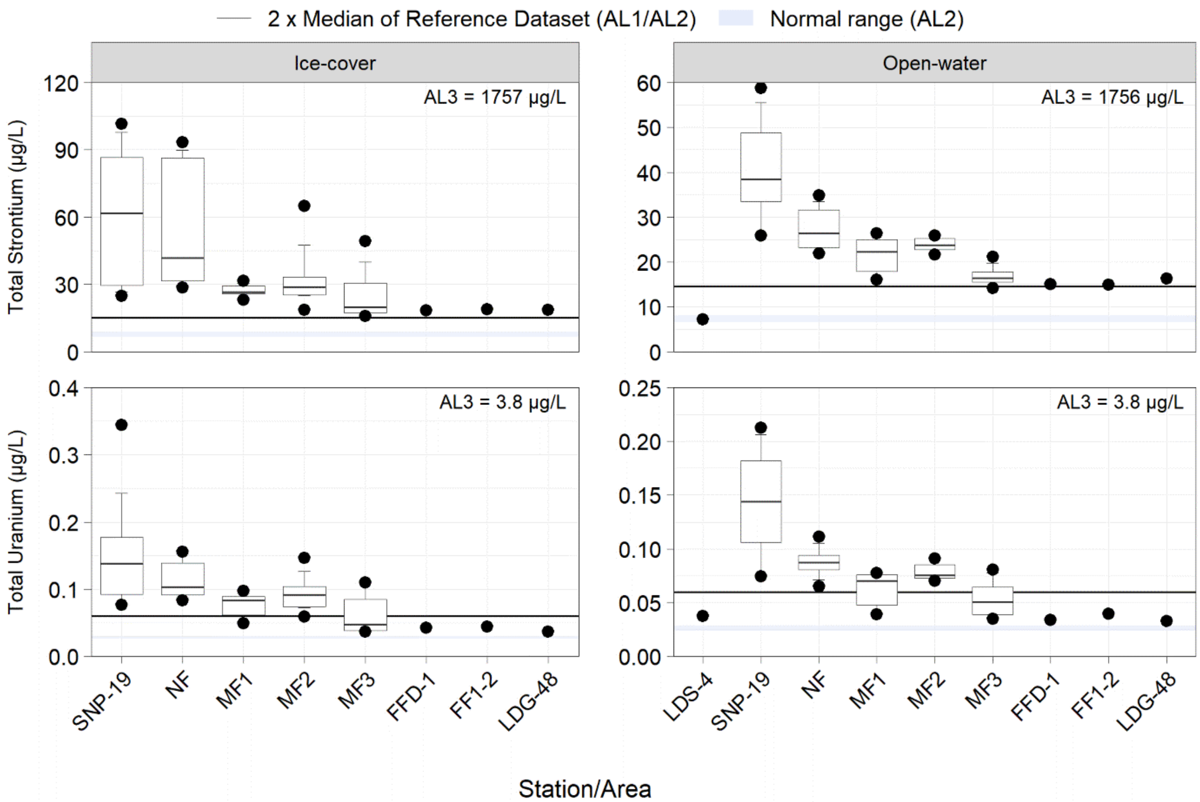
Figure 3-30 Concentration of Total Copper, Total Manganese, Total Molybdenum, and Total Silicon at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2021



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Filled symbols represent the 5th and 95th percentile concentrations, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-31 Concentration of Total Strontium and Total Uranium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2021



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Filled symbols represent the 5th and 95th percentile concentrations, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6 Gradient Analysis

Spatial trends in concentrations of SOIs were evaluated statistically along the three MF transects. A pattern of a significantly decreasing concentration with increasing distance from the diffusers was considered to be consistent with the interpretation that increases observed in the NF area were related to the Mine effluent discharge. Trends were identified using linear regression analysis (Section 2.4.5.2) and a graphical (i.e., visual) evaluation of the data plotted by distance from the diffusers (Figure 3-32 to Figure 3-51).

The concentrations of SOIs at the Lac de Gras outflow to the Coppermine River (LDG-48) and the Lac du Sauvage outflow to Lac de Gras (LDS-4), were compared visually to those at AEMP stations within the main body of Lac de Gras. This comparison allowed an evaluation of the influence of the main natural inflow to Lac de Gras, and differences in SOI concentrations flowing into and out of the lake.

In general, clear spatial trends of decreasing concentrations with distance from the Mine effluent diffusers were evident for most variables that triggered Action Levels. Spatial trends were generally more pronounced during the ice-cover season than during open-water conditions. Further details are provided in the subsections that follow for SOIs that met Criteria 1 to 3 (Section 2.4.1).

3.6.1 Conventional Variables, Total Dissolved Solids, and Associated Ions

Results of the gradient analysis indicated that turbidity had a significant increasing trend with distance from the diffuser along all three MF transects during the ice-cover season. Turbidity had a significant decreasing trend along only one (i.e., MF1) of the three MF transects during the open-water season (Table 3-10; Figure 3-32).

During the ice-cover season, gradient analysis indicated that TDS and major ions (i.e., calcium, chloride, magnesium, potassium, sodium, and sulphate) had significant decreasing trends with distance from the diffuser along all three MF transects (Table 3-10; Figure 3-33 to Figure 3-39). During the open-water season, magnesium and sodium had significant decreasing trends along two (i.e., MF1 and MF3) of the three MF transects. Potassium had a significant decreasing trend along the MF1 transect only. TDS, calcium, chloride, and sulphate had significant decreasing trends with distance from the diffuser along all three MF transects.

The spatial analysis of the MF3 transect involved the use of a piecewise model (Model 3) during both the ice-cover and open-water seasons for TDS, calcium, chloride, potassium, sodium and sulphate, and during the ice-cover season for turbidity and magnesium. Breakpoints in the piecewise model generally occurred between two and sixteen kilometres from the effluent discharge. The piecewise analysis for these parameters indicated a more pronounced decrease in concentration at stations closer to the effluent discharge (i.e., stations located within 2 to 16 km of the effluent discharge) compared to stations farther away, and compared to SOIs that were analyzed using a standard linear approach. The trend direction for magnesium in the ice-cover season, and potassium and sulphate in the open-water season changed from a decreasing trend for the first slope (extending from the NF area to the breakpoint) to an increasing trend for the second slope (extending from the breakpoint through MF3-7). The trend direction for turbidity changed from an increasing trend for the first slope to a decreasing trend for the second slope.

Concentrations of TDS and major ions were generally lower at LDS-4 compared to most stations located in Lac de Gras, with the exception of turbidity. Turbidity was greater at LDS-4 than at most of the stations in Lac de Gras. During the ice-cover season, concentrations of most SOIs at LDG-48 were slightly greater than those encountered at the far end of the MF3 transect (i.e., MF3-7), whereas concentrations at LDG-48 were generally similar those at the far end of the MF3 transect in the open-water season.

Table 3-9 Gradient Analysis for Conventional Variables, Total Dissolved Solids, and Associated Ions, 2021

Variable	Season	Model	Trans-formation[a]	Gradient	Slope Direction[b]	Break-point (km)[c]	*P*-value[d]	R^2 or r^{2}[e]
Turbidity	Ice-cover[f]	Model 2	log	MF1	↑	-	**<0.001**	0.77
				MF2	↑	-	**0.002**	
		Model 3		MF3 (1st slope)	↑	15.7	**0.028**	0.63
				MF3 (2nd slope)	↓		**-**	
	Open-water[g]	Model 1	log	MF1	↓	-	**0.002**	0.26
				MF2	↑	-	0.577	
				MF3	↓	-	0.357	
Total Dissolved Solids, calculated	Ice-cover[h]	Model 2	log	MF1	↓	-	**<0.001**	0.92
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	5.5	**0.001**	0.95
				MF3 (2nd slope)	↓		-	
	Open-water	Model 2	log	MF1	↓	-	**<0.001**	0.71
				MF2	↓	-	**0.013**	
		Model 3		MF3 (1st slope)	↓	4.7	**0.001**	0.92
				MF3 (2nd slope)	↓		-	
Calcium (dissolved)	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.93
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	8.3	**0.001**	0.96
				MF3 (2nd slope)	↓		-	
	Open-water[i]	Model 2	none	MF1	↓	-	**<0.001**	0.78
				MF2	↓	-	**0.009**	
		Model 3		MF3 (1st slope)	↓	5.8	**0.014**	0.87
				MF3 (2nd slope)	↓		-	
Chloride	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.88
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	5.1	**0.004**	0.92
				MF3 (2nd slope)	↓		-	
	Open-water	Model 2	none	MF1	↓	-	**<0.001**	0.67
				MF2	↓	-	**0.031**	
		Model 3		MF3 (1st slope)	↓	1.6	**0.016**	0.92
				MF3 (2nd slope)	↓		-	
Magnesium (dissolved)	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.76
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	5.6	**0.015**	0.81
				MF3 (2nd slope)	↑		-	
	Open-water	Model 1	log	MF1	↓	-	**0.004**	0.5
				MF2	↓	-	0.612	
				MF3	↓	-	**0.04**	
Potassium (dissolved)	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.81
				MF2	↓	-	**0.001**	
		Model 3		MF3 (1st slope)	↓	4.8	**0.009**	0.86
				MF3 (2nd slope)	↓		**-**	
	Open-water[j]	Model 2	log	MF1	↓	-	**<0.001**	0.64
				MF2	↓	-	0.395	
		Model 3		MF3 (1st slope)	↓	4.2	0.072	0.79
				MF3 (2nd slope)	↑		-	
Sodium (total)	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.89
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	5.3	**0.001**	0.94
				MF3 (2nd slope)	↓		-	
	Open-water	Model 2	log	MF1	↓	-	**<0.001**	0.62
				MF2	↓	-	0.056	
		Model 3		MF3 (1st slope)	↓	4.6	**0.001**	0.93
				MF3 (2nd slope)	↓		-	

Table 3-9 Gradient Analysis for Conventional Variables, Total Dissolved Solids, and Associated Ions, 2021

Variable	Season	Model	Trans-formation(a)	Gradient	Slope Direction(b)	Break-point (km)(c)	*P*-value(d)	R^2 or $r^{2(e)}$
Sulphate	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.85
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	9.5	**0.007**	0.92
				MF3 (2nd slope)	↓		**-**	
	Open-water	Model 2	log	MF1	↓	-	**<0.001**	0.73
				MF2	↓	-	**0.002**	
		Model 3		MF3 (1st slope)	↓	12.1	**<0.001**	0.93
				MF3 (2nd slope)	↑		**-**	

a) Models used and transformation rules are described in Section 2.4.5.2

b) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.

c) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

d) *P*-values were not calculated for the second MF3 slope.

e) For Model 3 (i.e., MF3 broken stick models), r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, since there is more than one predictor, i.e., distance and gradient.

f) Influential points removed: <0.05 NTU and 0.9 NTU.

g) Outlier removed: 0.76 NTU.

h) Influential point removed: 22.9 mg/L.

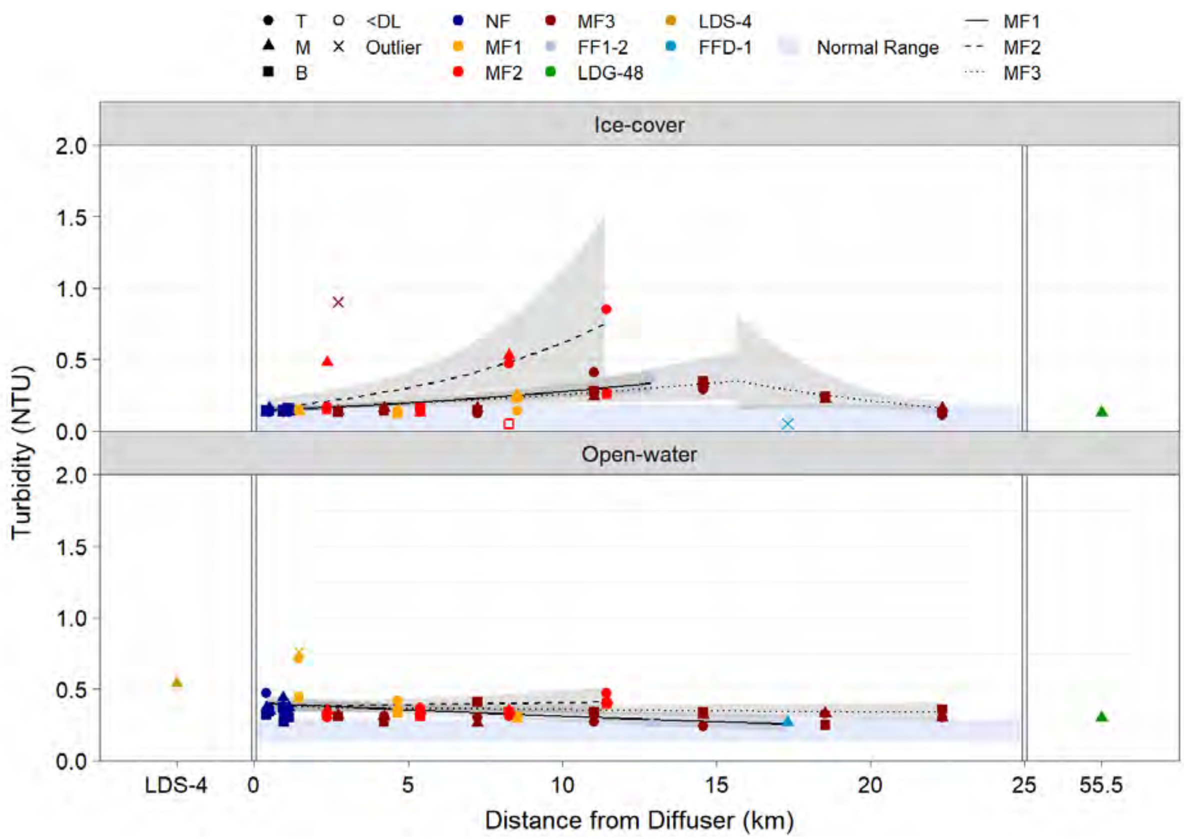
i) Influential point removed: 2.79 mg/L.

j) Influential points removed: 1.44 mg/L and 1.44 mg/L.

Note: **Bold** indicates *P*-value is significant at <0.05.

- = not applicable; MF = mid-field.

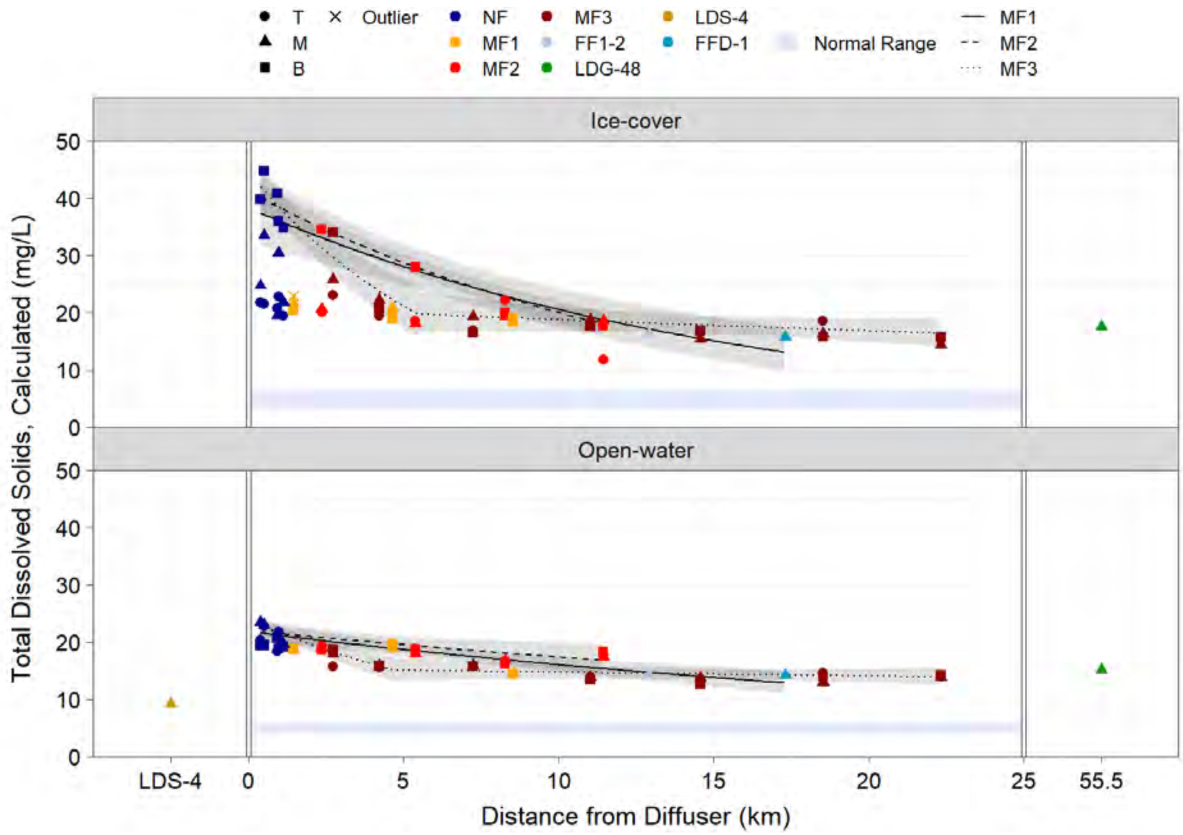
Figure 3-32 Turbidity According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; x = statistical outlier; NTU = nephelometric turbidity unit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

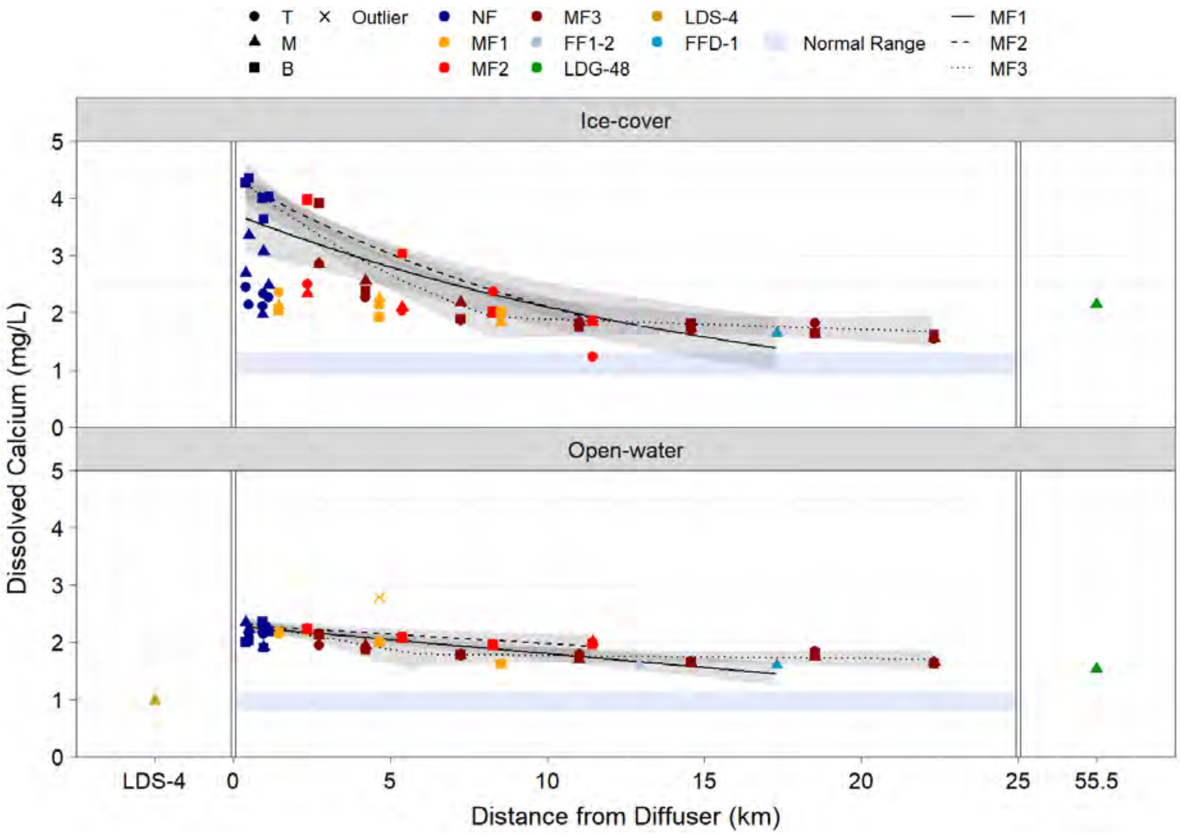
Figure 3-33 Concentrations of Total Dissolved Solids (Calculated) According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

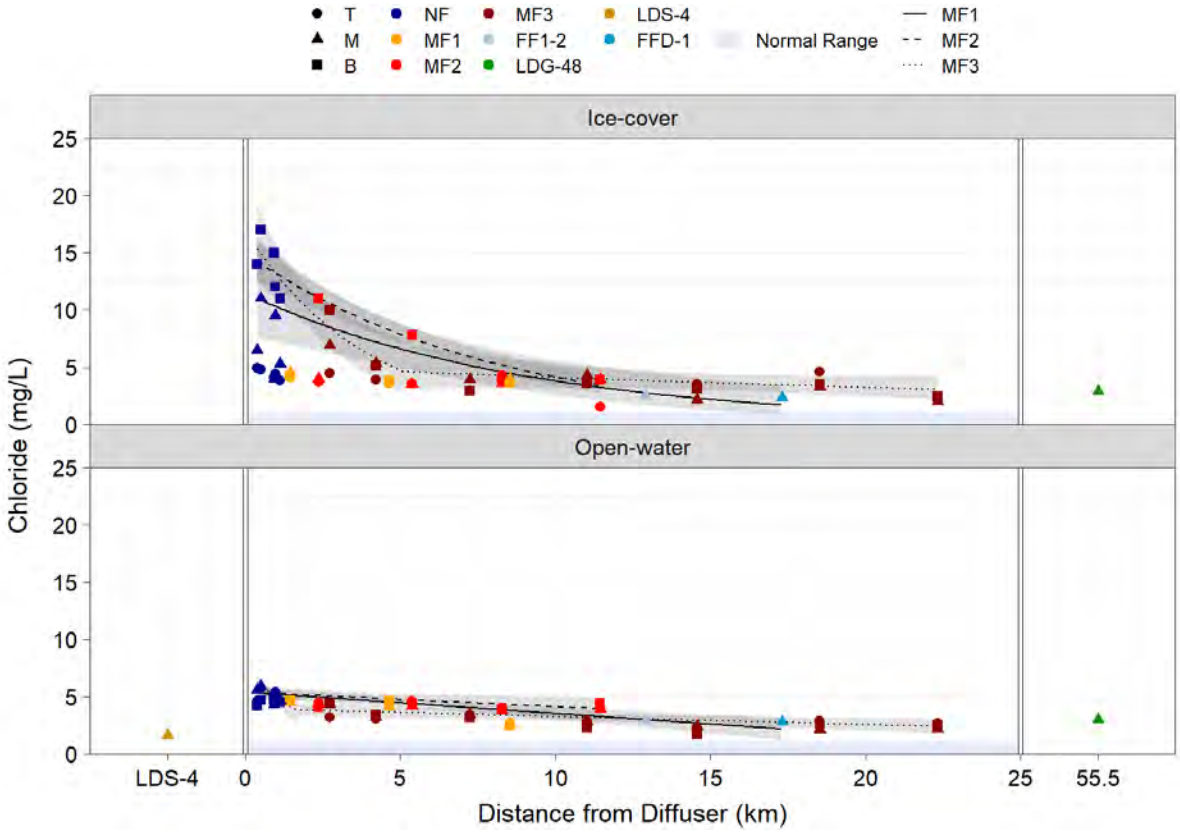
Figure 3-34 Concentrations of Calcium (Dissolved) According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage

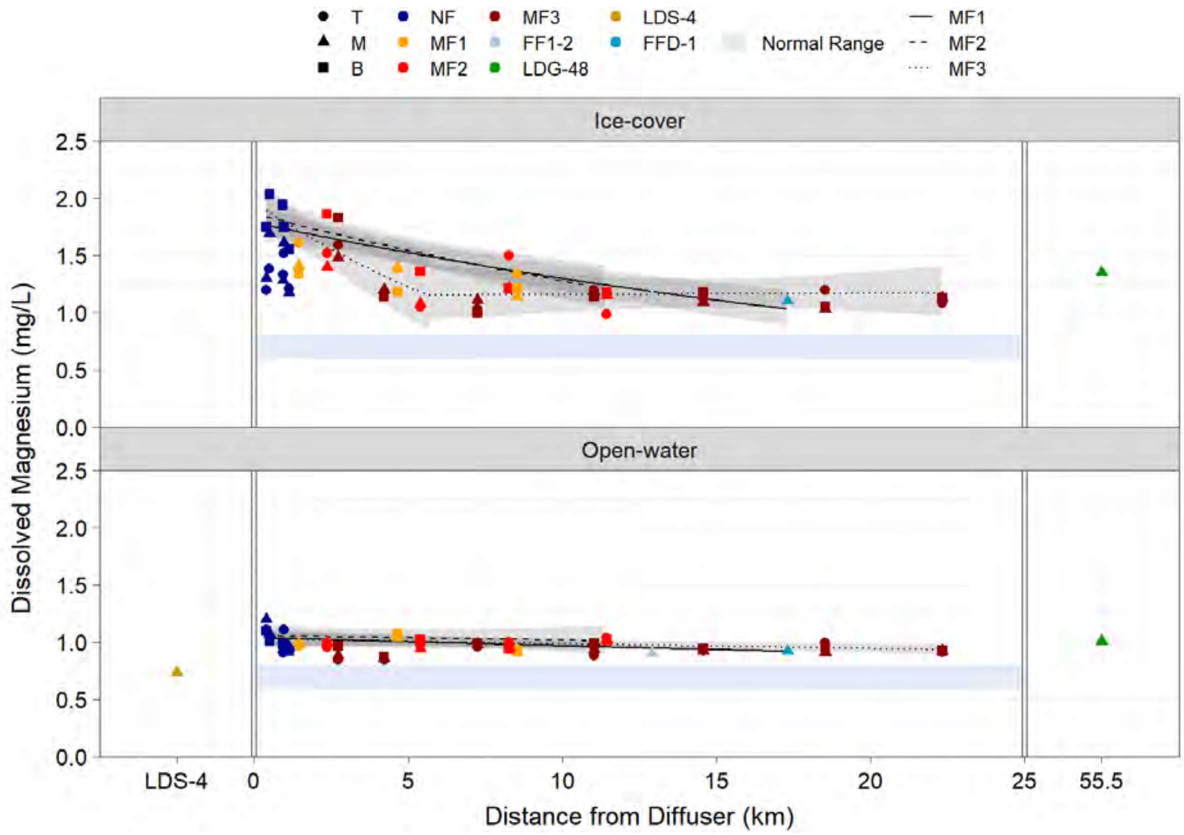
Figure 3-35 Concentration of Chloride According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

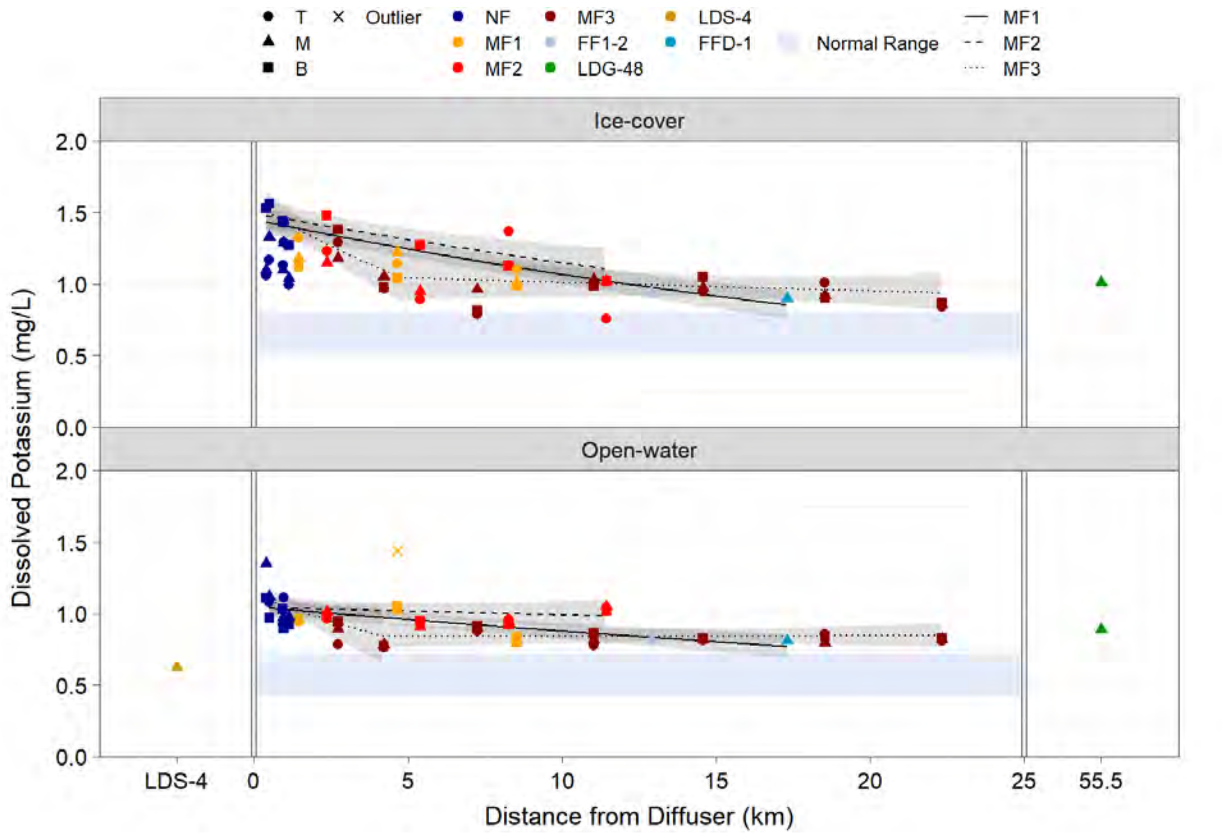
Figure 3-36 Concentrations of Magnesium (Dissolved) According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

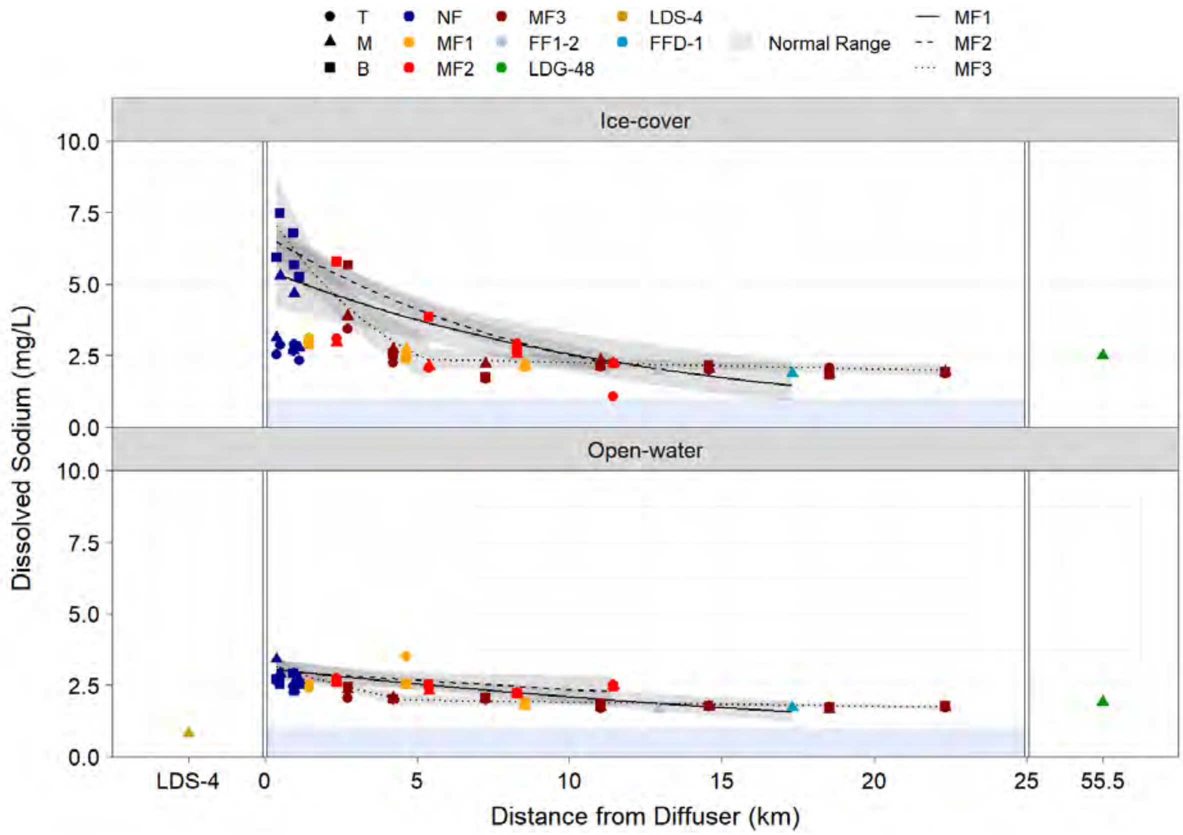
Figure 3-37 Concentration of Potassium (Dissolved) According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

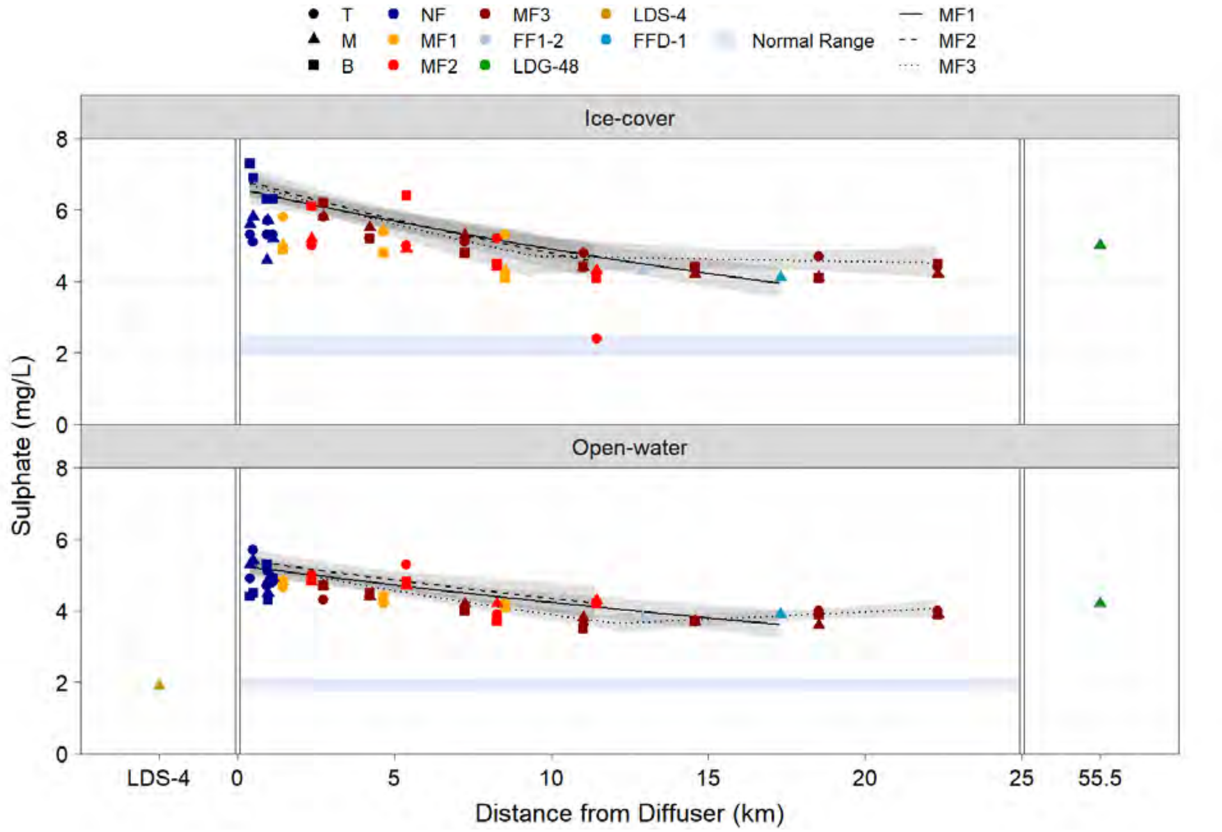
Figure 3-38 Concentration of Sodium (Dissolved) According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-39 Concentration of Sulphate According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6.2 Nitrogen Variables

The slope of the linear regression for ammonia was significantly different from zero for the MF1 transect in the open-water season (Table 3-11). This slope was negative, indicating decreasing concentrations with distance from the effluent discharge.

Nitrate had significant decreasing trends with distance from the diffuser along all three MF transects during the ice-cover season (Table 3-11). The spatial analysis of the MF3 transect for nitrate detected a breakpoint at 7.2 km from the effluent discharge. During the open-water season, nitrate had significant decreasing trends with distance from the diffuser along two (i.e., MF1 and MF3) of the three MF transects.

The open-water concentration of ammonia at LDS-4 was generally similar to those in Lac de Gras (Figure 3-40) whereas the concentration of nitrate at LDS-4 was generally lower than those in Lac de Gras (Figure 3-41). The concentration of ammonia at LDG-48 was similar to those at the MF3-7 station at the far end of the MF3 transect during the ice-cover season and lower than MF3-7 in the open-water season. The concentrations of nitrate at LDG-48 were similar to those at MF3-7 in both seasons.

Table 3-10 Gradient Analysis for Nitrogen Variables, 2021

Variable	Season	Model	Transformation[a]	Gradient	Slope[b]	Breakpoint (km)[c]	*P*-value[d]	R^2 or r^2[e]
Ammonia	Ice-cover	Model 1	log	MF1	↑	-	0.967	-0.13
				MF2	↑	-	0.287	
				MF3	↓	-	0.551	
	Open-water[f]	Model 1	log	MF1	↓	-	**0.009**	0.21
				MF2	↑	-	0.342	
				MF3	↓	-	0.385	
Nitrate	Ice-cover[g]	Model 2	none	MF1	↓	-	**<0.001**	0.85
				MF2	↓	-	**0.009**	
		Model 3		MF3 (1st slope)	↓	7.2	**0.03**	0.94
				MF3 (2nd slope)	↓		-	
	Open-water	Model 1	0.5	MF1	↓	-	**<0.001**	0.63
				MF2	↓	-	0.093	
				MF3	↓	-	**<0.001**	

a) Models used and transformation rules are described in Section 2.4.5.2

b) Slope direction was represented by an upward arrow (↑) indicating increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.

c) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

d) *P*-values were not calculated for the second MF3 slope.

e) For Model 3 (i.e., MF3 broken stick models), r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, since there is more than one predictor, i.e., distance and gradient.

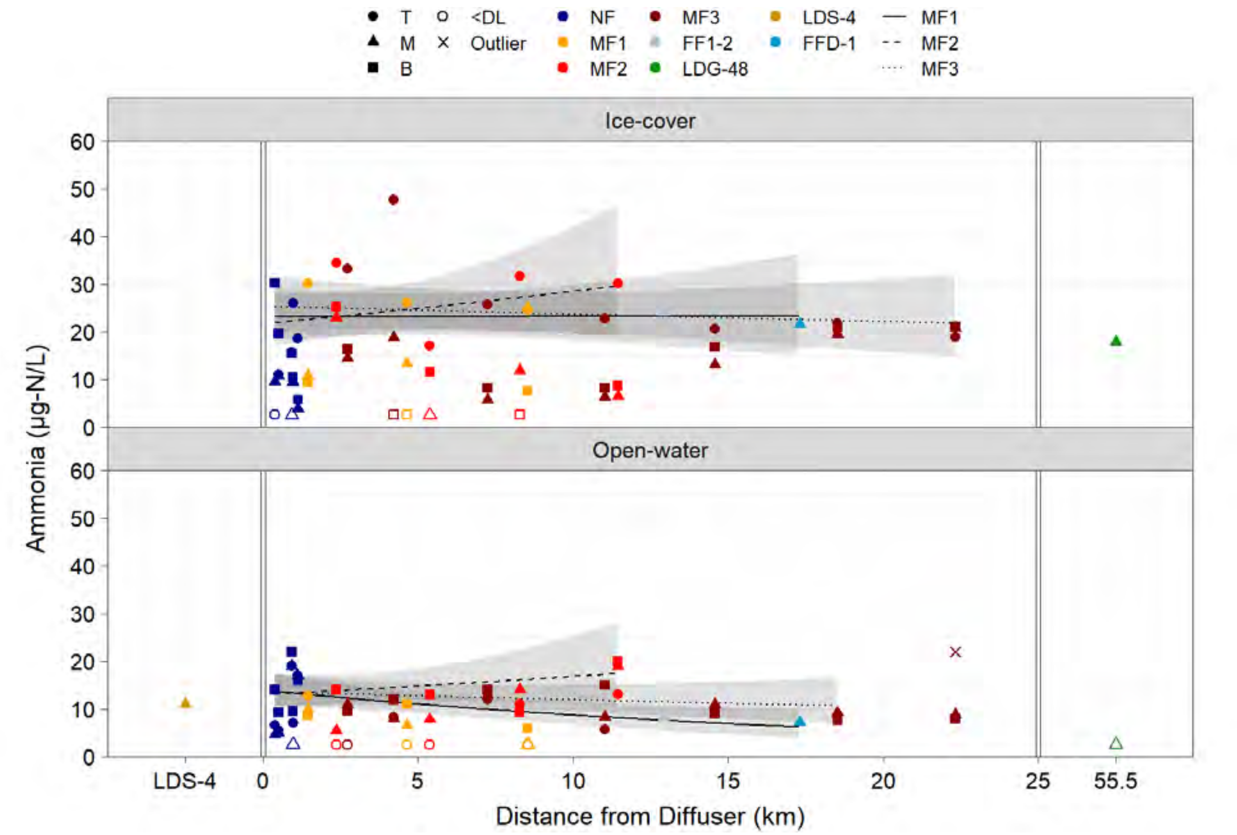
f) Influential point removed: 22 µg-N/L.

g) Outlier removed: 140 µg-N/L.

Note: **Bold** indicates *P*-value is significant at <0.05.

- = not applicable; n/a = not analyzed; MF = mid-field.

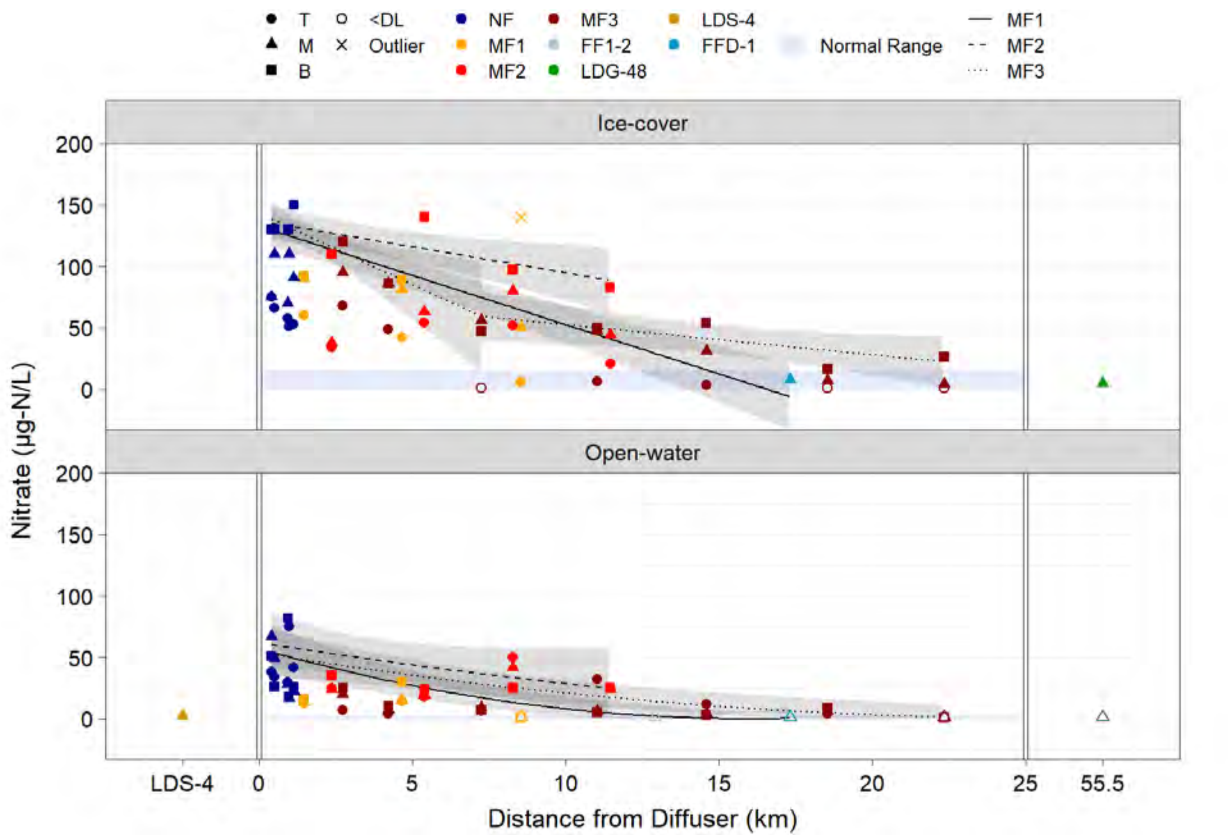
Figure 3-40 Concentrations of Ammonia According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; µg-N/L = micrograms of nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-41 Concentrations of Nitrate According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; µg-N/L = micrograms of nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6.3 Total Metals

The total metal SOIs for which linear regression analysis was completed consisted of aluminum, barium, copper, manganese, molybdenum, strontium, and uranium (Figure 3-42, Figure 3-44, Figure 3-46, Figure 3-47, Figure 3-48, Figure 3-50, and Figure 3-51). Linear regressions were not performed for antimony (both seasons; Figure 3-43), chromium (both seasons; Figure 3-45), and silicon (both seasons; Figure 3-49), due to the considerations discussed in Section 2.4.5.2; however, spatial trends are discussed qualitatively herein.

During the ice-cover season, concentrations of most total metals decreased significantly with distance from the diffuser along all three MF transects (Table 3-12). The exceptions were copper (which had a significant regression along the MF1 transect only) and manganese (which had non-significant slopes along all three MF transects).

During the open-water season, slopes of the linear regressions for molybdenum and uranium were significantly different from zero along all three MF transects. Aluminum, barium, manganese, and strontium had significant regressions along two (i.e., MF1 and MF3) of the three MF transects, and copper had non-significant slopes along all three MF transects. In most cases, slopes were negative, indicating decreasing concentrations with distance from the effluent discharge. However, slopes of linear regressions were positive in direction along the MF1 and MF3 transects for manganese, indicating increasing concentrations with distance from the effluent discharge, which is inconsistent with a Mine-related effect.

Piecewise regression was used for the analysis of the MF3 transect for total metals, with the exception of aluminum (open-water), copper (both seasons), manganese (ice-cover), and uranium (open-water), which used a standard linear approach. Breakpoints identified by the piecewise analysis generally occurred between 1 and 10 km from the effluent discharge. The exception was manganese during the open-water season, which had a breakpoint at approximately 13.2 km from the effluent discharge. The trend direction for aluminum in the ice-cover season changed from a decreasing trend for the first slope (extending from the NF area to the breakpoint) to a generally flat slope (extending from the breakpoint through to MF3-7). The trend direction for manganese changed from an increasing trend for the first slope to a decreasing trend for the second slope. The trend direction in other total metal SOIs with significant regressions along the MF3 transect was a decrease in concentration with distance away from the diffusers, consistent with a Mine-related effect.

In the ice-cover season, concentrations of antimony, chromium, and silicon generally decreased with distance from the diffuser along all three MF transects. In the open-water season concentrations of antimony and chromium varied without a distinct pattern and concentrations of silicon were generally non-detect with sporadic results at low concentrations.

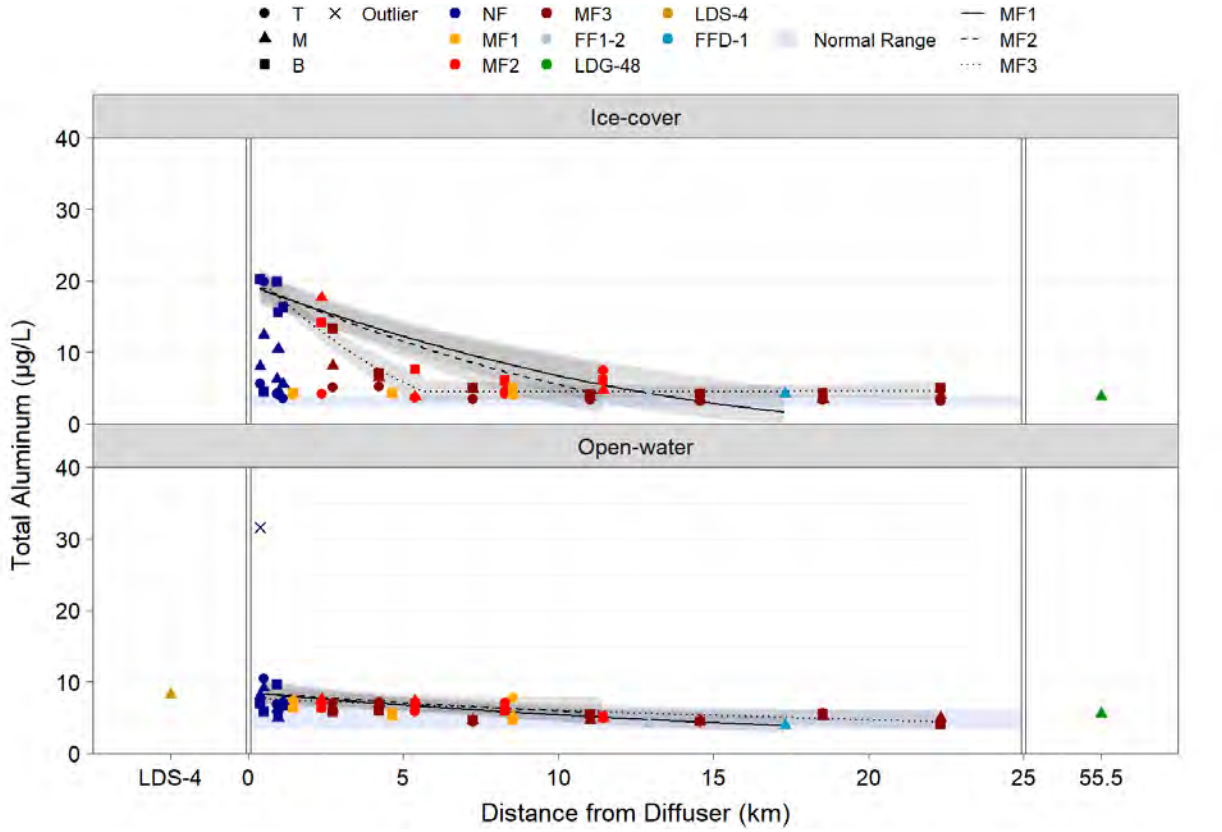
Open-water concentrations of barium, molybdenum, strontium and uranium were generally lower at LDS-4 compared to stations located in Lac de Gras, whereas the concentrations of copper, manganese, and silicon were slightly greater at LDS-4 compared to stations in Lac de Gras. Concentrations of aluminum, antimony, and chromium were generally similar at LDS-4 compared to concentrations measured in Lac de Gras. Concentrations of most total metal SOIs at LDG-48 were similar to those encountered at MF3-7 during both seasons. The exceptions were chromium (open-water), copper (open-water), and silicon (open-water), which had greater concentrations at LDG-48 than at MF3-7.

Table 3-11 Gradient Analysis for Total Metals, 2021

Variable	Season	Model	Transformation[a]	Gradient	Slope[b]	Break-point (km)[c]	*P*-value[d]	R^2 or r^2[e]
Aluminum	Ice-cover[f]	Model 2	0.5	MF1	↓	-	**<0.001**	0.80
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	5.6	**<0.001**	0.97
				MF3 (2nd slope)	↑		-	
	Open-water[g]	Model 1	log	MF1	↓	-	**0.001**	0.48
				MF2	↓	-	0.069	
				MF3	↓	-	**0.006**	
Antimony	Ice-cover	n/a						
	Open-water	n/a						
Barium	Ice-cover[h]	Model 2	log	MF1	↓	-	**<0.001**	0.95
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	6.1	**<0.001**	0.98
				MF3 (2nd slope)	↓		-	
	Open-water	Model 2	log	MF1	↓	-	**<0.001**	0.63
				MF2	↓	-	0.123	
		Model 3		MF3 (1st slope)	↓	1.4	**0.001**	0.94
				MF3 (2nd slope)	↓		-	
Chromium	Ice-cover	n/a						
	Open-water	n/a						
Copper	Ice-cover	Model 1	log	MF1	↓	-	**0.003**	0.33
				MF2	↑	-	0.686	
				MF3	↓	-	0.096	
	Open-water	Model 1	log	MF1	↑	-	0.667	0.05
				MF2	↑	-	0.325	
				MF3	↑	-	0.145	
Manganese	Ice-cover[i]	Model 1	none	MF1	↓	-	0.557	-0.19
				MF2	↓	-	0.877	
				MF3	↑	-	0.922	
	Open-water	Model 2	log	MF1	↑	-	**0.038**	0.11
				MF2	↓	-	0.773	
		Model 3		MF3 (1st slope)	↑	13.2	**0.014**	0.81
				MF3 (2nd slope)	↓		-	
Molybdenum	Ice-cover	Model 2	0.5	MF1	↓	-	**<0.001**	0.86
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	6.1	**<0.001**	0.99
				MF3 (2nd slope)	↓		-	
	Open-water	Model 2	0.5	MF1	↓	-	**<0.001**	0.71
				MF2	↓	-	**0.041**	
		Model 3		MF3 (1st slope)	↓	1.7	**0.014**	0.93
				MF3 (2nd slope)	↓		**-**	
Silicon	Ice-cover	n/a						
	Open-water	n/a						
Strontium	Ice-cover[j]	Model 2	log	MF1	↓	-	**<0.001**	0.96
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	6.2	**<0.001**	0.99
				MF3 (2nd slope)	↓		-	
	Open-water	Model 2	log	MF1	↓	-	**<0.001**	0.58
				MF2	↓	-	0.272	
		Model 3		MF3 (1st slope)	↓	1.4	**0.003**	0.93
				MF3 (2nd slope)	↓		-	
Uranium	Ice-cover	Model 2	none	MF1	↓	-	**<0.001**	0.83
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	9.2	**<0.001**	0.98
				MF3 (2nd slope)	↓		-	
	Open-water	Model 1	log	MF1	↓	-	**<0.001**	0.82
				MF2	↓	-	**0.029**	
				MF3	↓	-	**<0.001**	

a) Models used and transformation rules are described in Section 2.4.5.2
b) Slope direction was represented by an upward arrow (↑) indicating increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.
c) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.
d) *P*-values were not calculated for the second MF3 slope.
e) For Model 3 (i.e., MF3 broken stick models), r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, since there is more than one predictor, i.e., distance and gradient.
f) Influential points removed: 4.32 µg/L and 4.38 µg/L.
g) Influential points removed: 31.6 µg/L.
h) Influential points removed: 3.57 µg/L.
i) Influential points removed: 28.5 µg/L and 51.4 µg/L.
j) Outlier removed: 32.6 µg/L.
Note: **Bold** indicates *P*-value is significant at <0.05.
- = not applicable; n/a = not analyzed; MF = mid-field.

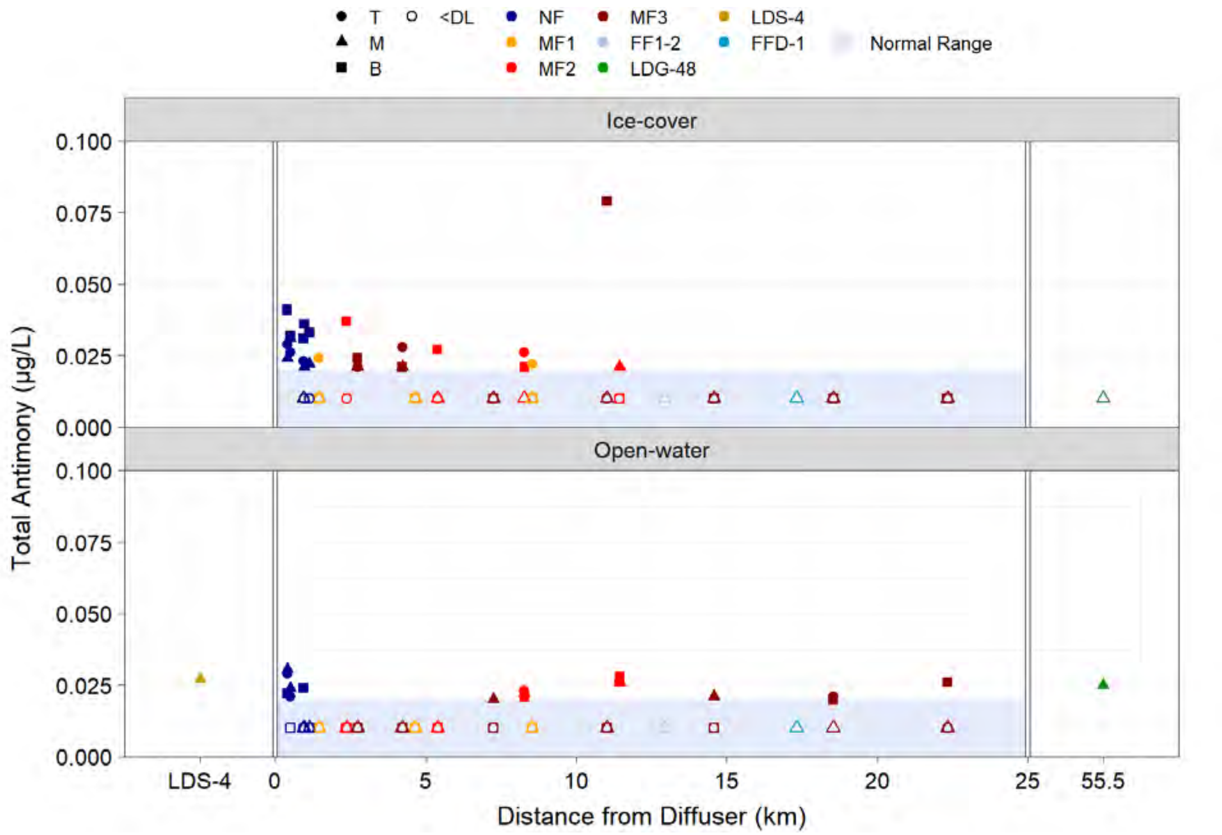
Figure 3-42 Concentration of Total Aluminum According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

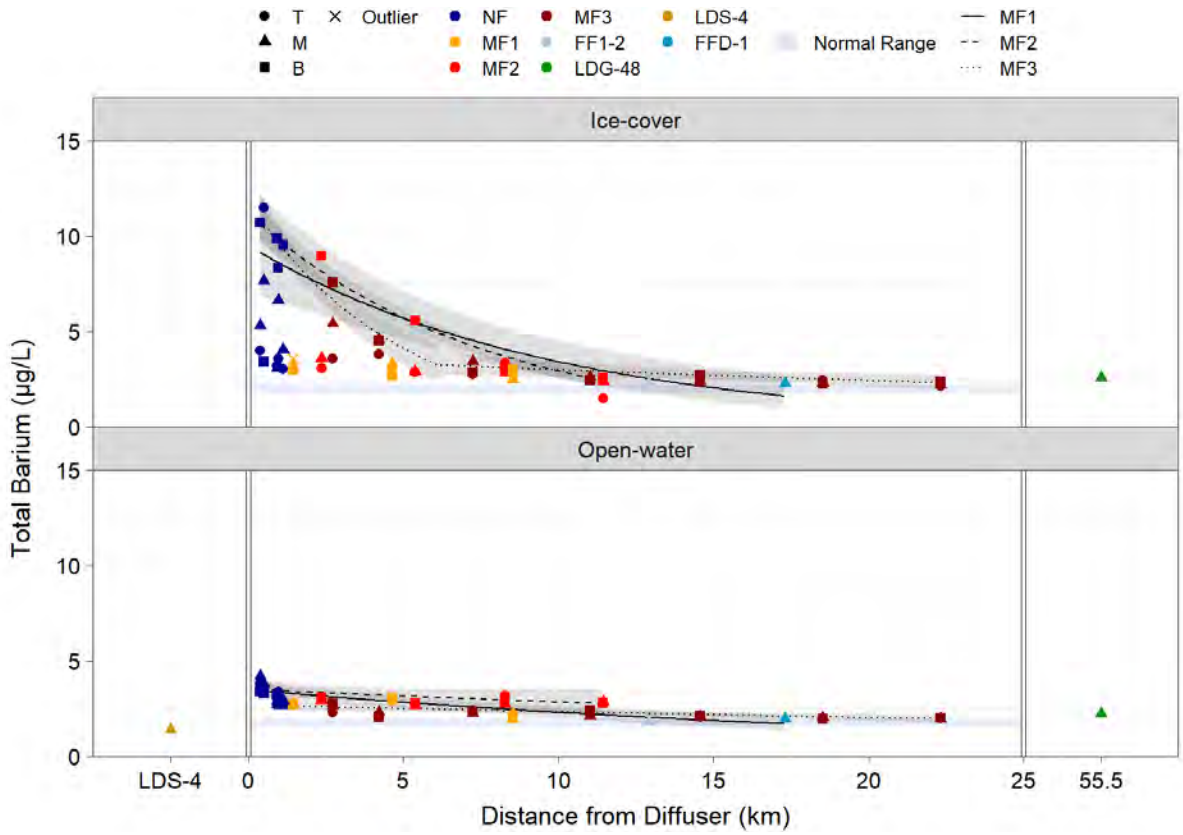
Figure 3-43 Concentration of Total Antimony According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

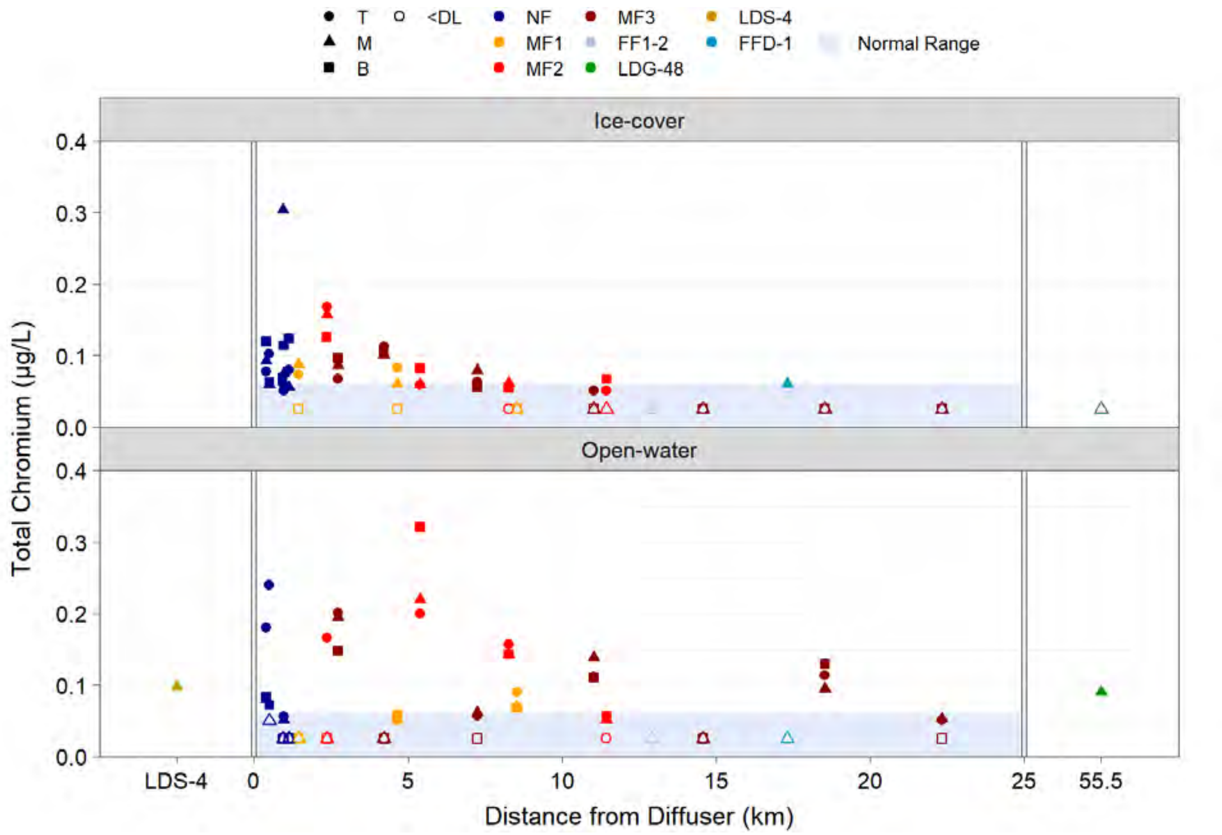
Figure 3-44 Concentration of Total Barium According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

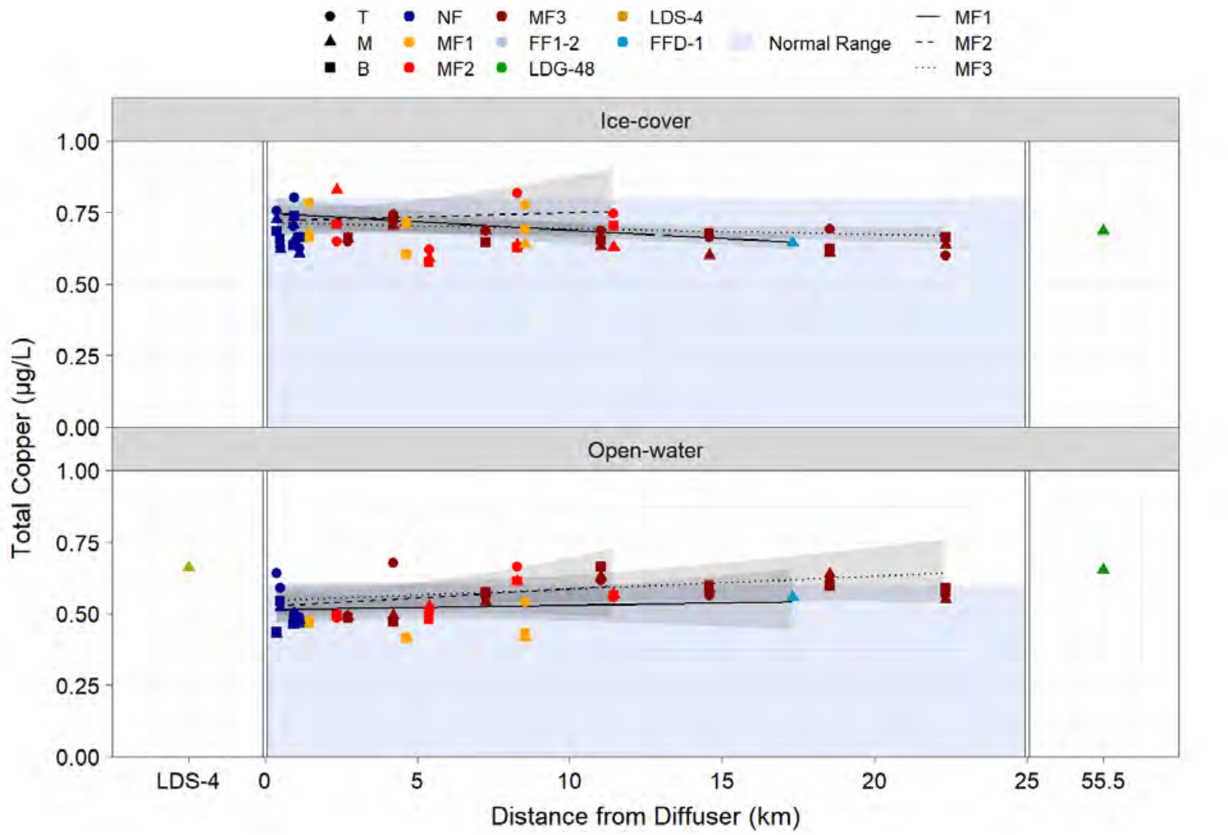
Figure 3-45 Concentration of Total Chromium According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

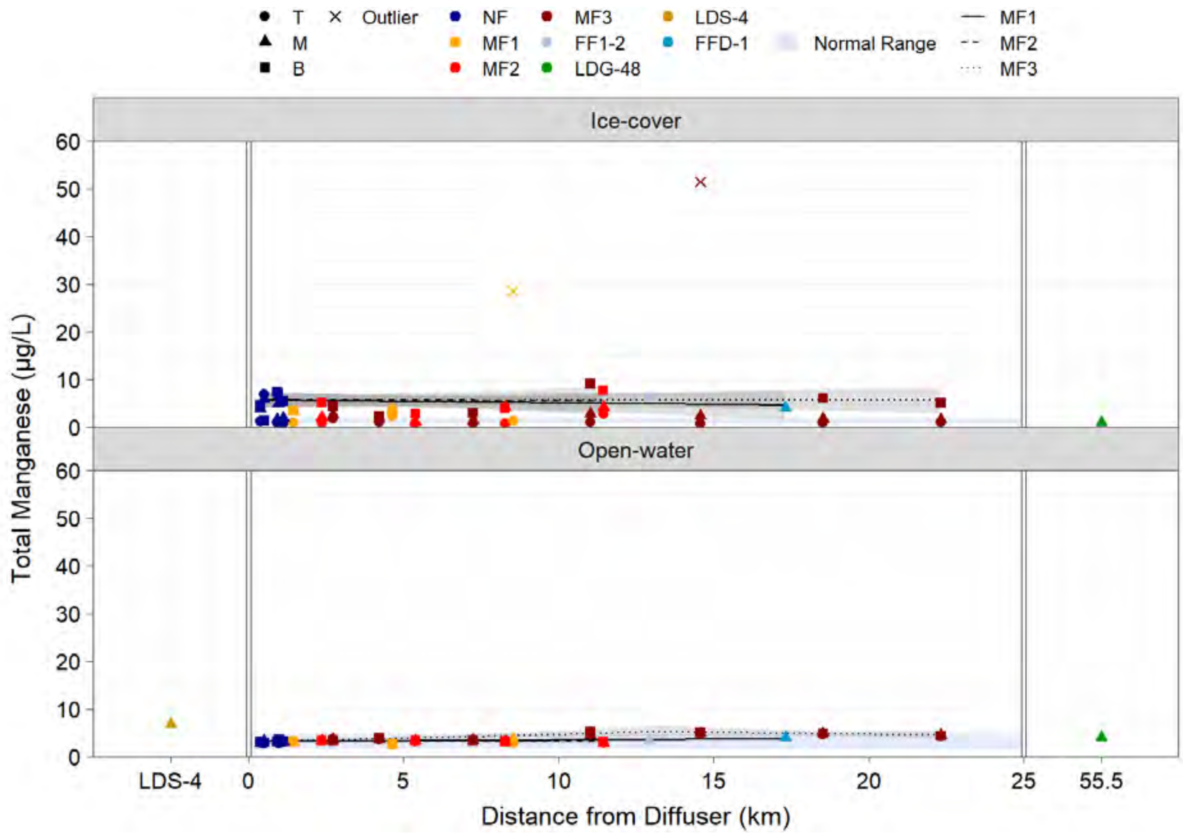
Figure 3-46 Concentration of Total Copper According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

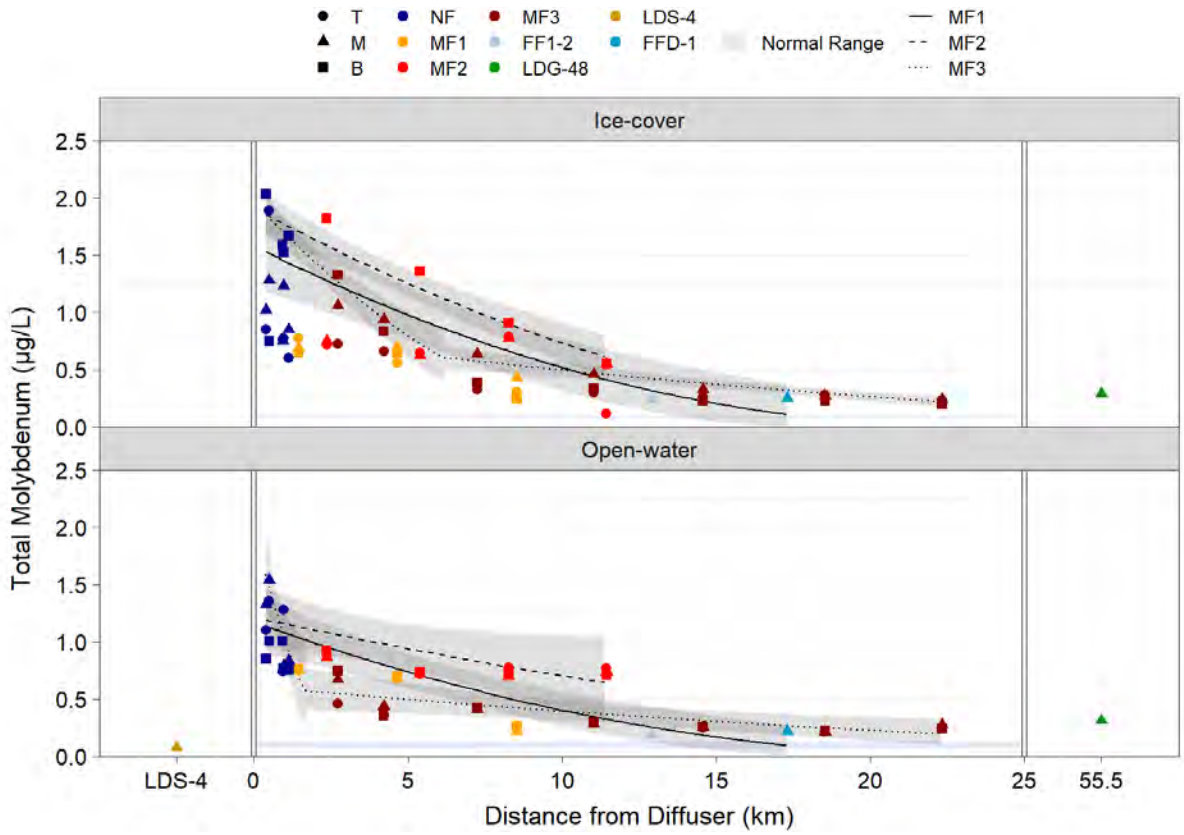
Figure 3-47 Concentration of Total Manganese According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

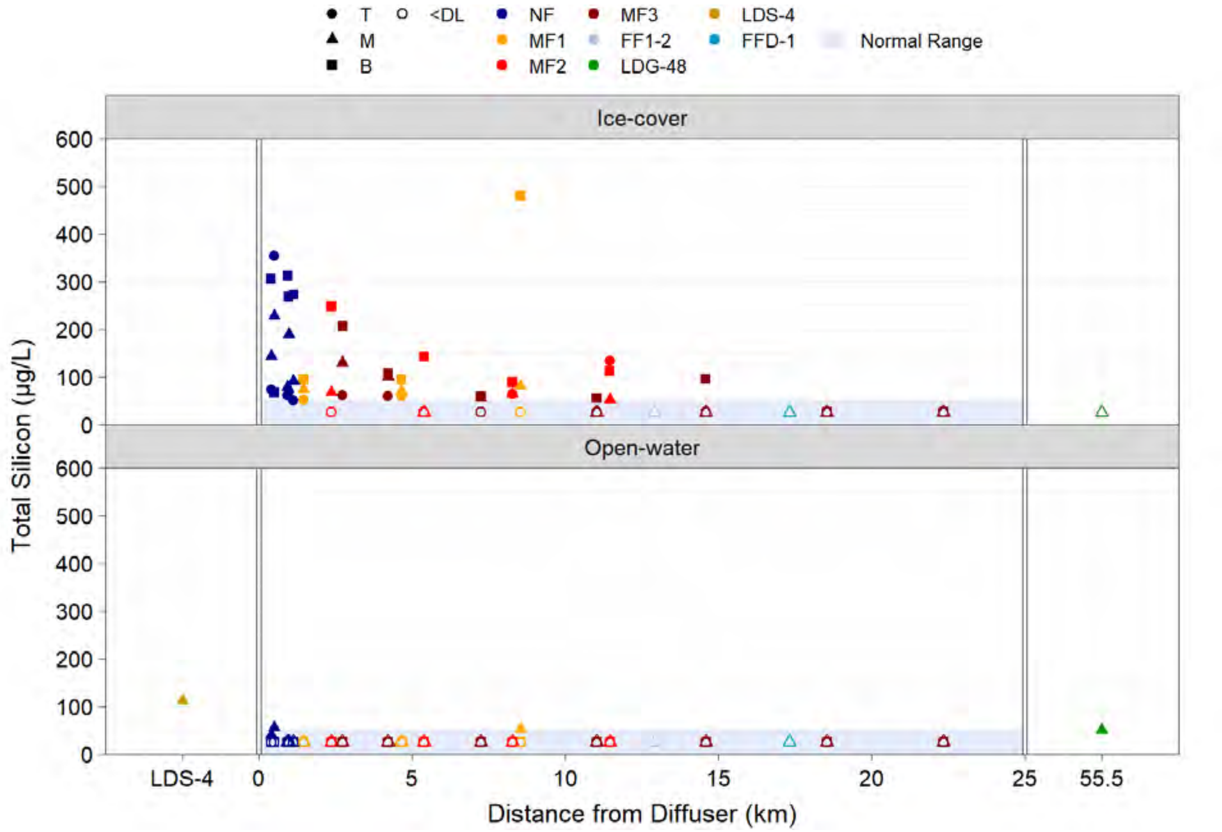
Figure 3-48 Concentration of Total Molybdenum According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

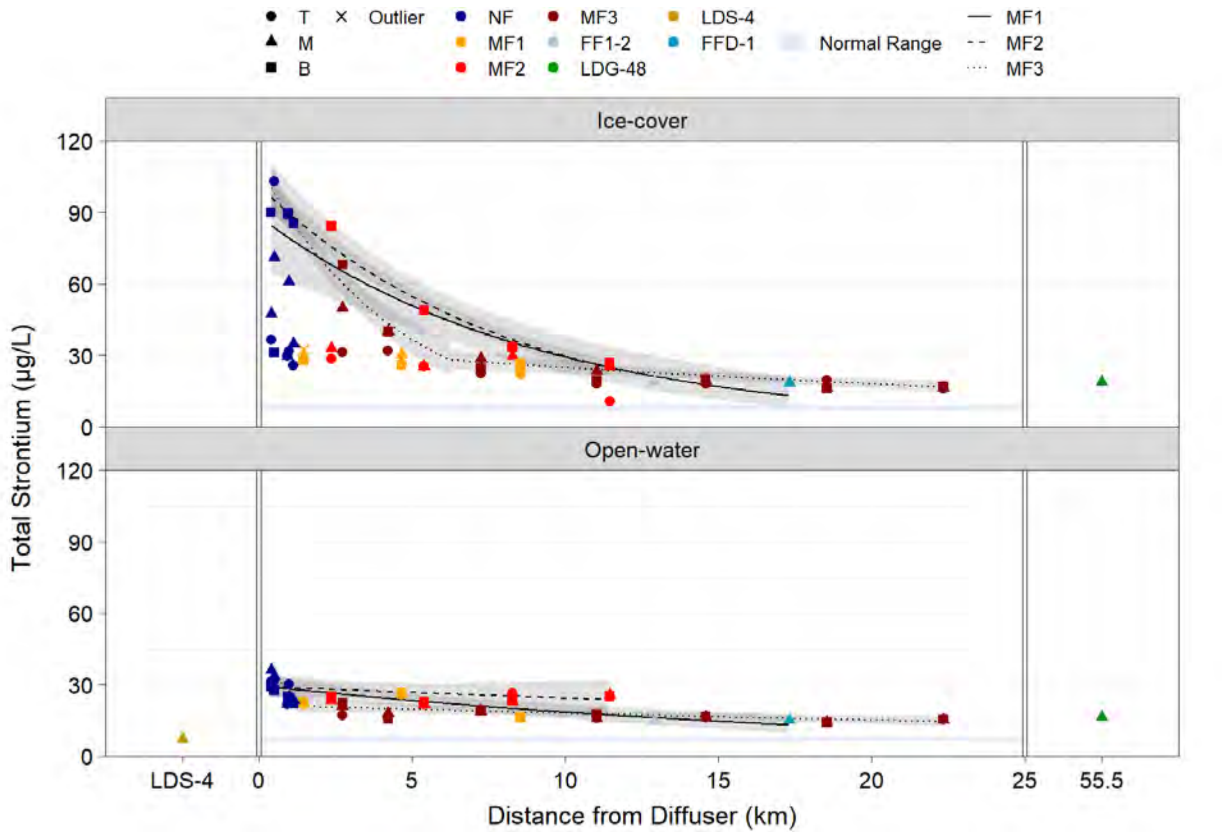
Figure 3-49 Concentration of Total Silicon According to Distance from the Mine Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

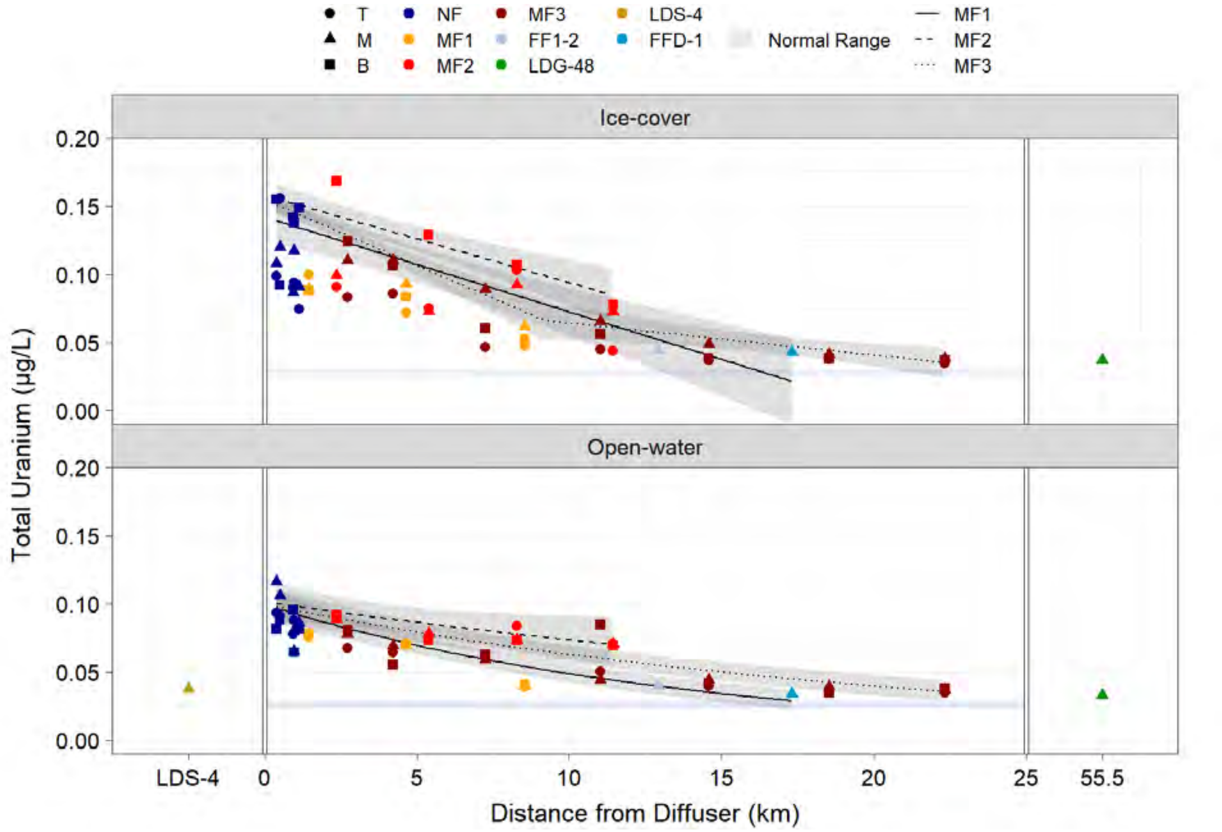
Figure 3-50 Concentration of Total Strontium According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-51 Concentration of Total Uranium According to Distance from the Effluent Discharge, 2021



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.7 Effects from Dust Deposition

In 2021, median concentrations of 15 SOIs met Criterion 4 in the SOI selection process (Section 2.4.1; i.e., TDS, turbidity, calcium, chloride, sodium, sulphate, ammonia, nitrate, boron, chromium, lithium, molybdenum, strontium, uranium, and zinc), because their concentration exceeded two times the median of the reference dataset at one or more of the four MF area stations located within the estimated ZOI from dust deposition (i.e., MF1-1, MF3-1, MF3-2, and MF3-3; Table 3-13).

Of the 15 SOIs, 12 also triggered Action Level 1 in the NF area (identified by footnote [c] in Table 3-13), indicating that the exceedances of the dust criterion at the MF stations were likely caused by dispersion of Mine effluent into the lake; however, as the NF area is located within the ZOI, there is some potential that dust deposition may also be contributing to the increases observed in these variables in the NF area.

Compared to the highest NF station median concentration, four of the 15 SOIs were elevated at one or more of the four MF stations (i.e., turbidity, boron, chromium, and lithium). These results may represent variability in the area close to the discharge, analytical variation in concentrations close to the DL, or potentially a factor other than the dispersion of effluent in the lake. Spatial trends for these variables are shown on Figure 3-52.

Turbidity exceeded the criterion at MF1-1 and concentrations of chromium exceeded the criterion at MF3-1. Both turbidity and chromium also triggered Action Level 1 in the NF area. While there is some potential that these increases may be related to dust deposition, this interpretation is not supported by similar increases at the other stations within the ZOI or in the concentrations of other sediment-associated variables such as total metals. The elevated concentrations at single stations may be caused by noise in the data, which can occur when concentrations are measured close to the analytical DL.

Concentrations of boron and lithium exceeded two times the median of the reference dataset value at MF1-1 and MF3-1, respectively, but did not trigger Action Level 1 in the NF area in either season, indicating that the increases at the MF stations may not be solely related to effluent. Concentrations of boron in 2021 snow water samples representing approximately six months of dust deposition were all non-detect (<5.0 mg/L), indicating that dust deposition was unlikely to be the source of the increase. Concentrations of lithium in 2021 snow water samples ranged from <0.5 µg/L to 15.4 µg/L (median = 1.7 µg/L), whereas concentrations of lithium in the effluent ranged from 8.4 µg/L to 16.7 µg/L (median = 12.8 µg/L). These results indicate that although dust deposition may be a small contributor to the increased lithium concentration, the main contribution is from effluent.

Overall, analysis of the 2021 AEMP water quality data did not provide clear evidence to suggest an effect of dust deposition from the Mine site on the water quality of Lac de Gras. Although some variables had higher concentrations at one or two MF area stations within the ZOI compared to NF area stations, similar increases at the other stations within the ZOI were not observed. Spatial trends in variables triggering Action Level 1 showed clear gradients related to the Mine discharge within the ZOI from dust deposition. A step change (i.e., decline) in concentration was not apparent outside the ZOI for any of the evaluated variables. These results suggest that dust deposition is unlikely to be an important source of effects on water quality of Lac de Gras. This interpretation is consistent with a limited potential for effects on lake water quality demonstrated by the *Dust Special Effects Study (SES)* included in the *2019 AEMP Annual Report* (Golder 2020c).

Although dust deposition has the potential to contribute to effects on water quality during certain times of the year (e.g., ice break-up, extreme wind events), several lines of evidence suggest that isolating the specific effects from dust emissions on water quality in Lac de Gras from other mine sources (e.g., effluent) is not possible, nor is it necessary to manage Mine-related effects in Lac de Gras:

- Analyses completed in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b), showed spatial confounding of dust and effluent effects; this does not allow a reliable evaluation of relative effects from the two sources based on spatial trends.
- There is a lack of a dust signature in lake water chemistry. The geochemical signature of lake water (represented by water quality samples collected as part of the Dust SES and AEMP) was similar to that of effluent, and the influence of dust could not be differentiated from that of effluent (Golder 2020c).
- There was no indication that the Dust SES stations sampled in 2019, which were located closer to dust sources than AEMP stations, were impacted by dust deposition on top of the effect of the Mine effluent (Golder 2020c).
- There have been several years of not being able to isolate effects of dust from effluent-related effects. The dust deposition analysis has been included in the AEMP annual reports since 2016 and the 2021 results again provided no useful evidence of a measurable effect on lake water quality from dust deposition.
- The parameters identified in 2021 based on the method applied were not present in snowmelt at concentrations that could result in an increase in their concentrations in lake water during the period of worst-case input of deposited dust.

Therefore, it is recommended that the analysis used to evaluate potential effects from dust emissions on water quality in Lac de Gras be discontinued in future AEMP reports. The AEMP sampling design provides sufficient and appropriate data to evaluate the combined effects in Lac de Gras from all Mine-related sources, including dustfall.

Table 3-12 Evaluation of Effects from Dust Deposition in Lac de Gras, 2021

Variable	Unit	2021 Detection Limit	Screening Value	2021 AEMP Result (Open-water)						Median of MF Station >2× Median of Reference Dataset[a] (Yes/No)
			2× Median of Reference Areas[a]	Median of NF Values	Highest NF Station Median Value	Median of MF Values[b]				
						MF1-1	MF3-1	MF3-2	MF3-3	
Conventional Parameters										
Total alkalinity	mg/L	0.5	8	6.04	6.62	4.45	4.48	4.12	4.47	No
Total dissolved solids, calculated	mg/L	-	10.0	19.5	22.8	18.7	18.0	15.9	15.8	**Yes[c]**
Total dissolved solids, measured	mg/L	1	20	26	37.6	24.4	24.4	20	16	[d]
Total suspended solids	mg/L	1	1	<1	<1	<1	<1	<1	<1	No
Total organic carbon	mg/L	0.2	4.4	2.4	2.6	2.5	2.5	2.8	2.3	No
Turbidity – lab	NTU	0.1	0.42	0.36	0.38	**0.71**	0.31	0.31	0.3	**Yes[c]**
Major Ions										
Calcium (dissolved)	mg/L	0.01	2.0	2.17	2.22	2.17	2.11	1.90	1.77	**Yes[c]**
Chloride	mg/L	0.5	2.0	4.6	5.7	4.7	4.3	3.2	3.4	**Yes[c]**
Fluoride	mg/L	0.01	0.044	0.028	0.031	0.030	0.030	0.028	0.023	No
Magnesium (dissolved)	mg/L	0.005	1.4	0.99	1.1	0.98	0.88	0.86	0.97	No
Potassium (dissolved)	mg/L	0.01	1.2	0.97	1.1	0.95	0.89	0.77	0.90	No
Sodium (dissolved)	mg/L	0.01	1.0	2.63	2.83	2.48	2.33	2.01	2.02	**Yes[c]**
Sulphate	mg/L	0.5	3.8	4.9	5.4	4.8	4.7	4.4	4.0	**Yes[c]**
Nutrients										
Ammonia	µg-N/L	5	5	9.5	19	9.9	9.6	8.3	13	**Yes[c]**
Nitrate	µg-N/L	2	2	34	51	14	20	7.1	7.2	**Yes[c]**
Nitrite	µg-N/L	1	2	1.8	2.6	<1	<1	<1	<1	No
Total Metals										
Aluminum	µg/L	0.2	8.8	6.9	9.1	6.5	6.2	7.0	4.7	No
Antimony	µg/L	0.02	0.02	<0.02	0.027	<0.02	<0.02	<0.02	<0.02	No
Arsenic	µg/L	0.02	0.34	0.24	0.28	0.23	0.23	0.20	0.20	No
Barium	µg/L	0.02	3.62	3.2	3.8	2.7	2.7	2.2	2.4	No
Beryllium	µg/L	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	No
Bismuth	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.01	<0.005	<0.005	No
Boron	µg/L	5	5	<5	6.2	**6.3**	<5	<5	<5	**Yes**
Cadmium	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	No
Calcium	mg/L	0.01	1.92	2.2	2.23	**2.24**	2.17	1.94	1.79	[d]
Chromium	µg/L	0.05	0.06	<0.05	0.083	<0.05	**0.195**	<0.05	0.057	**Yes[c]**
Cobalt	µg/L	0.005	0.04	0.018	0.021	0.018	0.021	0.025	0.023	No
Copper	µg/L	0.05	0.6	0.49	0.54	0.47	0.49	0.49	0.56	No
Iron	µg/L	1	10	7.1	9.5	7.5	8.5	8.7	7.2	No

Table 3-12 Evaluation of Effects from Dust Deposition in Lac de Gras, 2021 (continued)

Variable	Unit	2021 Detection Limit	Screening Value	2021 AEMP Result (Open-water)						Median of MF Station >2× Median of Reference Dataset[a] (Yes/No)
			2× Median of Reference Areas[a]	Median of NF Values	Highest NF Station Median Value	Median of MF Values[b]				
						MF1-1	MF3-1	MF3-2	MF3-3	
Lead	µg/L	0.005	0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	No
Lithium	µg/L	0.5	2.4	1.94	2.28	2.25	**2.41**	2.10	1.79	**Yes**
Magnesium	mg/L	0.005	1.26	1.0	1.19	0.96	0.94	0.87	0.99	[d]
Manganese	µg/L	0.05	4.88	3.0	3.08	3.07	3.60	3.62	3.40	No
Mercury	µg/L	0.002	0.01	<0.0019	<0.0019	<0.002	<0.002	<0.002	<0.002	No
Molybdenum	µg/L	0.05	0.18	0.85	1.4	0.76	0.67	0.36	0.43	**Yes[c]**
Nickel	µg/L	0.02	1.9	0.65	0.67	0.63	0.80	0.89	0.98	No
Potassium	mg/L	0.01	1.08	1.01	1.2	0.96	0.94	0.79	0.90	[d]
Selenium	µg/L	0.04	0.04	<0.04	0.02	<0.04	<0.04	<0.04	<0.04	No
Silicon	µg/L	50	50	<50	<50	<50	<50	<50	<50	No
Silver	µg/L	0.005	0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	No
Sodium	mg/L	0.01	1.26	2.66	3.01	2.54	2.51	2.00	2.04	[d]
Strontium	µg/L	0.05	14.6	25.1	31.7	22.5	21.1	16.0	19.1	**Yes[c]**
Sulphur	mg/L	0.5	1.82	<0.5	0.81	<0.5	<0.5	<0.5	1.35	No
Thallium	µg/L	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	No
Tin	µg/L	0.01	0.01	<0.01	<0.2	<0.01	<0.01	<0.01	<0.01	No
Titanium	µg/L	0.5	0.5	<0.5	<2	<0.5	<0.5	<0.5	<0.5	No
Uranium	µg/L	0.002	0.056	0.086	0.094	0.078	0.078	0.065	0.060	**Yes[c]**
Vanadium	µg/L	0.05	0.1	<0.05	0.11	<0.05	<0.05	<0.05	<0.05	No
Zinc	µg/L	0.1	1.5	0.91	2.4	1.03	<0.1	1.95	0.47	**Yes**
Zirconium	µg/L	0.05	0.05	<0.05	<0.1	<0.05	<0.05	<0.05	<0.05	No

a) The 2× the median value was based on the reference area median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference area median value was considered to be equal to half of the DL.

b) The median of MF area values was calculated from data pooled across all sample depths (i.e., top, middle, and bottom).

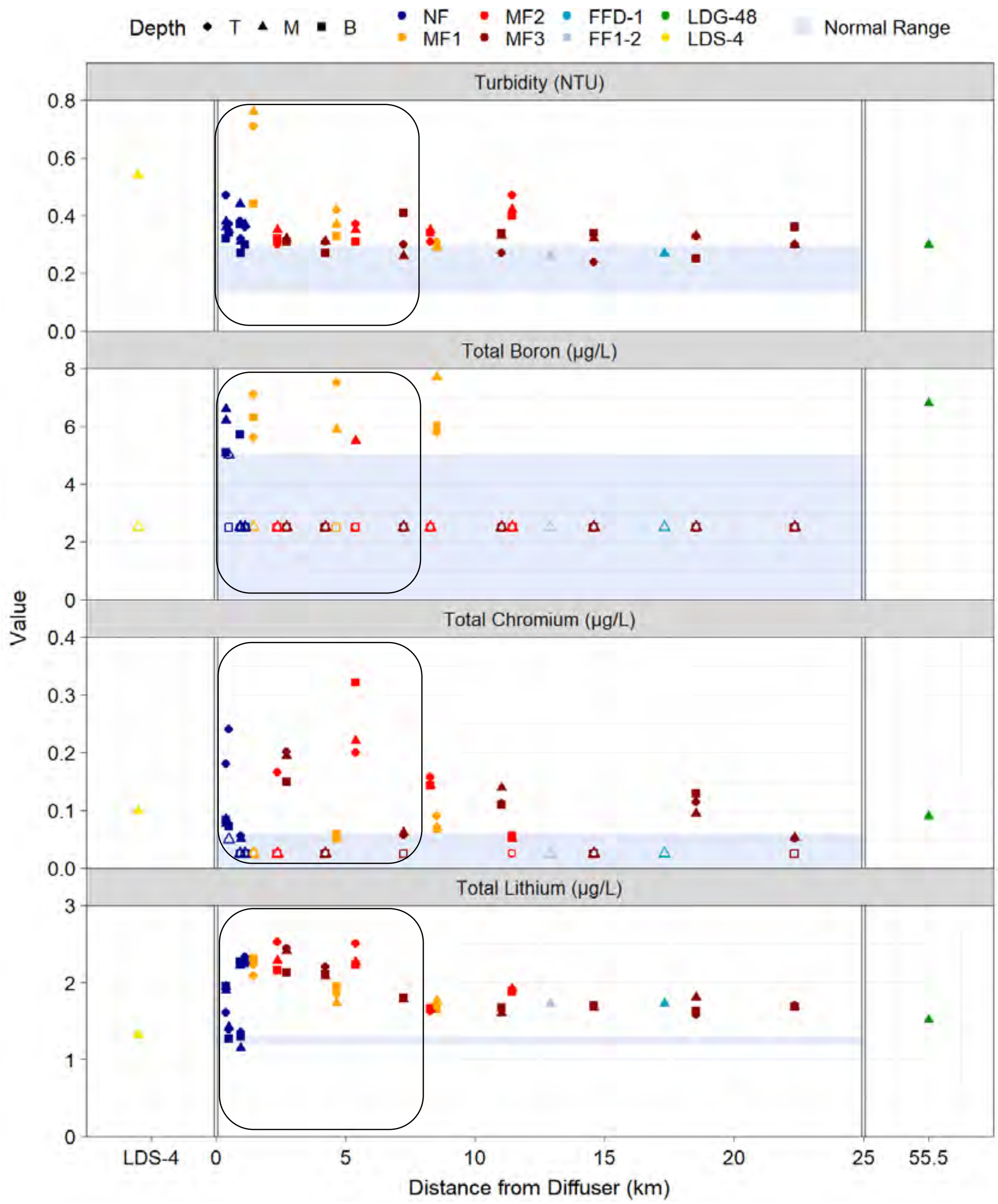
c) Concentration in the NF area triggered both Action Level 1 (during one or both seasons) and an effect equivalent to Action Level 1 at one or more MF area stations located within the estimated zone of influence from dust deposition.

d) "Yes" applied to dissolved or calculated value to avoid duplication.

Note: Shading indicates that a MF median value exceeded two times the reference dataset median. **Bolding** indicates that the MF median value is greater than the highest NF station median value.

NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; >= greater than; < = less than; 2 x = two times; NF = near-field; MF = mid-field.

Figure 3-52 Spatial Variation in Turbidity, Total Boron, Total Chromium, and Total Lithium According to Distance from the Effluent Discharge, Open-water Season, 2021



Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; NTU = nephelometric turbidity unit; LDG = Lac de Gras; LDS = Lac du Sauvage.

Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

One total boron value (NF1T = 53 µg/L) was omitted from this figure because the elevated value resulted in a graphic scale that obscured details.

4 SUMMARY AND DISCUSSION

Concentrations of variables with EQC were within applicable limits in samples collected in 2021 and no variables were added to the SOI list based on effluent screening. Toxicity testing results in 2021 indicated that effluent samples were not toxic to aquatic test organisms. None of the mixing zone chemistry variables with Effects Benchmarks were added to the SOI list because concentrations in all samples analyzed during the 2021 reporting period were below Effects Benchmarks.

Water quality variables measured in Lac de Gras as part of the 2021 AEMP were assessed for a Mine-related effect according to Action Levels. Twenty variables triggered Action Level 1, which is an early-warning indicator of effects in Lac de Gras, and were retained as SOIs in 2021. The SOI variables had NF area median concentrations that were greater than two times the median concentrations in the reference condition dataset. Each of the SOIs that triggered Action Level 1 was detected in the NIWTP effluent at a higher concentration than in lake water or was identified in dust associated with the Mine, indicating that the increase observed in the NF area could be linked to the Mine. Of the 20 variables that triggered Action Level 1 and were retained as SOIs, nine also triggered Action Level 2. None of the SOIs triggered Action Level 3 in 2021.

Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for most of the 20 SOIs that triggered Action Level 1 or 2 in 2021, based on a graphical and statistical evaluation of the data. The results of these analyses provided confirmation that the changes for these variables observed in the NF area were related to the Mine effluent discharge.

In 2021, three additional variables (i.e., boron, lithium, and zinc) were included in the list of SOIs in 2021, as concentrations of these variables were greater than two times the median of the reference dataset value at stations in the MF area within the estimated ZOI from dust deposition from the Mine, but not in the NF area. These variables had median concentrations at one or more of the four MF stations that were elevated compared to the median of the NF area concentrations. While there is some potential that these elevated values may be related to dust deposition, this interpretation is not supported by similar increases at the other stations within the ZOI, and spatial trends within the ZOI were consistent with effects originating from the Mine effluent. Overall, analysis of the 2021 AEMP water quality data indicate that effluent is the main source of Mine effects on Lac de Gras, with a negligible contribution from dust deposition, consistent with previous years' assessments.

5 RESPONSE FRAMEWORK

Water quality variables were assessed for a Mine-related effect according to Action Levels in the Response Framework. Twenty variables triggered Action Level 1 (i.e., TDS [calculated], turbidity, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, manganese, molybdenum, silicon, strontium, and uranium). No management action is required under the Response Framework when a variable triggers Action Level 1. Of the 20 variables that triggered Action Level 1, nine also triggered Action Level 2 (i.e., TDS [calculated], chloride, sodium, sulphate, nitrate, molybdenum, silicon, strontium, and uranium). The required management action when a water quality variable triggers Action Level 2 is to establish an AEMP Effects Benchmark for that variable if one does not already exist. All nine variables that triggered Action Level 2 have existing Effects Benchmarks; therefore, no action was required. No water quality variables triggered Action Level 3 in 2021.

6 CONCLUSIONS

Based on the analysis of water quality data collected during the 2021 AEMP program, the following conclusions can be drawn:

- The 2021 effluent toxicity results indicated that the effluent discharged to Lac de Gras in 2021 was non-toxic; all effluent samples submitted for lethal and sublethal toxicity testing passed test criteria.
- The concentrations of all regulated effluent variables were below applicable EQC values.
- Nearly all concentrations (>99%) measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water.
- In the ice-cover season, elevated conductivity was measured in the bottom two-thirds of the water column in the NF area, indicating the depth range where the effluent plume was located. During the open-water season, in situ water quality measurements were typically uniform throughout the water column.
- Concentrations of nearly all variables in samples collected during the 2021 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water. In most cases, identified exceedances appeared to be caused by contamination or data errors, or were attributable to natural conditions in Lac de Gras.
- In 2021, 20 water quality variables demonstrated an effect equivalent to Action Level 1 (i.e., TDS [calculated], turbidity, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, manganese, molybdenum, silicon, strontium, and uranium), and were included in the list of SOIs in 2021 (Table 6-1).
- Of the 20 SOIs that triggered Action Level 1, nine also triggered Action Level 2 (i.e., TDS [calculated], chloride, sodium, sulphate, nitrate, molybdenum, silicon, strontium, and uranium; Table 6-1); these nine variables already have existing Effects Benchmarks.
- None of the SOIs triggered Action Level 3 (Table 6-1).
- Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for most SOIs based on a graphical and statistical evaluation of the data. An exception was turbidity, which had an increasing trend with distance from the Mine effluent discharge in the ice-cover season.
- Fifteen variables triggered an effect equivalent to Action Level 1 at one or more of the four MF area stations located within the estimated ZOI from dust deposition from the Mine site. Of these 15 SOIs, 12 also triggered Action Level 1 in the NF area, indicating that the exceedances at the MF stations were most likely caused by dispersion of Mine effluent into the lake. Analysis of the 2021 AEMP water quality data did not provide evidence to suggest an effect of dust deposition from the Mine site on the water quality of Lac de Gras.

Table 6-1 Action Level Summary for Water Quality Substances of Interest, 2021

2021 SOIs	Action Level Classification
Conventional Parameters	
Total dissolved solids, calculated	2
Turbidity – lab	1
Major Ions	
Calcium (dissolved)	1
Chloride	2
Magnesium (dissolved)	1
Potassium (dissolved)	1
Sodium (dissolved)	2
Sulphate	2
Nutrients	
Ammonia	1
Nitrate	2
Total Metals	
Aluminum	1
Antimony	1
Barium	1
Chromium	1
Copper	1
Manganese	1
Molybdenum	2
Silicon	2
Strontium	2
Uranium	2

1 = Action Level 1 triggered; 2 = Action Level 2 triggered.

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8 CLOSURE

We trust the information in this report meets your requirements at this time. If you have any questions relating to the information contained in this report, please do not hesitate to contact the undersigned.

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ATTACHMENT A

2021 AEMP SAMPLING SCHEDULE

Table A-1 2021 AEMP Sampling Schedule

Stations	Ice-cover											Open-water										
	April						May					August		September								
	19	20	21	23	24	25	2	3	7	8	9	15	27	1	2	3	6	10	11	13	14	15
NF1											An			Anp								
NF2						An							Anp									
NF3						An											Anp					
NF4										An							Anp[a]					
NF5						An							Anp									
MF1-1					An											Anp						
MF1-3					An[a]										Anp[a]							
MF1-5		An	n[a]												Anp							
MF2-1									An							Anp						
MF2-3										An						Anp						
FF2-2	An																			Anp[a]		
FF2-5	An[a]																			Anp[a]		
MF3-1										An[a]							Anp					
MF3-2									An								Anp					
MF3-3									An											Anp		
MF3-4							An	An												Anp		
MF3-5							An											Anp				
MF3-6							An											Anp				
MF3-7				An																	Anp	An
FF1-2		Mn[a]																	Mnp			
FFD-1		Mn																			Mnp	
LDG-48											Mn	Mn[b]										
LDS-4												Mn[b]										

Notes:

A = water quality sampled collected from surface, middle depth and bottom depth; M = mid-depth sample collected; n = nutrient sample collected; p = plankton sample collected; QA/QC = quality assurance/quality control.

a) Quality control samples were collected for total ammonia only.

b) Only chlorophyll *a* was sampled, not plankton.

Note: QA/QC samples are colour coded: Grab Water (GW), Equipment Blank (EBW), Field Blank (FBW), Trip Blank (TBW), and Duplicate 1/Duplicate 2 (DUP1/DUP2).

NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

ATTACHMENT B

QUALITY ASSURANCE AND QUALITY CONTROL METHODS AND RESULTS

QUALITY ASSURANCE AND QUALITY CONTROL METHODS AND RESULTS

Introduction

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting. Quality assurance encompasses management and technical practices designed to generate data of consistent and appropriate quality to address the objectives of the monitoring program. Quality control is an aspect of quality assurance and includes the techniques used to assess data quality and the corrective actions to be taken when the data quality objectives are not met. Details of the QA/QC practices applied during the Aquatic Effects Monitoring Program (AEMP) are described in the *Quality Assurance Project Plan (QAPP) Version 3.1* (Golder 2017). This appendix describes QA/QC practices applied during the 2021 AEMP, evaluates QC data, and describes the implications of QC results to the interpretation of study results.

Quality Assurance

Field Staff Training and Operations

Diavik Diamond Mines (2012) Inc. (DDMI) field staff are trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality sampling. Field work was completed according to specified instructions and standard operating procedures (SOP) as follows:

- ENVI-923-0119 “AEMP SOP Combined Open Water and Ice Cover”
- ENVI-915-0119 “SOP SNP Sampling”
- ENVI-902-0119 “SOP Quality Assurance Quality Control”
- ENVI-900-0119 “SOP Chain of Custody”
- ENVI-905-0119 "SOP pH Analysis”
- ENVI-906-0119 "SOP Turbidity Analysis”
- ENVI-904-0119 “SOP Total Suspended Solids”
- ENVI-918-0119 “SOP Field Meter”
- ENVI-684-0317 “SOP YSI ProDSS”

These SOPs include guidelines for field record-keeping and sample tracking, procedures for use and calibration of sampling equipment, relevant technical procedures, and sample labelling, shipping and tracking protocols.

Laboratory Analyses

Samples were sent for analysis to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics Inc.), a laboratory accredited by the Canadian Association of Laboratory Accreditation (CALA). Duplicate samples for ammonia analysis were also sent to ALS Laboratories (ALS), another CALA accredited lab. Under the accreditation program, performance assessments are completed annually for laboratory procedures, analytical methods, and internal quality control.

Quality assurance completed by the DDMI Environmental Sampling team encompasses all quality-related activities related to aquatic testing and analysis, and relevant technical support.

DDMI's quality assurance places an emphasis on four aspects:

- infrastructure (i.e., instruments, testing capabilities, calibrations, SOPs)
- control measures (e.g., internal and external blanks and duplicates)
- personnel (i.e., competence, ethics and integrity)
- data management

Field and Office Operations

A QA system was established as an organized system of data control, analysis and filing. Relevant elements of this system are as follows:

- pre-field meetings to discuss specific work instructions with field crews
- field crew check-in with task managers every 24 to 48 hours to report work completed during that period
- designating two crew members responsible for:
  - collecting all required samples
  - downloading and storing electronic data
  - completing chain-of-custody and analytical request forms; labelling and documentation
  - processing, where required, and delivering samples to the analytical laboratory in a timely manner
- cross-checking chain-of-custody forms and analysis request forms by the task manager to verify that the correct analysis packages had been requested
- review of field sheets by the task manager for completeness and accuracy
- reviewing laboratory data immediately after receipt from the analytical laboratory
- creating backup files before data analysis
- completing appropriate logic checks and verifying accuracy of calculations

Quality Control

Quality control is a specific aspect of quality assurance and includes the techniques used to assess data quality and the remedial measures to be taken when the data quality objectives are not met. The field QC program included collection of field blanks, trip blanks, equipment blanks, and duplicate samples to assess potential sample contamination, and within-station variation (i.e., sampling precision). Quality control samples were submitted to BV Labs for analysis of the full list of variables, and to ALS for analysis of ammonia.

Field blanks consisted of samples prepared in the field using laboratory-provided de-ionized water to fill a set of sample bottles, which were then submitted to the appropriate laboratory for the same analyses as the original water samples. Trip blanks consisted of sample bottles filled with high-grade de-ionized water from the laboratory. They accompanied the other samples through sample collection, handling, shipping and analysis, but remained sealed. Equipment blanks consisted of de-ionized water exposed to all aspects of sample collection and analysis, using the same procedures as used in the field, including contact with all sampling devices (i.e., beta bottle) and other equipment (i.e., filters, tubing). Equipment blanks provide information regarding potential cross-contamination between samples and contamination introduced by field equipment.

The field, trip and equipment blanks were used to detect potential sample contamination during collection, shipping and analysis. Although concentrations of all variables should be below their respective detection limit (DL) in these blanks, their concentrations were considered notable if they were greater than five times the corresponding DL. This threshold is based on the Practical Quantitation Limit defined by the United States Environmental Protection Agency (US EPA 1994, 2007; BC MOE 2009), which takes into account the potential for data accuracy errors when variable concentrations approach or are below DLs.

Notable results observed in the blanks were evaluated relative to concentrations observed in the lake-water samples to determine whether sample contamination was limited to the QC sample. If, based on this comparison, sample contamination was not isolated to the QC sample, the field data were flagged and further interpretation of results was made with this limitation in mind.

Duplicate samples were used to check within-station variation and the precision of field sampling and analytical methods. Duplicate samples consisted of two samples collected from the same location at the same time, using the same sampling and sample handling procedures. They were labelled and preserved individually and submitted separately to the analytical laboratory for identical analyses. Differences between concentrations measured in duplicate water samples were calculated as the relative percent difference (RPD) for each variable. Before calculating the RPD, concentrations below the DL were replaced with 0.5 times the DL value. The RPD was calculated using the following formula:

RPD = (|difference in concentration between duplicate samples| / mean concentration) x 100

The RPD value for a given variable was considered notable if:

- it was greater than 40%; and
- concentrations in one or both samples were greater than or equal to five times the DL.

The number of variables that exceeded the assessment criteria was compared to the total number of variables analyzed to evaluate analytical precision. Analytical precision was rated as follows:

- high, if less than 10% of the total number of variables were notably different between duplicate samples
- moderate, if 10% to 30% of the total number of variables were notably different between duplicate samples
- low, if more than 30% of the total number of variables were notably different between duplicate samples

Quality Control Results

Detection Limits

Water quality samples were submitted to BV Labs for analysis. BV Labs is an accredited analytical laboratory and has a dedicated inductively coupled plasma mass spectrometer (ICP-MS) specifically for ultra-low trace metal analysis. The ultra-low analytical DLs can only be obtained on water samples with very low particulate matter (i.e., turbidity less than 0.5 nephelometric turbidity unit [NTU]).

BV Labs used analyte-specific DLs to report results for water quality variables analyzed in 2021. The DLs used by BV Labs in 2021 are listed in Tables B-1 and B-2 (see also Section 2.2, Table 2-2 of the 2021 Effluent and Water Chemistry Report [Appendix II]). Deviations from the target DLs and a discussion of potential effects on data quality are provided below:

- The DL for total dissolved solids, measured, (i.e., 1 mg/L) was raised to 1.3 mg/L in one sample (NF3T) in the ice-cover season due to insufficient sample volume.
- Similar to previous years, sulphate was analyzed at a DL of 0.5 mg/L (versus the requested DL of 0.05 mg/L) due to limitations of the current analytical method. BV Labs is currently investigating ways to provide the requested DL. Only the QC blank results were below the DL. As a result, use of the elevated DL does not affect data quality.
- The DLs for nitrate + nitrite were elevated above the requested values (i.e., 2 µg-N/L requested and 2.2 µg-N/L reported) in all ice-cover samples (i.e., 66 samples) due to an issue with the calculation used for the DL. The DL was corrected for the open-water season. Use of the elevated DL is not expected to affect data quality because the majority of the samples were greater than the DL and the elevated DL is close to the requested DL.
- The DL for total dissolved phosphorus (i.e., 1 µg-P/L) was raised to 4 µg-P/L in one sample (MF3-6B-5) in the ice-cover season, due to dilution to bring analyte within the calibrated range.
- The DLs for total and dissolved sulphur were elevated above the requested values (i.e., 0.1 mg/L requested and 0.5 mg/L or 0.6 mg/L reported) due to limitations of the current analytical method. BV Labs is currently investigating ways to provide the requested DL. The raised DL does not interfere with the evaluation of Action Levels, because the elevated DLs were below reference conditions for Lac de Gras. As a result, use of the elevated DL does not affect data quality.
- During the open-water season, the DLs for 23 total metals (i.e., aluminum, barium, bismuth, boron, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, nickel, potassium, silver, sodium, tin, titanium, uranium, vanadium, zinc, and zirconium) were elevated in three samples

(NF1T, NF2T, and NF2M) due to the original results exceeding the calibration range, which required sample dilution.

Blank Samples

Of the 95 variables analyzed during the ice-cover season, six variables (i.e., ammonia, dissolved organic carbon [DOC], total dissolved nitrogen, total sulphur, dissolved sulphur, and dissolved zinc) were measured in QC blank samples at a concentration above the data quality objective (DQO) of less than five times the DL (Table B-1). Details of the ice-cover blank sample DQO exceedances are as follows:

- Ammonia (BV) exceeded the DQO in the equipment blank prepared at MF1-5T.
- Ammonia (ALS) and dissolved zinc exceeded the DQO in the field blank collected at MF2-1B.
- Dissolved organic carbon, total dissolved nitrogen, and dissolved sulphur exceeded the DQO in the travel blank assigned to MF3-3T.
- Ammonia (ALS), total sulphur, and dissolved sulphur exceeded the DQO in the equipment blank prepared at MF3-4B.

Exceedances of the DQO occurred in 2.3% of the ice-cover blank sample results and, therefore, the blank results indicated acceptable data quality. The variability in ammonia concentrations affected the reliability of the data. This is discussed further below (see “Ammonia Investigation”). Nitrogen variables are evaluated in the QA/QC Attachment of the Eutrophication Indicators Report (Appendix XIII). Since the AEMP analyses focus on the total metal concentrations, the potential contamination identified for dissolved sulphur and zinc did not interfere with the evaluation of Action Level exceedances. Concentrations of DOC in MF3-3T-3 and total sulphur at MF3-4B-1 were similar to those measured in the lake-water samples. The potential contamination was relatively minor and did not interfere with the evaluation of Action Levels, because DOC is not included in the Action Level evaluation and total sulphur concentrations in the NF area were below reference conditions for Lac de Gras despite the potential contamination identified in the blank sample.

During the open-water season, the concentrations of four (i.e., total chromium, total nickel, total zinc, and dissolved barium) of the 95 variables measured in QC blanks were greater than five times the DL (Table B-1). Details of the open-water blank sample DQO exceedances are as follows:

- Total chromium and total nickel exceeded the DQO in the field blank collected at MF2-3M.
- Dissolved barium exceeded the DQO in the travel blank assigned to MF3-4T.
- Total zinc exceeded the DQO in the equipment blank sample prepared at MF3-7B.

Exceedances of the DQO occurred in 1.0% of the open-water blank sample results and, therefore, the blank results indicate acceptable data quality. Concentrations of total chromium and total zinc were similar to those measured in the lake-water samples. An Action Level was triggered for total chromium similar to previous years. The potential contamination identified for chromium was relatively minor and did not interfere with the evaluation of Action Level exceedances. The potential contamination of total zinc was relatively minor and did not interfere with the Action Level evaluation, because total zinc concentrations in the NF area were below reference conditions for Lac de Gras despite the potential contamination identified in the blank sample. The concentration of total nickel reported in the blank sample was below those measured in the lake-water samples. Since the AEMP analyses focus on the total metal concentrations, the potential contamination identified for dissolved barium did not interfere with the Action Level evaluation.

As the DQO exceedances for these parameters were infrequent, it is unlikely that the contamination found in blank samples affected the reliability of the data used in the AEMP Effluent and Water Chemistry Report.

Field Duplicate Samples

A total of 6 out of 95 water quality variables analyzed in 2021 exceeded the DQO of both the 40% RPD and five times DL criteria for field duplicate samples at least once (Table B-2). These variables included turbidity, ammonia (BV), total phosphorus, total zinc, dissolved sulphur, and dissolved zinc. These results were considered notable, because the differences in concentrations between duplicate samples for these analytes (i.e., RPD of 41% to 158%) were appreciably greater than the QC objectives used by BV Labs to identify unacceptable differences between laboratory duplicate samples (i.e., RPD of 20% to 25%). Laboratory duplicates consist of two independently analyzed portions of the same sample and would, therefore, be expected to have lower variability among paired duplicate samples than field duplicates, which consist of two separate grab samples.

In total, 2.1% of the field duplicate data assessed exceeded the DQO, which indicates a high level of analytical precision for the 2021 samples. Therefore, duplicate sample results indicate that data are of acceptable quality. Generally, concentrations in duplicate samples with DQO exceedances were within the range of values reported at other nearby AEMP stations, indicating that the QC issues identified with these variables did not likely interfere with the evaluation of Mine-related effects.

Table B-1 Blank Sample Results, 2021

Parameter	Unit	DL	Ice-Cover								Open-Water							
			NF1B-2	MF1-3B-3-4	MF1-5T-1-4	MF2-1B-2	FF2-5T-1-4	MF3-3T-3	MF3-4B-1	FF1-2M-2-4	NF3T-2	NF4B-3	MF1-3T-1	MF2-3M-2	FF2-2T-2	FF2-5T-3	MF3-4T-3	MF3-7B-1
			9-May-2021	24-Apr-2021	21-Apr-2021	7-May-2021	19-Apr-2021	7-May-2021	3-May-2021	20-Apr-2021	6-Sep-2021	6-Sep-2021	2-Sep-2021	3-Sep-2021	13-Sep-2021	13-Sep-2021	13-Sep-2021	15-Sep-2021
			Field Blank	Travel Blank	Equipment Blank	Field Blank	Equipment Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Travel Blank	Equipment Blank
Conventional Parameters																		
Total alkalinity as $CaCO_3$	mg/L	0.5	<0.5	-	-	<0.5	-	<0.5	0.75	-	<0.5	-	-	<0.5	-	-	<0.5	0.83
Specific conductivity	µS/cm	1	<1	-	-	1	-	<1	1	-	<1	-	-	<1	-	-	<1	<1
Total hardness as $CaCO_3$	mg/L	0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	-	-	<0.5	<0.5
pH - lab	-	-	5.57	-	-	5.51	-	5.55	5.45	-	4.76	-	-	4.79	-	-	4.96	5.93
Total dissolved solids, calculated	mg/L	0.5	0.5	-	-	0.8	-	0.6	1.2	-	1.2	-	-	1.3	-	-	<0.5	0.5
Total dissolved solids, measured	mg/L	1	<1	-	-	<1	-	<1	2.4	-	<1	-	-	<1	-	-	<1	1.2
Total suspended solids	mg/L	1	1.3	-	-	<1	-	<1	<1	-	<1	-	-	<1	-	-	<1	<1
Total organic carbon	mg/L	0.2	<0.2	-	-	<0.2	-	<0.2	<0.2	-	<0.2	-	-	<0.2	-	-	<0.2	<0.2
Turbidity - lab	NTU	0.1	<0.1	-	-	<0.1	-	<0.1	0.2	-	<0.1	-	-	<0.1	-	-	<0.1	<0.1
Dissolved organic carbon	mg/L	0.2	<0.2	-	-	<0.2	-	**2.4**	<0.2	-	<0.2	-	-	0.66	-	-	<0.2	<0.2
Major Ions																		
Bicarbonate	mg/L	0.5	<0.5	-	-	<0.5	-	<0.5	0.92	-	<0.5	-	-	<0.5	-	-	<0.5	1.01
Calcium (dissolved)	mg/L	0.01	<0.01	-	-	0.019	-	<0.01	<0.01	-	<0.01	-	-	<0.01	-	-	<0.01	<0.01
Carbonate	mg/L	0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	-	-	<0.5	<0.5
Chloride	mg/L	0.5	<0.5	-	-	<0.5	-	<0.5	0.74	-	0.52	-	-	0.65	-	-	<0.5	<0.5
Fluoride	mg/L	0.01	<0.01	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	-	-	<0.01	<0.01
Hydroxide	mg/L	0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	-	-	<0.5	<0.5
Magnesium (dissolved)	mg/L	0.005	<0.005	-	-	<0.01	-	<0.01	<0.01	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Potassium (dissolved)	mg/L	0.01	<0.01	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	-	-	<0.01	<0.01
Sodium (dissolved)	mg/L	0.01	<0.01	-	-	0.014	-	<0.01	<0.01	-	<0.01	-	-	0.011	-	-	<0.01	<0.01
Sulphate	mg/L	0.5	0.55	-	-	0.73	-	0.64	<0.5	-	0.69	-	-	0.63	-	-	<0.5	<0.5
Nutrients																		
Ammonia (ALS)[a]	mg-N/L	0.005	<0.005	<0.005	<0.005	**0.0576**	<0.005	<0.005	**0.0568**	<0.005	<0.005	0.0213	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia (BV)[a]	mg-N/L	0.005	<0.005	<0.005	**0.044**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate	mg-N/L	0.002	<0.002	-	-	<0.002	-	<0.002	0.0034	-	<0.002	-	-	<0.002	-	-	0.0039	<0.002
Nitrite	mg-N/L	0.001	<0.001	-	-	<0.001	-	<0.001	<0.001	-	<0.001	-	-	<0.001	-	-	<0.001	<0.001
Nitrate + nitrite	mg-N/L	0.002	<0.002	-	-	<0.002	-	<0.002	0.0034	-	<0.0022	-	-	<0.0022	-	-	0.0039	<0.0022
Total Kjeldahl nitrogen	mg-N/L	0.02	<0.02	-	-	0.053	-	<0.02	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02
Total dissolved nitrogen	mg-N/L	0.02	<0.02	-	-	0.032	-	**0.12**	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02
Total nitrogen	mg-N/L	0.02	<0.02	-	-	0.053	-	<0.02	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02
Soluble reactive phosphorus	mg-P/L	0.001	<0.001	-	-	<0.001	-	<0.001	<0.001	-	<0.001	-	-	0.0011	-	-	<0.001	<0.001
Total dissolved phosphorus	mg-P/L	0.002	<0.002	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	0.0032	-	-	<0.002	<0.002
Total phosphorus	mg-P/L	0.002	<0.002	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	<0.002	-	-	<0.002	<0.002
Total Metals																		
Aluminum	µg/L	0.2	<0.2	-	-	<0.2	-	<0.2	<0.2	-	0.24	-	-	0.21	-	-	<0.2	0.22
Antimony	µg/L	0.02	<0.02	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02

Table B-1 Blank Sample Results, 2021 (continued)

Parameter	Unit	DL	Ice-Cover								Open-Water							
			NF1B-2	MF1-3B-3-4	MF1-5T-1-4	MF2-1B-2	FF2-5T-1-4	MF3-3T-3	MF3-4B-1	FF1-2M-2-4	NF3T-2	NF4B-3	MF1-3T-1	MF2-3M-2	FF2-2T-2	FF2-5T-3	MF3-4T-3	MF3-7B-1
			9-May-2021	24-Apr-2021	21-Apr-2021	7-May-2021	19-Apr-2021	7-May-2021	3-May-2021	20-Apr-2021	6-Sep-2021	6-Sep-2021	2-Sep-2021	3-Sep-2021	13-Sep-2021	13-Sep-2021	13-Sep-2021	15-Sep-2021
			Field Blank	Travel Blank	Equipment Blank	Field Blank	Equipment Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Travel Blank	Equipment Blank
Arsenic	µg/L	0.02	<0.02	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02
Barium	µg/L	0.02	0.066	-	-	0.033	-	0.027	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02
Beryllium	µg/L	0.01	<0.01	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	-	-	<0.01	<0.01
Bismuth	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Boron	µg/L	5	<5	-	-	<5	-	<5	<5	-	<5	-	-	8.3	-	-	<5	<5
Cadmium	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Calcium	µg/L	10	<10	-	-	<10	-	<10	<10	-	<10	-	-	<10	-	-	<10	<10
Chromium	µg/L	0.05	<0.05	-	-	0.051	-	<0.05	<0.05	-	<0.05	-	-	**0.276**	-	-	0.072	<0.05
Cobalt	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Copper	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Iron	µg/L	1	<1	-	-	<1	-	<1	<1	-	<1	-	-	1.2	-	-	<1	<1
Lead	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Lithium	µg/L	0.2	<0.2	-	-	<0.2	-	<0.2	<0.2	-	<0.5	-	-	<0.5	-	-	<0.5	<0.5
Magnesium	µg/L	10	<10	-	-	<10	-	<10	<10	-	<5	-	-	<5	-	-	<5	<5
Manganese	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Mercury	µg/L	0.0019	<0.0019	-	-	<0.0019	-	<0.0019	<0.0019	-	<0.0019	-	-	<0.0019	-	-	<0.0019	<0.0019
Molybdenum	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Nickel	µg/L	0.02	0.079	-	-	0.082	-	0.025	<0.02	-	<0.02	-	-	**0.159**	-	-	<0.02	0.047
Potassium	µg/L	10	<10	-	-	<10	-	<10	<10	-	<10	-	-	<10	-	-	<10	<10
Selenium	µg/L	0.04	<0.04	-	-	<0.04	-	<0.04	<0.04	-	<0.04	-	-	<0.04	-	-	<0.04	<0.04
Silicon	µg/L	50	<50	-	-	<50	-	<50	<50	-	<50	-	-	<50	-	-	<50	<50
Silver	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Sodium	µg/L	10	<10	-	-	<10	-	<10	<10	-	<10	-	-	<10	-	-	<10	<10
Strontium	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	0.058	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Sulphur	µg/L	500	<500	-	-	<500	-	<500	**1,600**	-	<500	-	-	<500	-	-	<500	<500
Thallium	µg/L	0.002	<0.002	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	<0.002	-	-	<0.002	<0.002
Tin	µg/L	0.01	<0.01	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	-	-	<0.01	<0.01
Titanium	µg/L	0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	-	-	<0.5	<0.5
Uranium	µg/L	0.002	<0.002	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	0.0031	-	-	<0.002	<0.002
Vanadium	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Zinc	µg/L	0.1	<0.1	-	-	<0.1	-	<0.1	<0.1	-	0.23	-	-	0.18	-	-	<0.1	**0.86**
Zirconium	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Dissolved Metals																		
Aluminum	µg/L	0.2	<0.2	-	-	0.22	-	<0.2	<0.2	-	<0.2	-	-	<0.2	-	-	0.32	<0.2
Antimony	µg/L	0.02	<0.02	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02
Arsenic	µg/L	0.02	<0.02	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	-	-	<0.02	<0.02
Barium	µg/L	0.02	<0.02	-	-	0.076	-	<0.02	<0.02	-	<0.02	-	-	<0.02	-	-	**0.115**	<0.02
Beryllium	µg/L	0.01	<0.01	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	-	-	<0.01	<0.01
Bismuth	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Boron	µg/L	5	<5	-	-	<5	-	<5	<5	-	<5	-	-	<5	-	-	<5	<5
Cadmium	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Chromium	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	0.147	-	-	0.08	<0.05
Cobalt	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	0.0062	<0.005
Copper	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05

Table B-1 Blank Sample Results, 2021 (continued)

Parameter	Unit	DL	Ice-Cover								Open-Water							
			NF1B-2	MF1-3B-3-4	MF1-5T-1-4	MF2-1B-2	FF2-5T-1-4	MF3-3T-3	MF3-4B-1	FF1-2M-2-4	NF3T-2	NF4B-3	MF1-3T-1	MF2-3M-2	FF2-2T-2	FF2-5T-3	MF3-4T-3	MF3-7B-1
			9-May-2021	24-Apr-2021	21-Apr-2021	7-May-2021	19-Apr-2021	7-May-2021	3-May-2021	20-Apr-2021	6-Sep-2021	6-Sep-2021	2-Sep-2021	3-Sep-2021	13-Sep-2021	13-Sep-2021	13-Sep-2021	15-Sep-2021
			Field Blank	Travel Blank	Equipment Blank	Field Blank	Equipment Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Travel Blank	Equipment Blank
Iron	µg/L	1	<1	-	-	<1	-	<1	<1	-	<1	-	-	<1	-	-	<1	<1
Lead	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Lithium	µg/L	0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	-	-	<0.5	<0.5
Manganese	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Mercury	µg/L	0.0019	<0.0019	-	-	<0.0019	-	<0.0019	<0.0019	-	<0.0019	-	-	<0.0019	-	-	<0.0019	<0.0019
Molybdenum	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Nickel	µg/L	0.02	<0.02	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	0.081	-	-	0.033	0.025
Selenium	µg/L	0.04	<0.04	-	-	<0.04	-	<0.04	<0.04	-	<0.04	-	-	<0.04	-	-	<0.04	<0.04
Silicon	µg/L	50	<50	-	-	<50	-	<50	<50	-	<50	-	-	<50	-	-	<50	<50
Silver	µg/L	0.005	<0.005	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	-	-	<0.005	<0.005
Strontium	µg/L	0.05	<0.05	-	-	0.068	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Sulphur	µg/L	500 - 600	<600	-	-	<600	-	530	**2,350**	-	<500	-	-	<500	-	-	<500	<500
Thallium	µg/L	0.002	<0.002	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	<0.002	-	-	<0.002	<0.002
Tin	µg/L	0.01	<0.01	-	-	0.011	-	<0.01	<0.01	-	<0.01	-	-	<0.01	-	-	<0.01	<0.01
Titanium	µg/L	0.5	<0.5	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	-	-	<0.5	<0.5
Uranium	µg/L	0.002	<0.002	-	-	<0.002	-	<0.002	<0.002	-	0.003	-	-	<0.002	-	-	0.0072	<0.002
Vanadium	µg/L	0.05	0.054	-	-	<0.05	-	0.062	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05
Zinc	µg/L	0.1	<0.1	-	-	**2.36**	-	<0.1	<0.1	-	<0.1	-	-	<0.1	-	-	0.17	0.32
Zirconium	µg/L	0.05	<0.05	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	-	-	<0.05	<0.05

a) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV Labs ammonia dataset was used for the open-water season (see the “Ammonia Investigation” section for further details).

Note: **Bold** values represent an exceedance of the data quality objective for blank samples (concentration greater than 5 times the DL).

NTU = nephelometric turbidity units; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; µS/cm = microsiemens per centimetre; DL = detection limit; $CaCO_3$ = calcium carbonate; NF = near-field; MF = mid-field; FF = far-field.

Table B-2 Duplicate Sample Results, 2021

Parameter	Unit	MDL	NF4M-4 Sample 8-May-21	NF4M-4 Duplicate 8-May-21	RPD	MF3-6B-4 Sample 2-May-21	MF3-6B-4 Duplicate 2-May-21	RPD	NF1M-4 Sample 1-Sep-21	NF1M-4 Duplicate 1-Sep-21	RPD	MF1-1T-4 Sample 3-Sep-21	MF1-1T-4 Duplicate 3-Sep-21	RPD
Conventional Parameters														
Total Alkalinity	mg/L	0.5	5.91	5.75	2.7%	4.17	4.45	6.5%	6.47	6.5	0.5%	4.48	4.99	10.8%
Specific Conductivity - lab	µS/cm	1	45.7	44.8	2.0%	31.8	32.2	1.3%	45.7	51.8	12.5%	38.9	38.5	1.0%
Total Hardness as CaCO3	mg/L	0.5	11.6	11.3	2.6%	8.39	8.58	2.2%	10.4	11.3	8.3%	9.29	9.34	0.5%
pH	-	-	6.59	6.59	0.0%	6.61	6.65	9.2%	6.01	6	2.3%	6.55	6.61	13.8%
Total Dissolved Solids, Calculated	mg/L	0.5	22.5	21.2	5.9%	15.1	16.5	8.9%	21.9	25	13.2%	18.7	18.8	0.5%
Total Dissolved Solids, Measured	mg/L	1	37.6	38	1.1%	18.4	18.8	2.2%	25.6	30.8	18.4%	27.2	28	2.9%
Total Suspended Solids	mg/L	1	<1	1.1	-	<1	<1	-	<1	<1	-	<0.99	<1	-
Total Organic Carbon	mg/L	0.2	2.2	2.2	0.0%	2.3	1.6	35.9%	2.4	2.4	0.0%	2.8	2.8	0.0%
Turbidity	NTU	0.1	0.14	0.13	-	0.25	0.23	-	0.38	0.36	-	0.71	1.2	**51.3%**
Dissolved organic carbon	mg/L	0.2	2.1	2.3	9.1%	2	2.3	14.0%	2.2	2	9.5%	2.2	2.7	20.4%
Major Ions														
Bicarbonate	mg/L	0.5	7.21	7.01	2.8%	5.08	5.43	6.7%	7.89	7.93	0.5%	5.46	6.09	10.9%
Calcium	mg/L	0.01	2.53	2.43	4.0%	1.65	1.64	0.6%	2.26	2.45	8.1%	2.16	2.13	1.4%
Carbonate	mg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Chloride	mg/L	0.5	5.4	5.1	5.7%	3.1	4	25.4%	5	6.2	21.4%	4.8	4.6	4.3%
Fluoride	mg/L	0.01	0.033	0.034	-	0.027	0.028	-	0.028	0.032	-	0.029	0.031	-
Hydroxide	mg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Magnesium	mg/L	0.01	1.19	1.16	2.6%	1.03	1.07	3.8%	1.15	1.25	8.3%	0.973	0.96	1.3%
Potassium	mg/L	0.01	1.04	1.04	0.0%	0.89	0.91	2.2%	1.26	1.44	13.3%	0.95	0.935	1.6%
Sodium	mg/L	0.01	2.89	2.66	8.3%	1.85	1.83	1.1%	3.12	3.69	16.7%	2.44	2.4	1.7%
Sulphate	mg/L	0.5	5.4	5	7.7%	4	4.2	4.9%	4.9	5.7	15.1%	4.6	4.7	2.2%
Nutrients														
Ammonia (ALS)[(a)]	mg-N/L	0.005	<0.005	0.0051	-	0.0198	0.0218	-	<0.005	0.0092	-	0.02	<0.005	-
Ammonia (BV)[(a)]	mg-N/L	0.005	<0.005	<0.005	-	0.082	0.31	**116.3%**	<0.005	0.0069	-	0.016	0.0096	-
Nitrate	mg-N/L	0.002	0.095	0.086	9.9%	0.015	0.018	18.2%	0.054	0.08	38.8%	0.012	0.013	8.0%
Nitrite	mg-N/L	0.001	<0.001	<0.001	-	<0.001	<0.001	-	0.0022	0.0044	-	<0.001	<0.001	-
Nitrate + nitrite	mg-N/L	0.002	0.095	0.086	9.9%	0.015	0.018	18.2%	0.056	0.084	40.0%	0.012	0.013	8.0%
Total Kjeldahl Nitrogen	mg-N/L	0.02	0.168	0.193	13.9%	0.105	0.131	22.0%	0.158	0.166	4.9%	0.174	0.168	3.5%
Total Dissolved Nitrogen	mg-N/L	0.02	0.24	0.2	18.2%	0.12	0.11	8.7%	0.19	0.21	10.0%	0.18	0.17	5.7%
Total Nitrogen	mg-N/L	0.02	0.27	0.28	3.6%	0.12	0.15	22.2%	0.21	0.25	17.4%	0.19	0.18	5.4%
Soluble Reactive Phosphorus	mg-P/L	0.001	0.0012	0.001	-	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	<0.001	-
Total Dissolved Phosphorus	mg-P/L	0.002	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	<0.002	-	0.0029	0.0033	-
Total Phosphorus	mg-P/L	0.002	<0.002	0.0031	-	<0.002	<0.002	-	<0.002	0.0022	-	0.0104	<0.002	**135.5%**
Total Metals														
Aluminum	µg/L	0.2	5.61	5.41	3.6%	4.19	4.34	3.5%	7.62	8.56	11.6%	8.22	6.51	23.2%
Antimony	µg/L	0.02	0.023	0.021	-	<0.02	<0.02	-	0.027	0.034	-	<0.02	<0.02	-

Table B-2 Duplicate Sample Results, 2021 (continued)

Parameter	Unit	MDL	NF4M-4		RPD	MF3-6B-4		RPD	NF4M-4		RPD	NF1M-4		RPD
			Sample	Duplicate		Sample	Duplicate		Sample	Duplicate		Sample	Duplicate	
			8-May-21	8-May-21		2-May-21	2-May-21		1-Sep-21	1-Sep-21		3-Sep-21	3-Sep-21	
Arsenic	µg/L	0.02	0.291	0.277	4.9%	0.254	0.226	11.7%	0.264	0.279	5.5%	0.227	0.224	1.3%
Barium	µg/L	0.02	4.25	3.84	10.1%	2.2	2.3	4.4%	3.89	4.5	14.5%	2.74	2.65	3.3%
Beryllium	µg/L	0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Bismuth	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Boron	µg/L	5	<5	<5	-	<5	<5	-	6.2	6.6	6.2%	7.1	5.6	23.6%
Cadmium	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Calcium	µg/L	10	2520	2440	3.2%	1640	1640	0.0%	2200	2450	10.8%	2200	2210	0.5%
Chromium	µg/L	0.05	0.057	0.055	-	<0.05	<0.05	-	0.076	0.085	11.2%	<0.05	<0.05	-
Cobalt	µg/L	0.005	0.0133	0.0138	-	0.0288	0.0323	11.5%	0.015	0.0166	10.1%	0.0177	0.0166	6.4%
Copper	µg/L	0.05	0.606	0.603	0.5%	0.647	0.599	7.7%	0.436	0.421	3.5%	0.489	0.466	4.8%
Iron	µg/L	1	2.8	3.8	-	4.4	4.7	-	6.2	6.3	1.6%	9.2	7.3	23.0%
Lead	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Lithium	µg/L	0.2	1.96	1.94	1.0%	1.65	1.63	1.2%	1.94	1.9	2.1%	2.08	2.23	7.0%
Magnesium	µg/L	10	1280	1260	1.6%	1040	1090	4.7%	1190	1250	4.9%	924	929	0.5%
Manganese	µg/L	0.05	1.99	1.79	10.6%	6.12	5.93	3.2%	2.69	2.76	2.6%	3.07	2.95	4.0%
Mercury	µg/L	0.0019	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-
Molybdenum	µg/L	0.05	0.889	0.812	9.1%	0.227	0.234	-	1.15	1.51	27.1%	0.758	0.741	2.3%
Nickel	µg/L	0.02	0.746	0.728	2.4%	0.993	1.05	5.6%	0.66	0.696	5.3%	0.633	0.614	3.0%
Potassium	µg/L	10	1180	1130	4.3%	923	909	1.5%	1270	1420	11.2%	960	934	2.7%
Selenium	µg/L	0.04	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-
Silicon	µg/L	50	97	84	-	<50	<50	-	<50	55	-	<50	<50	-
Silver	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Sodium	µg/L	10	3170	2930	7.9%	1840	1900	3.2%	3100	3520	12.7%	2540	2520	0.8%
Strontium	µg/L	0.05	36.4	33.4	8.6%	15.6	16.6	6.2%	33.3	38.8	15.3%	22	21.7	1.4%
Sulphur	µg/L	100 - 600	2500	2500	0.0%	2520	1740	36.6%	1050	1020	-	500	<500	-
Thallium	µg/L	0.002	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	<0.002	-
Tin	µg/L	0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Titanium	µg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Uranium	µg/L	0.002	0.093	0.0889	4.5%	0.0385	0.0384	0.3%	0.104	0.128	20.7%	0.0777	0.0736	5.4%
Vanadium	µg/L	0.05	<0.05	<0.05	-	<0.05	<0.05	-	0.136	0.138	1.5%	<0.05	<0.05	-
Zinc	µg/L	0.1	0.43	0.21	-	<0.1	<0.1	-	2.53	0.62	**121.3%**	1.66	0.56	**99.1%**
Zirconium	µg/L	0.05	<0.05	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-
Dissolved Metals														
Aluminum	µg/L	0.2	4.69	4.41	6.2%	3.13	3.5	11.2%	6.31	6.63	4.9%	4.4	4.2	4.7%
Antimony	µg/L	0.02	<0.02	<0.02	-	<0.02	<0.02	-	0.028	0.035	-	<0.02	<0.02	-
Arsenic	µg/L	0.02	0.262	0.245	6.7%	0.187	0.167	11.3%	0.266	0.282	5.8%	0.217	0.219	0.9%

Table B-2 Duplicate Sample Results, 2021 (continued)

Parameter	Unit	MDL	NF4M-4		RPD	MF3-6B-4		RPD	NF4M-4		RPD	NF1M-4		RPD
			Sample	Duplicate		Sample	Duplicate		Sample	Duplicate		Sample	Duplicate	
			8-May-21	8-May-21		2-May-21	2-May-21		1-Sep-21	1-Sep-21		3-Sep-21	3-Sep-21	
Barium	µg/L	0.02	3.61	3.33	8.1%	2.2	2.26	2.7%	3.89	4.61	16.9%	2.71	2.67	1.5%
Beryllium	µg/L	0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Bismuth	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Boron	µg/L	5	<5	<5	-	<5	<5	-	<5	<5	-	<5	5.8	-
Cadmium	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Chromium	µg/L	0.05	<0.05	<0.05	-	<0.05	<0.05	-	0.098	0.08	-	0.307	0.295	4.0%
Cobalt	µg/L	0.005	0.013	0.0124	-	0.0248	0.0177	-	0.0092	0.0098	-	0.0119	0.014	-
Copper	µg/L	0.05	0.501	0.508	1.4%	0.608	0.574	5.8%	0.424	0.413	2.6%	0.453	0.445	1.8%
Iron	µg/L	1	3.4	3.5	-	2.9	3.7	-	3.2	3.2	-	4.8	4.8	-
Lead	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Lithium	µg/L	0.5	1.87	1.83	-	1.59	1.54	-	1.84	2	-	2.22	2.21	-
Manganese	µg/L	0.05	2	1.8	10.5%	2.64	2.04	25.6%	0.886	1.01	13.1%	1.08	1.25	14.6%
Mercury	µg/L	0.0019	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-
Molybdenum	µg/L	0.05	0.81	0.745	8.4%	0.226	0.233	-	1.21	1.53	23.4%	0.738	0.75	1.6%
Nickel	µg/L	0.02	0.649	0.66	1.7%	0.951	0.946	0.5%	0.707	0.687	2.9%	0.939	0.885	5.9%
Selenium	µg/L	0.04	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-
Silicon	µg/L	50	92	77	-	<50	<50	-	<50	54	-	<50	<50	-
Silver	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Strontium	µg/L	0.05	32.2	30.9	4.1%	15.7	17.6	11.4%	33	39.1	16.9%	23.7	23.4	1.3%
Sulphur	µg/L	100 - 600	670	1070	**46.0%**	3530	2340	**40.5%**	1380	1530	-	<500	<500	-
Thallium	µg/L	0.002	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	<0.002	-
Tin	µg/L	0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Titanium	µg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Uranium	µg/L	0.002	0.0784	0.0712	9.6%	0.0364	0.0348	4.5%	0.103	0.121	16.1%	0.0679	0.0705	3.8%
Vanadium	µg/L	0.05	<0.05	<0.05	-	<0.05	<0.05	-	0.115	0.117	-	<0.05	<0.05	-
Zinc	µg/L	0.1	0.32	0.25	-	<0.1	<0.1	-	4.55	0.53	**158.3%**	1.52	0.24	**145.5%**
Zirconium	µg/L	0.05	<0.05	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-
Calculated Quantities														
RPD values over 40%	%	-	-	-	1.1	-	-	2.1	-	-	2.0	-	-	4.0
RPD values over 40%	#	-	-	-	1	-	-	2	-	-	2	-	-	4

a) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV Labs ammonia dataset was used for the open-water season (see the “Ammonia Investigation” section for further details).

Note: Bold RPD values are greater than 40%, and concentrations in one or both samples that were greater than or equal to five times the DL.

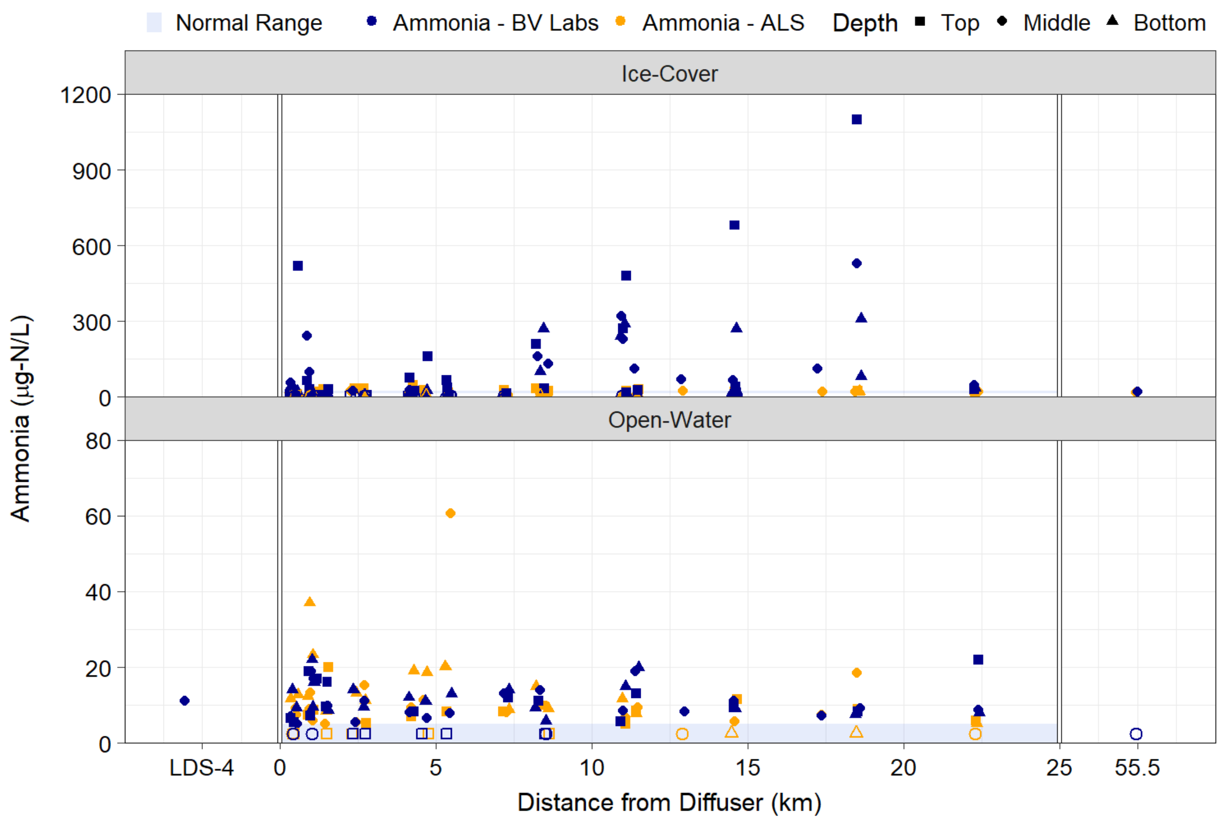
RPD = relative percent difference; - = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; µS/cm = microsiemens per centimetre; DL = detection limit; NF = near-field; MF = mid-field; FF = far-field.

Ammonia Investigation

The reader is directed to Appendix 4B of the *2014 to 2016 Aquatic Effects Re-evaluation Report Version 1.1* (Golder 2019a) and Appendix B of the 2017, 2018, 2019 and 2020 AEMP annual effluent and water chemistry reports (Golder 2018, 2019b, 2020b, 2021) for a review of the history of the ammonia contamination issue for the AEMP prior to 2021. The following text provides a summary of efforts that took place in 2021 and the selection of ammonia data used for analysis in this report.

Data quality issues with ammonia continue to be a concern in 2021, with incidental occurrences of contamination in blank samples, and relatively large variability between duplicate samples. In 2021, DDMI sent lake water quality samples to both BV Labs and ALS for analysis of ammonia, consistent with previous years. A comparison of the available ammonia data for Lac de Gras is shown in Figure B-1.

Figure B-1 Ammonia Concentrations in Lac de Gras Measured by BV and ALS, 2021



T = top depth; M = middle depth; B = bottom depth; µg-N/L = micrograms nitrogen per litre; <DL = less than detection limit.

As in the 2020 open-water season, BV Lab ammonia samples for 2021 were submitted unpreserved, due to concerns with contamination from the preservative observed in previous sampling rounds. After arriving at the laboratory, samples were preserved under controlled conditions. Considering the low pH, low biological activity, and demonstrated stability over 14 days with respect to ammonia for the AEMP samples, there is negligible chance of loss over the estimated 5 or 6 days between sampling and preservation at the laboratory. The same protocol is currently used successfully for metals.

BV Labs completed a review of the ice-cover season ammonia data and found that the total ammonia data from BV Labs was contaminated. The black caps of the ammonia vials were identified as a likely source of the ammonia contamination part-way through the ice-cover season. Following this discovery, BV Labs switched to the same vials with septa caps. Therefore, stations were mostly split between black capped, or septa capped vials, with both container types used at five stations (i.e., NF1, MF2-3, MF3-2, MF3-4, and MF3-5). At the stations where both vials were sampled, the septa cap vials clearly had lower values.

To further investigate data quality issues identified for ammonia, BV Labs completed an inter-laboratory comparison study evaluating differences in ammonia results for the 2021 ice-cover samples analyzed by BV Labs and ALS. The study is included in Annex A (following Attachment B). The key results of the study were as follows:

- A high level of contamination was identified in the BV Labs total ammonia black capped samples. The BV dataset generated from septa capped vials was the lowest and most consistent dataset, and is believed to be representative of ammonia concentrations in lake water.
- The ALS ice-cover dataset is subject to random low-level contamination.
- Continued use of unpreserved vials is recommended.

BV Labs recommended that the BV Labs data from stations sampled with septa cap vials and the ALS data from the other stations be used in reporting, or the full ALS dataset if it is not possible to mix the dataset. To avoid mixing datasets, and since total ammonia data generated by ALS for the ice-cover season had fewer data quality issues than the total ammonia data generated by BV Labs, the ALS ice-cover dataset was chosen for use in the data analyses, tables, and figures completed in support of the 2021 AEMP Annual Report.

BV Labs also completed an inter-laboratory comparison study of the 2021 open-water samples analyzed by BV Labs and ALS. The study is included in Annex B (following Attachment B). The key result of the study was that overall, the BV Labs and ALS datasets are similar; however, it is recommended that the BV ammonia dataset be reported for the following reasons:

- BV Labs data were slightly more self-consistent.
- BV Labs data had fewer data quality issues.
- All BV Labs samples were analyzed within hold times. Previous studies have shown that the chance of ammonia contamination increases with time.

Based on these results, the BV Labs open-water data was used in the data analyses, tables, and figures completed in support of the 2021 AEMP Annual Report.

The DL required for ammonia (i.e., 0.005 mg/L) for this AEMP is at the absolute limit of instrument sensitivity, and as a result, concentrations measured close to the DL are subject to large uncertainty. Especially at low levels, ammonia presents issues with respect to potential contamination, because it is airborne. Previous studies have shown that airborne ammonia contamination can be introduced over time into unopened containers (Golder 2019b). Considerable time and energy have been spent over the past years to minimize external contamination in the laboratory and BV Labs believes they now have a “clean” process, with the following key features:

- Samples are processed in the laboratory in an ammonia-free environment.
- Ammonia-free cleaners are used.
- BV labs provides containers and caps that are ammonia-free and resistant to intrusion of airborne ammonia.

This is reflected in the improved performance demonstrated in the open-water inter-laboratory comparison study. The recommendations and conclusions outlined in the inter-laboratory comparison study are those of BV Labs and do not necessarily reflect DDMI’s plan for the AEMP. However, the information gathered by these studies is valuable and will be used in future decision-making related to sampling and analysis of samples for ammonia, and reporting for the AEMP. DDMI will continue to work with the analytical laboratory to determine a path forward for the ammonia analysis for future monitoring. More work is planned in 2022 to help determine the path forward. Duplicate samples will again be provided to BV Labs and ALS for analysis in the ice-cover season of 2022.

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ALS / Bureau Veritas Environmental Laboratories Division Total Ammonia Inter-Lab Comparison 2022/02/26

Prepared by: Barry Loescher, PhD, PChem, QP

Background and Plan:

Due to an observed bias between Bureau Veritas Environmental Laboratories (BV) and ALS results for total ammonia in previous sampling rounds, a comprehensive comparison program was developed. This is the eighth study and fifth under ice intercomparison.

In this program, as in the previous rounds, field personnel sampled every site in duplicate using Bureau Veritas (BV) Labs bottles for samples to be submitted to BV and ALS bottles and preservatives for samples to be submitted to ALS. Previously, both labs use bottles pre-charged with sulphuric acid as preservative. Due to concerns with contamination from the acid preservative, BV samples for both Total and Dissolved ammonia were submitted, unpreserved. In addition, due to results from recent BV studies, two sample containers were used. Black capped vials which were previously in use and the same vials with septa caps. The studies had shown that the black caps are a likely source of ammonia contamination. Unfortunately, the results were obtained just as the sampling program started, thus the two types of containers. Sites were sampled as per Table 1. Note that 2 sites, MF3-5 and MF3-6 were sampled using both container types.

Table 1	BV Vial Type	
Site	Black	Septa
FF1	x	
FF2-2	x	
FF2-5	x	
FFD	x	
LDG		x
MF1-1	x	
MF1-3	x	
MF1-5	x	
MF2-1		x
MF2-3		x
MF3-1		x
MF3-2		x
MF3-3		x
MF3-4	x	x
MF3-5	x	x
MF3-6	x	
MF3-7	x	
NF1		x
NF2	x	
NF3	x	
NF4		x
NF5	x	

The sampling program was extensive. Over 140 samples were received at each lab. These included 4 Trip Blanks[1], 6 Field Blanks[2], and 6 Equipment Blanks[3].

The samples for ALS were submitted to ALS Calgary and samples for BV were submitted to BV Calgary. All data were submitted to Dr. Barry Loescher for compilation.

[1] Trip Blank sample bottle containing DI water travels unopened to and from the field.

[2] Lab-supplied DI water is poured into an empty sample bottle in the field which is sealed and returned to the lab.

[3] Lab-supplied DI water is poured though the sampling apparatus into an empty sample bottle in the field which is sealed and returned to the lab.

Analytical Methods:

Both labs used automated chemistry analysis. There were significant differences in the methods, however, which are summarized in the following table. Both methods have comparable sensitivity, accuracy and precision. Since the sample matrix is very clean, with no high concentrations of any analyte, no significant interferences are anticipated.

Because of issues with preservative contamination in previous rounds, BV samples for Total ammonia were submitted in unpreserved vials, identical to those used for dissolved ammonia. On arrival at the lab, samples were immediately delivered to the instrument lab, where preservation and filtration / preservation was conducted in a fume hood shown to be ammonia free. Samples were immediately recapped and returned to sample receiving for log in and storage at < 6C until analysis. The filtration process involved first rinsing the syringe / filter with sample then pipetting a sample aliquot into the syringe body with filter attached. The plunger was inserted into the syringe body and the aliquot pushed through the filter into a new vial with preservative. This process minimizes the chance of ammonia contamination or loss through volatilization. The method Blanks were taken through exactly the same process as the samples. This is best evidence that the filtering / preserving steps do not introduce contamination. Note that these values are raw instrument data. All but one were below the Reporting Limit (RDL) of 0.005.

	method blank
n	33
average mg/L	-0.001
stdev %	0.003
Maximum	0.005

Instrument Method Detail

Lab	*Reference*	*Instrument*	*Operating Principle*	*Colourimetry*	*Calibration*
BV Labs Calgary	US EPA, Method 350.1	Thermo Scientific Gallery Plus	Discrete Analyzer	Phenate	Quadratic
ALS Calgary	J. Environ. Monit., 2005, 7, 37-42	FIA Lab	Flow Injection / Fluorescence	OPA Fluorescence	Quadratic

Data Analysis:

The 3 sets of data (BV Total, BV Dissolved, ALS Total were tabulated and comparisons done for each of three combinations. Raw instrument data was used for the BV results. In order to permit statistical evaluation ALS samples reported as <0.005 were assigned a value of 0.003.

Because of the markedly different BV results obtained from the septa cap vials versus the black cap vials black cap vs septa cap was also studied as well as septa cap vs ALS.

The following parameters were evaluated

- T-tests,
- # of pairs meeting duplicate criteria
- # of 4,5 duplicate pairs for each data set meeting duplicate criteria

In addition, the Field QC was evaluated

Finally, outliers were evaluated. This was done making the following assumptions:

- Ammonia results from the Bottom Middle and Top Depth samples from each site should be similar. Results from the depth integrated samples from each site should be similar
- Results from BV Total, BV Dissolved and ALS Total Ammonia should be similar. (See below for reasons BV believes D ≈ T)

- Outliers were calculated using the Z score statistic. The mean and standard deviation of the 3 data sets were calculated. Each data set was sorted in descending order

  Z = (X1-Xav)/ stdev
  Z = Z score
  X1 = highest value
  Xav = average of all values
  stdev = standard deviation of all values
  Z scores > 3 are considered outliers (P = 0.01)

	Outliers	
Data Set	Site	Value mg/L
BV D	MF3-6B-5-4	0.223
	MF3-7B-4	0.119
	MF1-5T-4	0.106
BV T	MF3-6T-5	1.242
	MF3-6T-4	1.120
	MF3-7T-5	0.620
ALS	MF3-2T-4	0.048

Based on the above, BV D and BV T had 3 outliers, ALS had 1. All BV outliers were from black cap vials. Only 2 outliers were from the same site and sampling occurred on 3 different days. The ALS outlier was also from a different site on a different day. Of note, the BV outliers were significantly higher than the ALS. All of this suggests substantial random contamination from the black cap vials and no site related sampling problems.

For the following reasons, BV believes that D ≈T

- Ammonia salts are all very soluble
- Turbidity of all the AEMP samples was < 1 NTU,
- Average TSS was also very low.
- All samples were pH < 7, at which 99.9% of the ammonia is in the form of the ammonium ion, NH_4^+ which is not volatile and Heterotrophic Plate Count measurements showed low or no biological activity such that no losses of ammonia would be expected between sampling and preservation at the lab.

All data in found in the appended Excel Workbook. Field QC data is separated from the sample data. Results are colour coded to permit easy interpretation. The Workbook was left unprotected to allow users sorting capabilities.

Observations:

Ammonia Interferences / Contamination

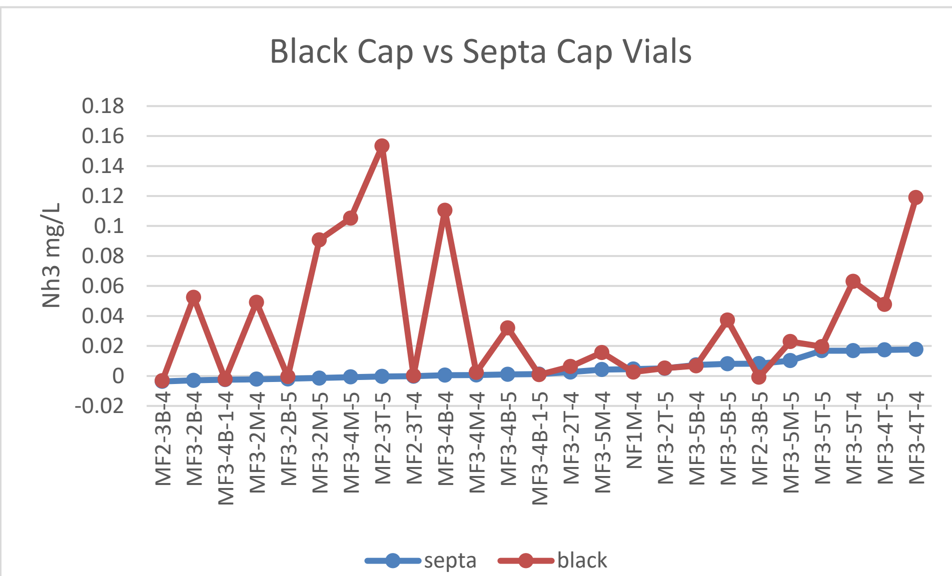
As discussed earlier, because of the very clean matrix and the ruggedness of the analytical techniques, no chemical interferences are expected. Particulates can potentially cause a positive interference. Ammonia is airborne and ubiquitous. Also, even at pH 7, 99.9% of ammonia is non-v0latile NH_4 In short, it is very difficult how there could be anomalously low values. As such, the following observations are based on the premise that anomalously high values are due to contamination from field, transport, or lab issues. and low values are more representative of the lake water.

Septa Cap vs Black Cap Vials:

Ammonia mg/L	septa	black
n	25	25
average	0.004	0.037
maximum	0.018	0.153
# greater	3	22
# > 0.020	0	8

The most important observation is the differences between the BV black cap vials and septa cap vials. As shown in the summary table, for sites where both vials were sampled, the septa cap vials are clearly lower.

From the graph below it can be seen that the bias is due to random contamination as opposed to systemic issues.



Ammonia mg/L	BV Total		BV Disolved	
	black	septa	black	septa
n	68	61	68	58
average	0.146	0.004	0.024	0.004
maximum	1.240	0.026	0.223	0.024

Similar behavior was observed for BVT &BVD black cap vs septa cap for the whole data set less QC. The septa cap data is much lower with no high outliers. Also, there is no bias between BVT and BVD using a paired t-test (P = 0.05)

Ammonia mg/L	cap	n	average	max
BVTotal	septa cap	61	0.004	0.026
BV Dissolved	septa cap	58	0.004	0.024
ALS	bottle	58	0.014	0.048
BVTotal	black cap	68	0.146	1.240
BV Dissolved	black cap	68	0.024	0.223
ALS	bottle	66	0.018	0.044

Extending the comparison to include the ALS data, the ALS samples corresponding to the BV samples taken in septa cap vials were compared. Similarly for the black cap vials.
The ALS data is significantly higher than the BV septa vial samples (P = 0.001) and lower than the BV T black cap vials with the same probability.

Range mg/L	Colour
< 0.005	
0.030 - 0.050	
0.050 - 0.100	
> 0.100	1.000

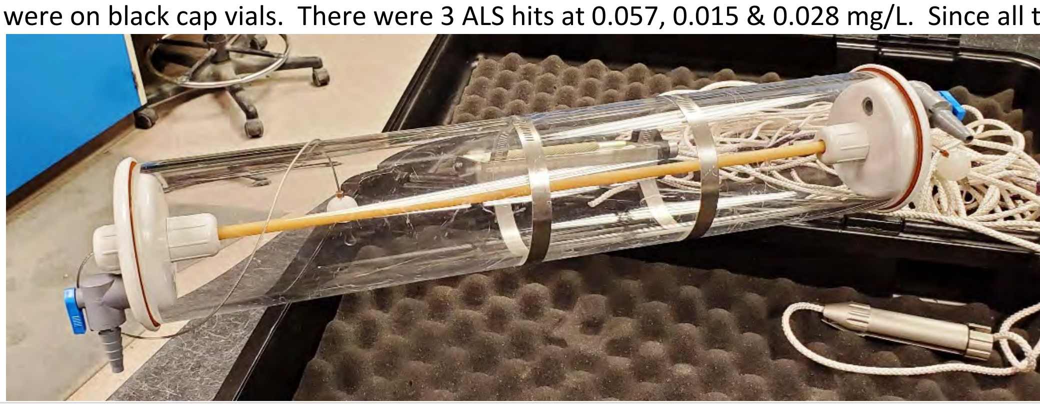
Field QC:

Similar to the previous under ice study the field QC was very good.

Blank Summary		BV D	BV T	ALS
Trip	n	2	4	4
	#<	2<	4 <	4 <
Field	n	4	6	6
	#<	4<	6<	4 <
Equipment	n	2	6	6
	#<	2<	4<	3<

- All trip blanks were non-detect.
- 2 ALS field blanks had hits at 0.058 and 0.012 mg/L. Since the same water and same sampling protocol was used for BV and ALS field blanks it suggests either a container or lab contamination issue for the ALS hits.

- Equipment blanks are performed back in the Diavik laboratory. The beta bottle (pictured below) is first rinsed then filled again and samples collected from the stop cock (bottom left). The 2 BV T hits at 0.043 & 0.163 mg/L were on black cap vials. There were 3 ALS hits at 0.057, 0.015 & 0.028 mg/L. Since all the BV septa cap values were non-detect and only one of the BV T hits corresponded to the ALS sample, this suggests an ALS container or lab issue as opposed to



contamination of the beta bottle.

Data Set Relationships:

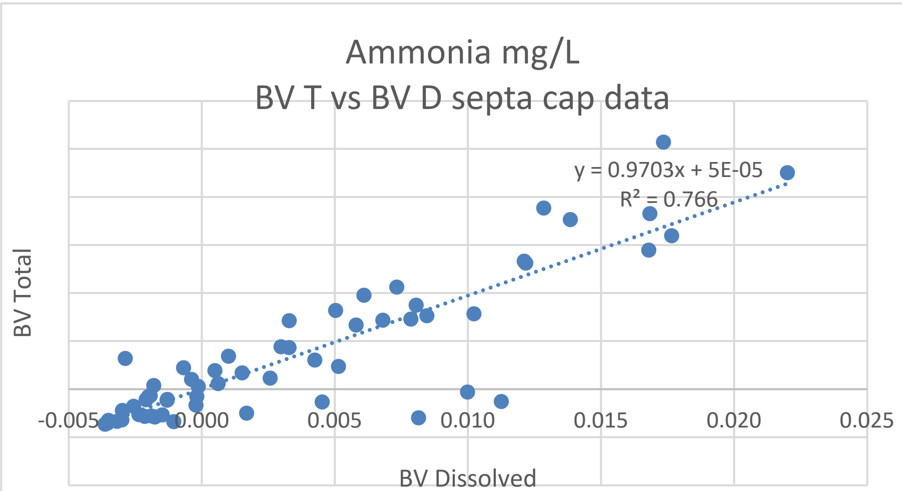
Because of the obvious substantial contamination in the BV T samples in black cap vials, this data was not used for comparison.

BV Dissolved Ammonia Data:

As had been observed previously, the BV D samples in black cap vials exhibited substantially less contamination than BV T. Both samples were collected in vials with no preservative. Filtration / preservation and preservation are conducted at the same time in the same location in the lab. As discussed above BVT should be ≈BVD, which is the case for the septa cap samples. Filtration is accomplished by pressure using a syringe and disc filter. As is shown in the accompanying table, routine filtered spikes show no losses of dissolved ammonia. All samples have low turbidity and TSS. However, the turbidity and TSS tests are conducted on samples from a separate HDPE bottle. Although the samples in the black cap vials are visibly clear and ammonia salts are soluble, it is possible that there are small amounts of particulate which would interfere in the colourimetric determination. Regardless, the black cap vials are no longer in use.

Ammonia Filtered Spike Standards			
Conc. mg/L		**result mg/L**	**difference**
0.005ppm 1	NH4	0.008	0.003
0.005 ppm 2	NH4	0.007	0.002
0.005 ppm 3	NH4	0.006	0.001
0.05ppm 1	NH4	0.051	0.001
0.05 ppm 2	NH4	0.050	0.000
0.05ppm 3	NH4	0.048	-0.002
0.1ppm 1	NH4	0.104	0.004
0.1ppm 2	NH4	0.098	-0.002
0.1ppm 3	NH4	0.103	0.003
Average			0.001

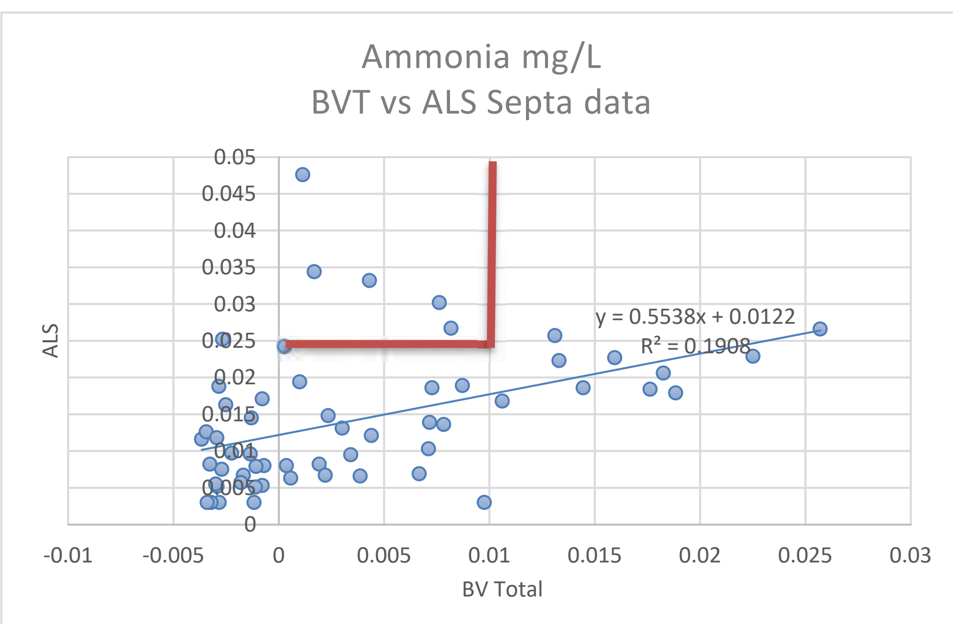
BVD and BVT Comparison Septa Cap samples only:



ammonia mg/L BV Septa Only		
	BVT	**BVD**
n		
average	0.004	0.004
max	0.026	0.022
P ttest*	0.889	
* value < 0.05 significant at the 0.05 level		

- There is no bias between the data sets (paired t-test P=0.05) and there is a reasonable correlation between the two data sets. Slope of 0.97 and an intercept of 0.000 mg/L. The correlation coefficient of 0.77 is good for such low level data.
- All 58 BVT & BVD values met Lab duplicate criteria (abs. difference < 0.010)
- 30 of 31 BV T BV D duplicate pairs met lab duplicate criteria
- 27 of 28 4 – 5 duplicate pairs met lab duplicate criteria

BVT and ALS Comparison Septa Cap samples only:



ammonia mg/L BV Septa Only		
	BVT	**ALS**
n	61	58
average	0.004	0.014
max	0.026	0.048
P ttest	0.000	

- The ALS data is significantly higher than the BVT.
- There is no correlation between the data sets, (R^2 = 0.19) mainly due to a number of relatively high ALS values. (ALS > 0.025 BV < 0.010 mg/L).

- The high values are not correlated to a particular site, thus indicative of random contamination
- 21 of 29 ALS 4 – 5 field duplicate pairs met duplicate pairs, with the majority of the misses associated with the high outlier values, again suggesting random contamination.
- In contrast the LDG and MF2-1M data is very consistent in all three data sets. This may just be random chance, but suggests contamination is not in all samples.

	BV D	BVT	ALS
LDG48-4	0.013	0.019	0.018
LDG48-5	0.014	0.018	0.018
MF2-1M-4	0.022	0.023	0.023
MF2-1M-5	0.006	0.007	0.007

Conclusions / Recommendations:

Table 1	BV Vial Type		Table 1	BV Vial Type	
Site	Black	Septa	Site	Black	Septa
FF1	x		MF3-2		x
FF2-2	x		MF3-3		x
FF2-5	x		MF3-4	x	x
FFD	x		MF3-5	x	x
LDG		x	MF3-6	x	
MF1-1	x		MF3-7	x	
MF1-3	x		NF1		x
MF1-5	x		NF2	x	
MF2-1		x	NF3	x	
MF2-3		x	NF4		x
MF3-1		x	NF5	x	

- The BV data generated from septa capped vials is the lowest and most consistent data set and we believe the most representative of the ammonia levels in the water.
- It is recommended that the BV T data from these sites be reported and the ALS data be reported from the other sites
- If that is not possible, then the full ALS data set should be used, minus the one statistical outlier
- BV has spent considerable time and energy over the past years to minimize external contamination in the laboratory and believe we now have a “clean” process
  - Processing samples in the lab in an ammonia free environment
  - Use of ammonia free cleaners
  - Finding and proving a container and cap that are ammonia free and resistant to intrusion of airborne ammonia
- It is unfortunate that the process has taken so long, but we look forward to providing much improved data going forward.

ALS / Bureau Veritas Environmental Laboratories Division Total Ammonia Inter-Lab Comparison 2022/02/26

Prepared by: Barry Loescher, PhD, PChem, QP

Background and Plan:

Due to an observed bias between Bureau Veritas Environmental Laboratories (BV) and ALS results for total ammonia in previous sampling rounds, a comprehensive comparison program was developed. This is the ninth study and fifth open water intercomparison.

In this program, as in the previous rounds, field personnel sampled every site in duplicate using Bureau Veritas (BV) Labs bottles for samples to be submitted to BV and ALS bottles and preservatives for samples to be submitted to ALS. Previously, both labs use bottles pre-charged with sulphuric acid as preservative. Due to concerns with contamination from the acid preservative, BV samples for both Total and Dissolved ammonia were submitted, unpreserved. Septa cap vials were used exclusively for the BV samples.

The sampling program was extensive. In all 129 samples were received at each lab and compared. These included 6 Trip Blanks[1], 4 Field Blanks[2], and 4 Equipment Blanks[3].

The samples for ALS were submitted to ALS Vancouver and samples for BV were submitted to BV Calgary. All data were submitted to Dr. Barry Loescher for compilation.

Analytical Methods:

Both labs used automated chemistry analysis. There were significant differences in the methods, however, which are summarized in the following table. Both methods have comparable sensitivity, accuracy and precision. Since the sample matrix is very clean, with no high concentrations of any analyte, no significant interferences are anticipated.

Because of issues with preservative contamination in previous rounds, BV samples for Total ammonia were submitted in unpreserved vials, identical to those used for dissolved ammonia. On arrival at the lab, samples were immediately delivered to the instrument lab, where preservation and filtration / preservation was conducted in a fume hood shown to be ammonia free. Samples were immediately recapped and returned to sample receiving for log in and storage at < 6C until analysis. The filtration process involved first rinsing the syringe / filter with sample then pipetting a sample aliquot into the syringe body with filter attached. The

[1] Trip Blank sample bottle containing DI water travels unopened to and from the field.

[2] Lab-supplied DI water is poured into an empty sample bottle in the field which is sealed and returned to the lab.

[3] Lab-supplied DI water is poured though the sampling apparatus into an empty sample bottle in the field which is sealed and returned to the lab.

plunger was inserted into the syringe body and the aliquot pushed through the filter into a new vial with preservative. This process minimizes the chance of ammonia contamination or loss through volatilization.

Instrument Method Detail

Lab	*Reference*	*Instrument*	*Operating Principle*	*Colourimetry*	*Calibration*
BV Labs Calgary	US EPA, Method 350.1	Thermo Scientific Gallery Plus	Discrete Analyzer	Phenate	Quadratic
ALS Vancouver	J. Environ. Monit., 2005, 7, 37-42	FIA Lab	Flow Injection / Fluorescence	OPA Fluorescence	Quadratic

Data Analysis:

Since the BV Dissolved and Total ammonia data sets were comparable, for simplicity only the ALS and BV Total ammonia data were compared. The 2 sets of data were tabulated and comparisons done. In order to permit statistical evaluation samples reported as <0.005 were assigned a value of 0.003.

The following parameters were evaluated:

- T-tests,
- # of ALS, BV sample pairs meeting lab duplicate criteria
- # of 4,5 duplicate pairs for each data set meeting duplicate criteria

In addition, the Field QC was evaluated.

Finally, outliers were evaluated comparing individual results against the whole data set for each lab.

Observations:

All data in found in the appended Excel Workbook. Field QC data is separated from the sample data. Results are colour coded to permit easy interpretation. The Workbook was left unprotected to allow users sorting capabilities.

Evaluation of Outliers:

- Outliers were calculated using the Z score statistic. The mean and standard deviation of the data sets were calculated. Each data set was sorted in descending order.

  Z = (X1-Xav)/ stdev
  Z = Z score
  X1 = highest value
  Xav = average of all values
  stdev = standard deviation of all values
  Z scores > 3 are considered outliers (P = 0.01)

Site	ALS Outliers	BV	Site	ALS	BV Outliers
MF2-3M	0.061	0.008	NF3-4	0.009	0.025
NF3B	0.037	0.022	NF3-5	0.033	0.025
NF3-5	0.033	0.025			

Based on the above, ALS had 3 outliers and BV had 2. Of note, for NF3B and NF3-5, the BV results were also high.

An outlier means that the results is significantly higher than the average of the entire data set. Notably all but one of the high outliers from the NF3 site. The table below shows that overall, NF3 was higher than the other sampling locations, (excluding field QC). The NF3 site was also high in the previous open water study. All evidence suggests that the statistically higher NF3 values are true and not sampling or lab related artifacts.

Average NH3 mg/L		
Site	ALS	BV
FF1	0.003	0.008
FF2	0.010	0.014
MF1	0.007	0.007
MF2	0.007	0.008
MF3	0.008	0.010
NF1	0.012	0.011
NF2	0.009	0.008
NF3	0.020	0.022
NF4	0.012	0.017
NF5	0.009	0.008

Thus, the only true outlier is the ALS MF2-3M result of 0.061 mg/L. This is corroborated by the fact that the corresponding B & T and Depth Integrated samples were relatively low for both ALS and BV.

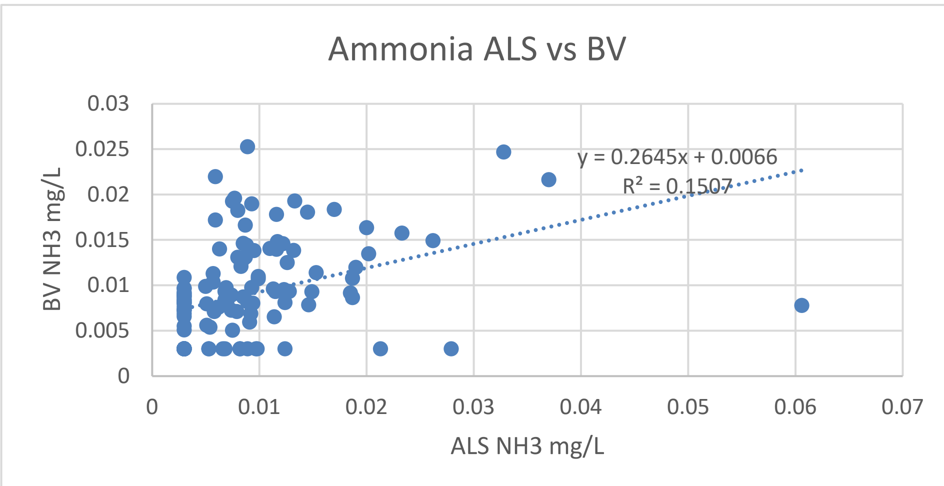
Overall the data is lower than in recent studies.

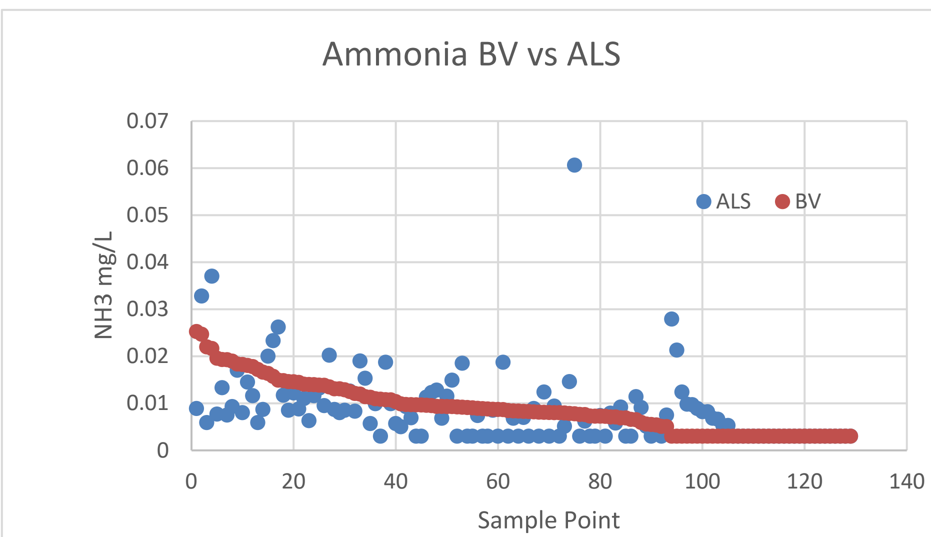
	ALS	BV
n	129	129
average	0.009	0.009
max	0.061	0.025
n > 0.03	3	0
n > 0.02	7	4
ttest	0.688	

The average result (n=129) was only 0.009 mg/L and aside from the one ALS outlier very few results > 0.020 mg/L. The average in the 2020 open water and 2021 under ice studies was BV 0.014, ALS 0.014, BV 0.014 ALS 0.016 respectively. Since the vast majority of the data is < 0.020 mg/L there is substantial variability between labs as shown by the paired t-test value of 0.688 which shows no statistical difference between the labs. A value of < 0.05 would indicate a significant difference between the labs.

Shaping a world of trust

The graphs below also illustrate the significant scatter of the low level data and the lack of correlation between the data sets . (R^2 = 0.15, values > 0.75 would be considered significant)





In the above graph, the x-axis is the 129 samples for which there is a BV and corresponding ALS result. The red line contains the 129 BV data points in descending order and the blue dots vertically above each BV data point are the corresponding ALS results. For example, point 75 is the ALS result of 0.061 and the corresponding BV result for point 75 is 0.008 mg/L. This meant to demonstrate the variability between the ALS and BV results. From point 105 on both results are 0.003 mg/L. When superimposed with the red the blue dots are masked.

Overall, he BV and ALS data sets are similar.

# of results within NH3 Ranges		
Range	**ALS**	**BV**
>0.020	9	4
0.010 to 0.020	29	43
0.005 to 0.010	44	46
<0.005	47	36
both < 0.005	24	24
n	129	129

- 117 of 129 BV : ALS data pairs met the lab duplicate criteria (absolute difference of < 0.010 or RPD < 20%)
- The overall average results are the same and the average results for each site as shown in the Average NH3 table above are all within 0.005 mg/L, the method detection limit.
- 24 sample pairs were < 0.005 in both labs. The groupings within ranges were also similar. ALS had more non-detects but also more 0.020 and above.
- The average difference of the whole data set (ALS – BV} is 0.000 mg/L.

The BV data is slightly more self-consistent

- All 24 BV 4- 5- field duplicates met the lab duplicate criteria (absolute difference of < 0.010 or RPD < 20%) while only 20 of 24 ALS pairs met this criterion.
- The BV blank data, particularly the Trip Blanks had fewer positive results and none > 0.008 mg/L

Field QC:

Unlike the previous studies where all trip blanks were non detect in both labs, ALS had hits on 6 of 9 trip blanks. BV had 2 very low level positives.

Field QC		**Ammonia mg/L**		**Field QC**		**Ammonia mg/L**	
Depth Integrated	n	ALS	BV	**Grab**	n	ALS	BV
Trip Blanks	6	0.015	0.008	**Trip Blanks**	3	0.021	<
		0.012	0.005			<	<
		0.007	<			<	<
		0.005	<				
		<	<				
		<	<				
Field Blanks	4	0.008	<	**Field Blanks**	3	<	<
		<	<			<	<
		<	<				
		<	<				
Equip. Blanks	4	0.028	<	**Equip. Blanks**	2	<	<
		<	<			<	<
		<	<				
		<	<				

ALS also had positives on one field blank and one trip blank while BV field and trip blanks were all non-detect. This may be due to the extended time between sampling and analysis for the ALS samples. 82 of 129 samples were analyzed past the 28 day hold time. (29 to

35 days). Previous studies have shown that chance of ammonia contamination increases with time. In contrast, all BV samples were analyzed within hold time, on average 12 days after sampling. The ALS "hits" could also be a problem in the trip blank preparation

.

Conclusions / Recommendations:

- Although the data sets are similar, it is recommended that the BV data set be reported for the following reasons
    - The BV data is somewhat more self-consistent as judged from the performance on field 4 – 5 duplicate pairs.
    - The are no outliers in the BV data
    - The BV Field QC data is better than ALS
    - All BV samples were analyzed within hold time
- BV has spent considerable time and energy over the past years to minimize external contamination in the laboratory and believe we now have a "clean" process
    - Processing samples in the lab in an ammonia free environment
    - Use of ammonia free cleaners
    - Finding and proving a container and cap that are ammonia free and resistant to intrusion of airborne ammonia

    This is reflected in the improved performance in this study
- Additional capacity has permitted improved delivery performance

ATTACHMENT C

INITIAL EFFLUENT AND WATER QUALITY DATA SCREENING

INITIAL EFFLUENT AND WATER QUALITY DATA SCREENING

Introduction

Data screening is the initial phase of data handling when analyzing chemistry datasets that contain occasional extreme values. Extreme values are frequently incorrect, reflecting field or laboratory errors, data transcription or calculation errors, or extreme natural variability. Data screening is undertaken prior to data analysis and interpretation to verify that the data quality objectives established by the *Quality Assurance Project Plan (QAPP) Version 3.1* (Golder 2017) and the *AEMP Design Plan Version 5.2* (Golder 2020) have been met. The purpose of data screening is to identify unusually high or low values (referred to as anomalous data), verify or correct them if possible, and make a decision whether to retain or exclude remaining anomalous data from further analysis.

The data screening approach used in this report includes a numerical method to aid in the identification of anomalous data, followed by visual/logical assessment of the identified values. This approach removes the subjectivity of classifying values based on visual evaluation of data alone. This initial screening is primarily applicable to chemistry data, because anomalous results are less common in biological (e.g., taxonomy) data and are typically resolved through contacting the taxonomist.

Methods

Initial screening of the annual AEMP datasets was completed using a method based on Chebyshev's theorem (Mann 2010) combined with the visual examination of scatterplots (Golder 2020). The method is applied by first identifying data that lie outside the 4.47 standard deviation (SD) on a scatterplot of annual data, and then visually verifying the anomalous values based on potential spatial trends. If a datapoint was visually anomalous, it was investigated to evaluate whether it was reported in error, or if it was consistent with associated variables (e.g., total dissolved solids and major ion concentrations) and data collected in previous years. No data were identified as anomalous based on visual evaluation alone.

In cases where numerical screening identified an elevated value in the NF area or at the mixing zone boundary as anomalous, the identified value was conservatively retained in the dataset used for analysis if the SD distance from the mean was less than two times the 4.47 SD criterion discussed above. Hence, only very extreme values, which were greater than approximately 9 SD from the mean, were removed from further analysis of NF area data, upon visual confirmation of screening results. Finally, in cases where the annual datasets contained a large proportion of non-detect data (i.e., censored values), only values that were greater than or equal to five times the detection limit were considered anomalous and were removed from the analysis if visual screening confirmed the numerical screening results.

Results

Results of the initial data screening are summarized herein for effluent, mixing zone and AEMP datasets (Tables C-1 to C-3; Figures C-1 to C-11). Results consist of a table of anomalous values removed from each dataset and scatterplots, which allow visual review of anomalous data and provide transparency. Overall, the number of anomalous values identified by the data screening procedure was very small compared to the amount of data summarized, accounting for less than 0.5% of the dataset.

SNP

Table C-1 List of Anomalous Values Removed from SNP Analyses, SNP 1645-18 and 1645-18B (Effluent)

Variable	Station	Value	Unit	Date	Standard Deviation Distance [(a)]
Acidity (pH 8.3)	1645-18	5	mg/L	09-Dec-2020	4.86
Total Dissolved Phosphorus	1645-18	39	µg-P/L	01-Feb-2021	5.96
Total Aluminum	1645-18	964	µg/L	14-May-2021	4.90
Total Bismuth	1645-18	0.046	µg/L	11-Oct-2021	7.48
Total Cadmium	1645-18	0.0589	µg/L	13-Jul-2021	5.93
Total Iron	1645-18	71.4	µg/L	19-Jun-2021	5.95
Total Tin	1645-18	0.222	µg/L	8-May-2021	5.45
Total Titanium	1645-18	3.46	µg/L	19-Jun-2021	4.91
Total Zinc	1645-18	7.45	µg/L	6-Aug-2021	4.50
Turbidity	1645-18B	2	NTU	13-Jul-2021	4.79
Total Aluminum	1645-18B	1,500	µg/L	19-Jun-2021	5.58
Total Cadmium	1645-18B	0.0572	µg/L	13-Jul-2021	5.43
Total Iron	1645-18B	111	µg/L	19-Jun-2021	6.53
Total Titanium	1645-18B	3.34	µg/L	19-Jun-2021	5.28
Total Zinc	1645-18B	7.11	µg/L	27-Nov-2020	5.02
Total Zinc	1645-18B	7.4	µg/L	11-Oct-2021	5.24

a) Number of standard deviations from the mean calculated for the 2021 monitoring period.

NTU = nephelometric turbidity unit; µg/L = micrograms per litre; µg-P/L= micrograms phosphorus per litre.

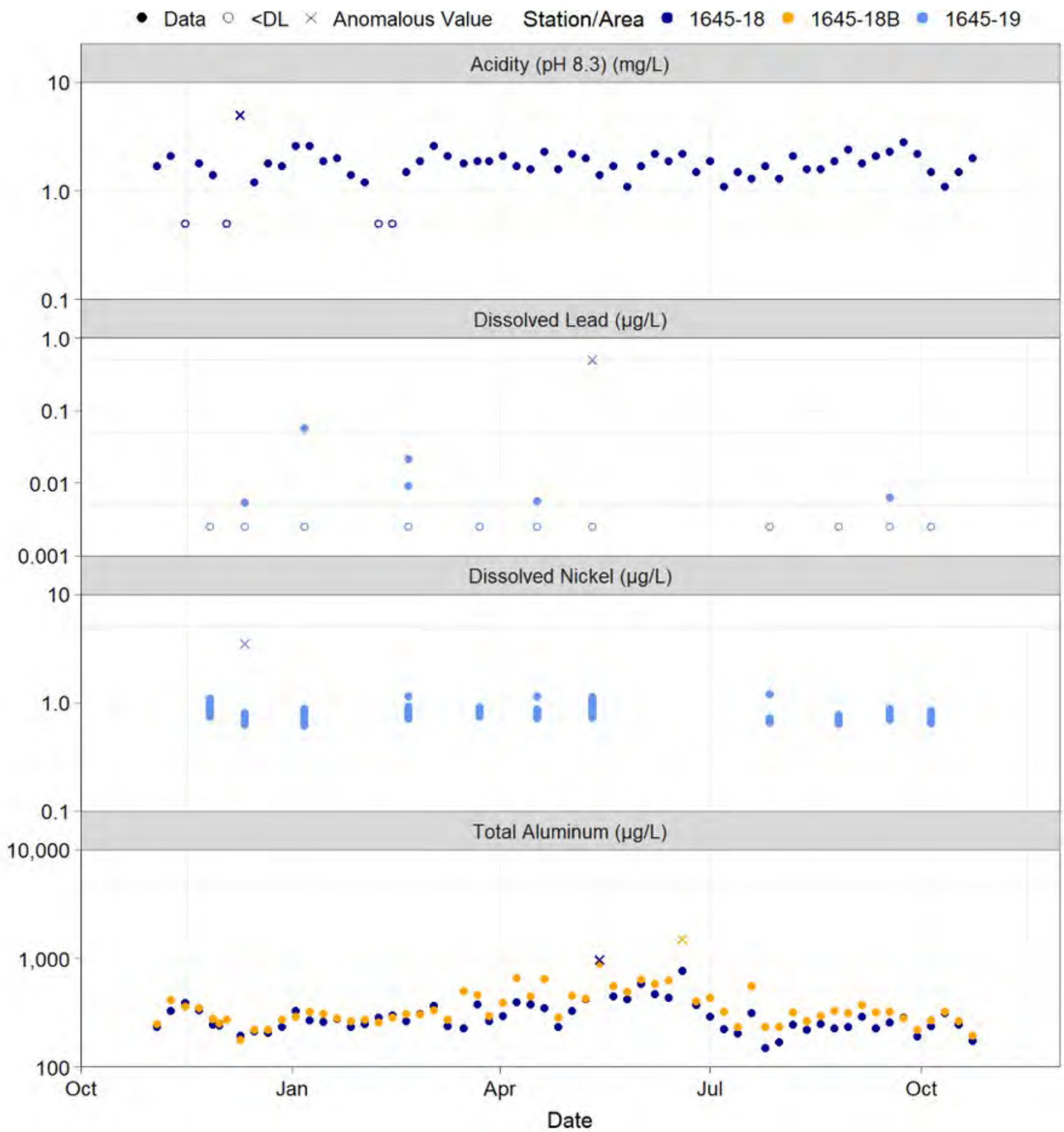
Table C-2 List of Anomalous Values Removed from SNP Analyses, SNP 1645-19A, 1645-19B and 1645-19C (Mixing Zone)

Variable	Station	Value	Unit	Date	Standard Deviation Distance [(a)]
Dissolved Lead	1645-19	0.498	µg/L	11-May-2021	12.12
Dissolved Nickel	1645-19	3.48	µg/L	11-Dec-2020	10.81
Total Chromium	1645-19	0.68	µg/L	20-Feb-2021	9.13
Total Iron	1645-19	49.4	µg/L	17-Apr-2021	9.19
Total Lead	1645-19	67.8	µg/L	20-Feb-2021	12.21
Total Nickel	1645-19	3.52	µg/L	11-Dec-2020	10.89
Total Tin	1645-19	93.2	µg/L	20-Feb-2021	12.21
Total Zinc	1645-19	17	µg/L	20-Feb-2021	10.31

a) Number of standard deviations from the mean calculated for the 2021 monitoring period.

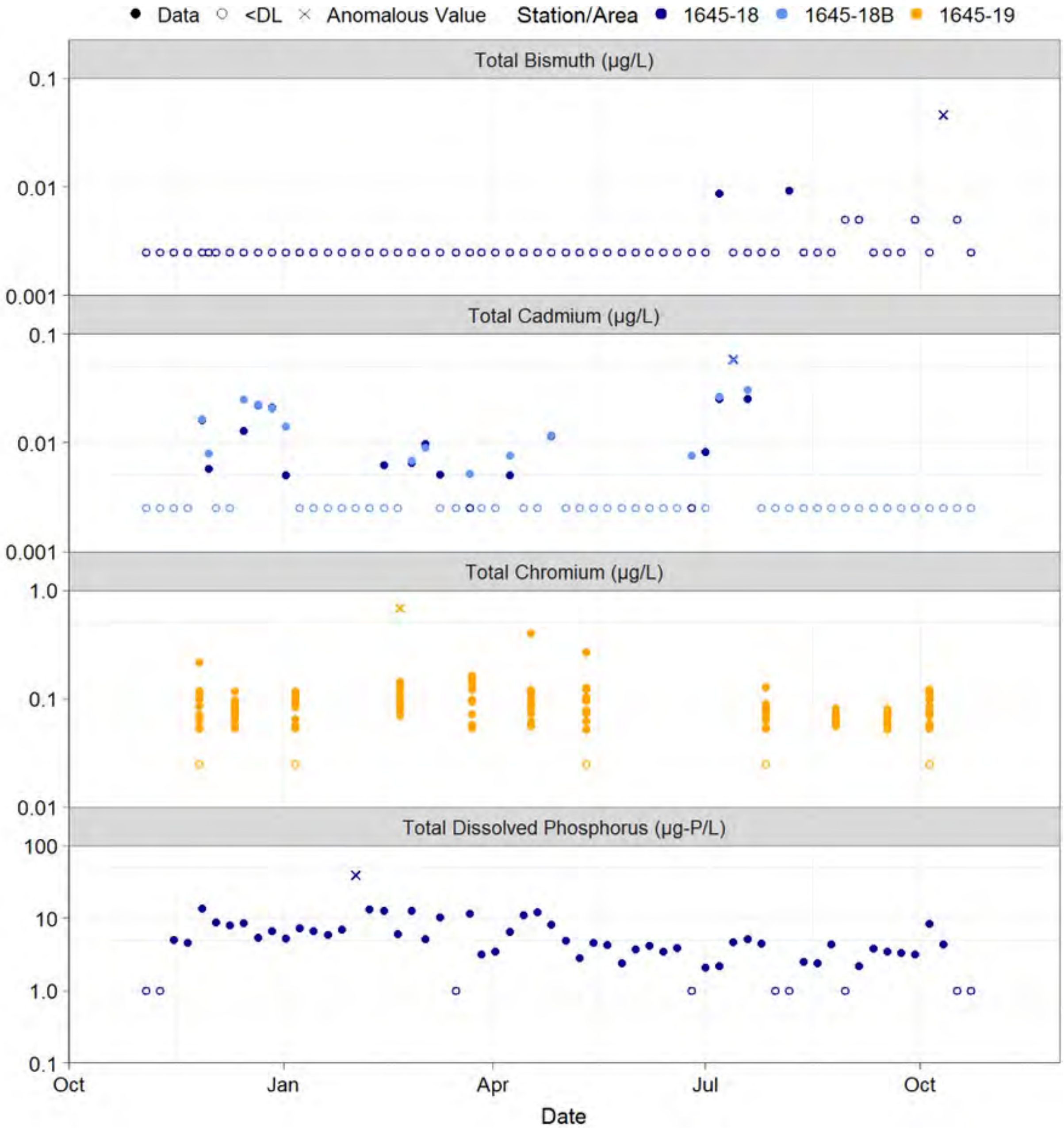
µg/L = micrograms per litre.

Figure C-1 Anomalous Data Removed from SNP Analyses Completed for Acidity (pH 8.3), Dissolved Lead, Dissolved Nickel, and Total Aluminum



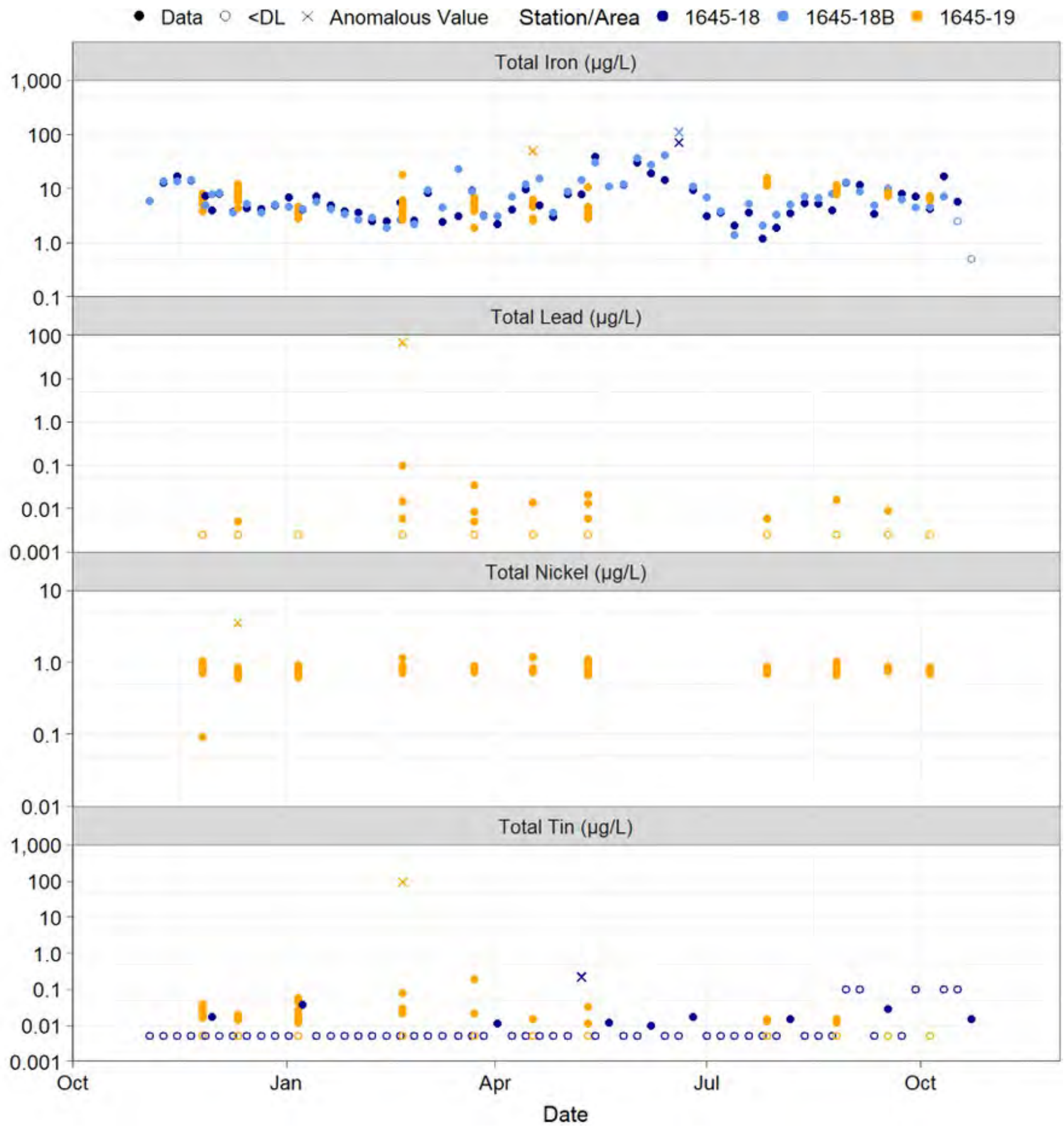
µg/L = micrograms per litre; DL= detection limit.

Figure C-2 Anomalous Data Removed from SNP Analyses Completed for Total Bismuth, Total Cadmium, Total Chromium, and Total Dissolved Phosphorus



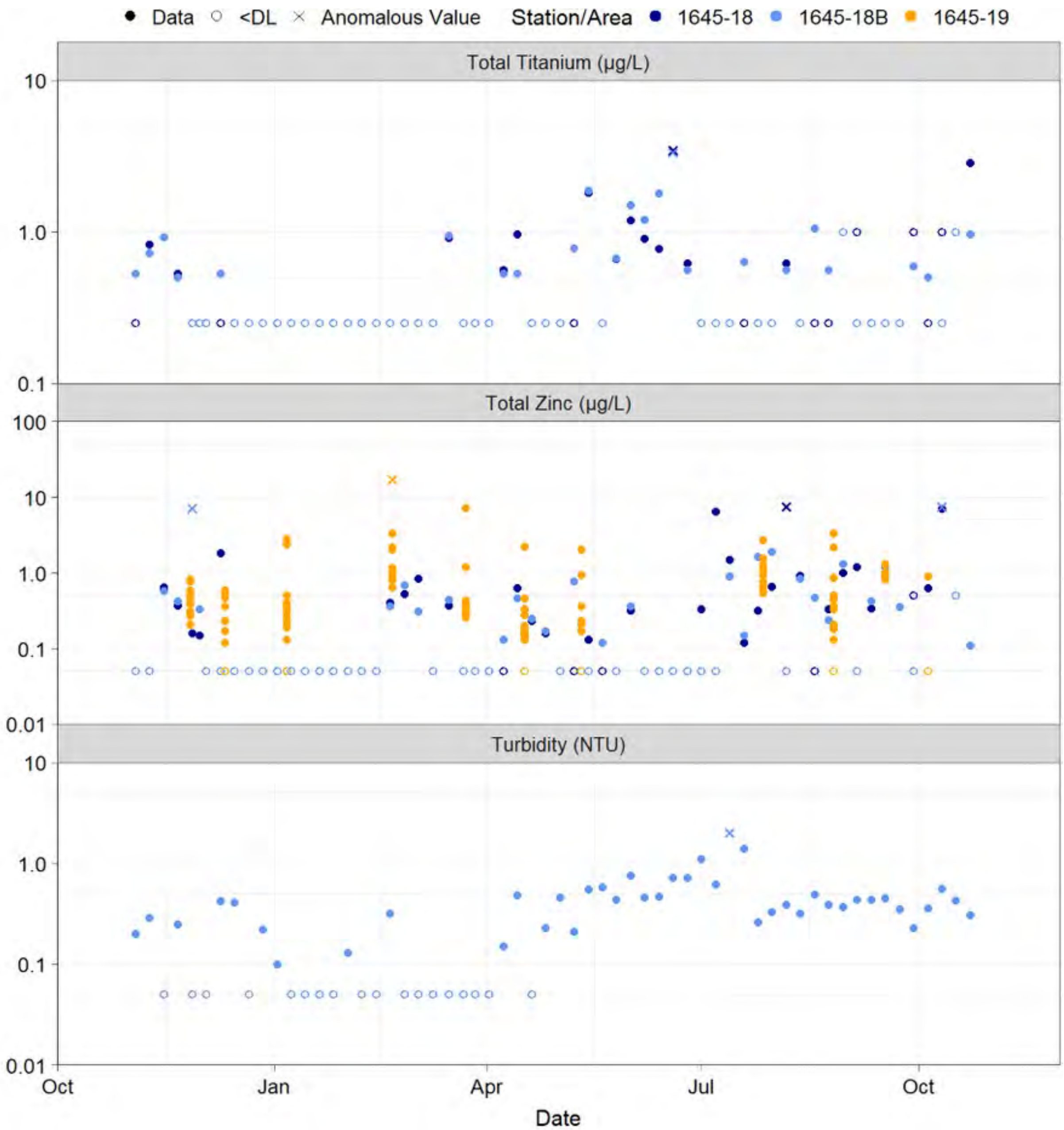
µg/L = micrograms per litre; µg-P/L = micrograms phosphorus per litre; DL= detection limit.

Figure C-3 Anomalous Data Removed from SNP Analyses Completed for Total Iron, Total Lead, Total Nickel, and Total Tin



µg/L = micrograms per litre; DL= detection limit.

Figure C-4 Anomalous Data Removed from SNP Analyses Completed for Total Titanium, Total Zinc, and Turbidity



NTU = nephelometric turbidity unit; µg/L = micrograms per litre; DL= detection limit.

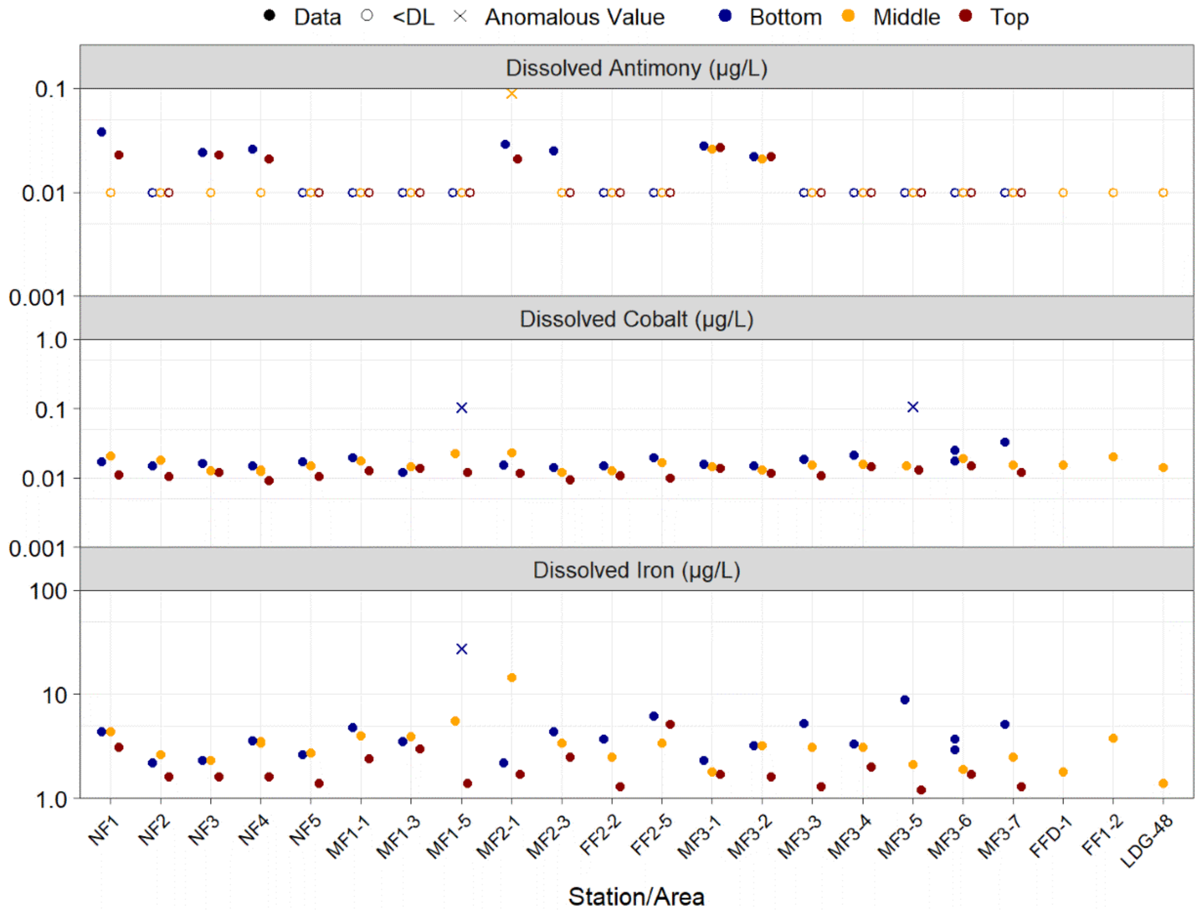
Table C-3 List of Anomalous Values Removed from AEMP Analyses

Variable	Station	Season	Value	Unit	Date	Standard Deviation Distance [(a)]
Dissolved Organic Carbon	MF3-3	IC	0.2	mg/L	07-May-2021	5.19
Turbidity	FF2-5	IC	1.9	NTU	19-Apr-2021	6.26
Dissolved Antimony	MF2-1	IC	0.09	µg/L	07-May-2021	6.33
Dissolved Cobalt	MF1-5	IC	0.103	µg/L	20-Apr-2021	5.17
Dissolved Cobalt	MF3-5	IC	0.106	µg/L	02-May-2021	5.35
Dissolved Iron	MF1-5	IC	27.4	µg/L	20-Apr-2021	6.45
Dissolved Manganese	MF1-5	IC	145	µg/L	20-Apr-2021	7.30
Total Antimony	MF2-1	IC	0.194	µg/L	07-May-2021	6.85
Total Cobalt	MF3-5	IC	0.121	µg/L	02-May-2021	4.98
Total Cobalt	MF1-5	IC	0.127	µg/L	20-Apr-2021	5.29
Total Dissolved Ammonia	MF3-6	IC	220	µg-N/L	02-May-2021	5.89
Total Dissolved Phosphorus	MF1-5	IC	10.1	µg-P/L	20-Apr-2021	6.79
Total Iron	MF1-5	IC	61.5	µg/L	20-Apr-2021	6.89
Total Manganese	MF1-5	IC	178	µg/L	20-Apr-2021	7.37
Total Organic Carbon	MF2-1	IC	0.2	mg/L	07-May-2021	5.16
Total Zinc	MF3-1	IC	5.34	µg/L	08-May-2021	4.63
Turbidity	MF1-1	OW	1.2	NTU	03-Sep-2021	6.02
Dissolved Magnesium	MF1-3	OW	1.42	mg/L	02-Sep-2021	4.76
Total Bismuth	FF2-2	OW	0.029	µg/L	13-Sep-2021	7.65
Total Iron	MF3-4	OW	16.1	µg/L	13-Sep-2021	5.09
Total Zinc	MF1-5	OW	9.54	µg/L	02-Sep-2021	6.61
Total Phosphorus	MF1-1	OW	10.4	µg-P/L	03-Sep-2021	5.30
Total Dissolved Phosphorus	FF1-2	OW	35.8	µg-P/L	11-Sep-2021	7.62

a) Number of standard deviations from the mean calculated for the 2021 monitoring period.

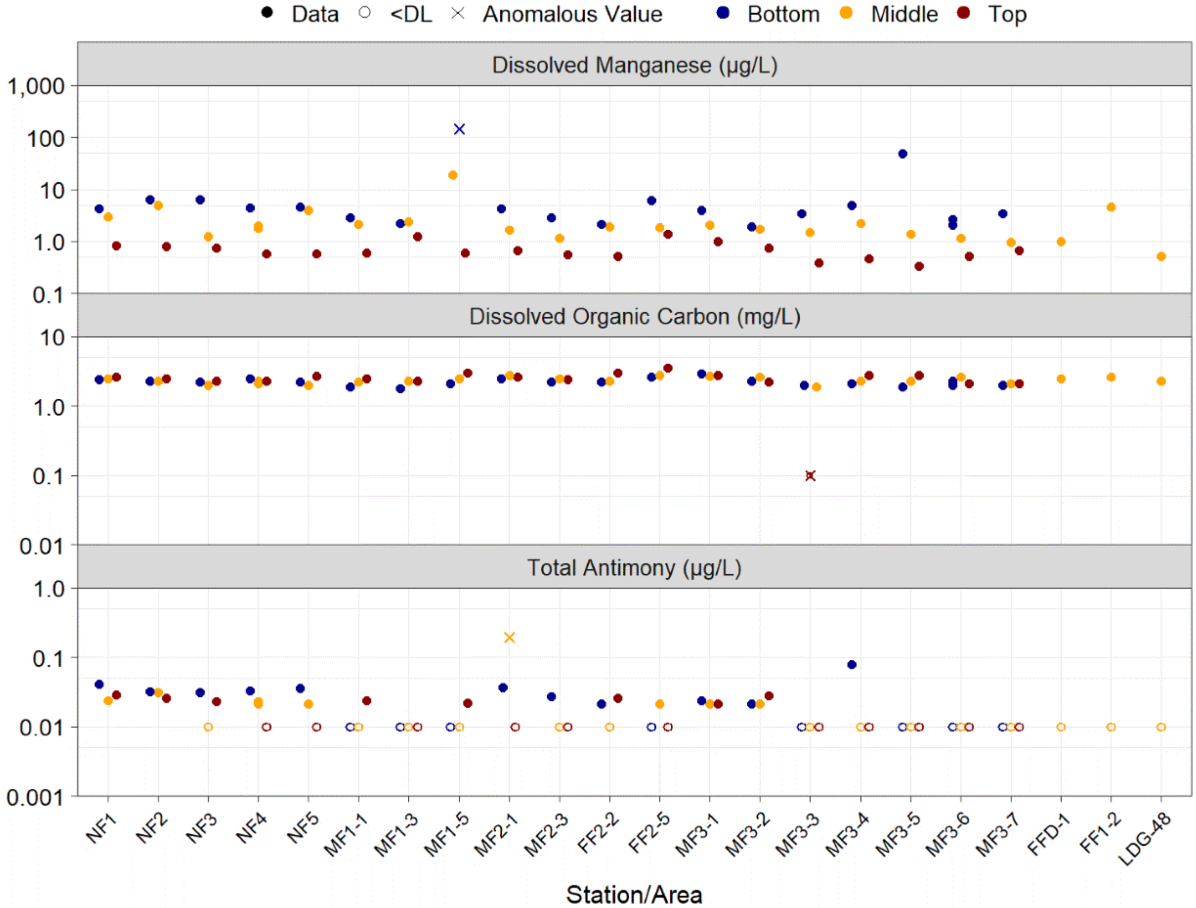
µg/L = micrograms per litre; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; IC = ice-cover; OW = open-water; T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac De Gras.

Figure C-5 Anomalous Data Removed from AEMP Analyses Completed for Dissolved Antimony, Dissolved Cobalt, and Dissolved Iron, Ice-Cover Season, 2021



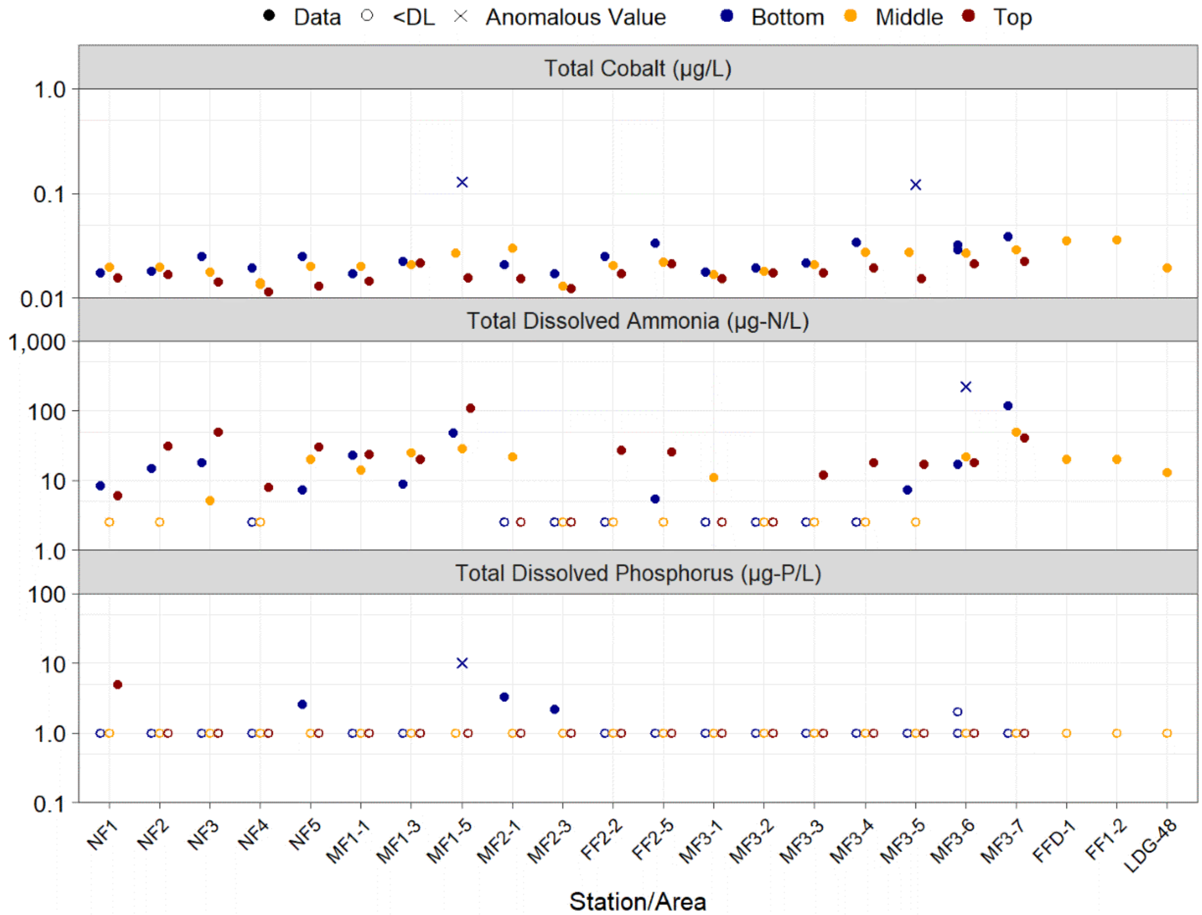
µg/L = micrograms per litre; DL= detection limit.

Figure C-6 Anomalous Data Removed from AEMP Analyses Completed for Dissolved Manganese, Dissolved Organic Carbon, and Total Antimony, Ice-Cover Season, 2021



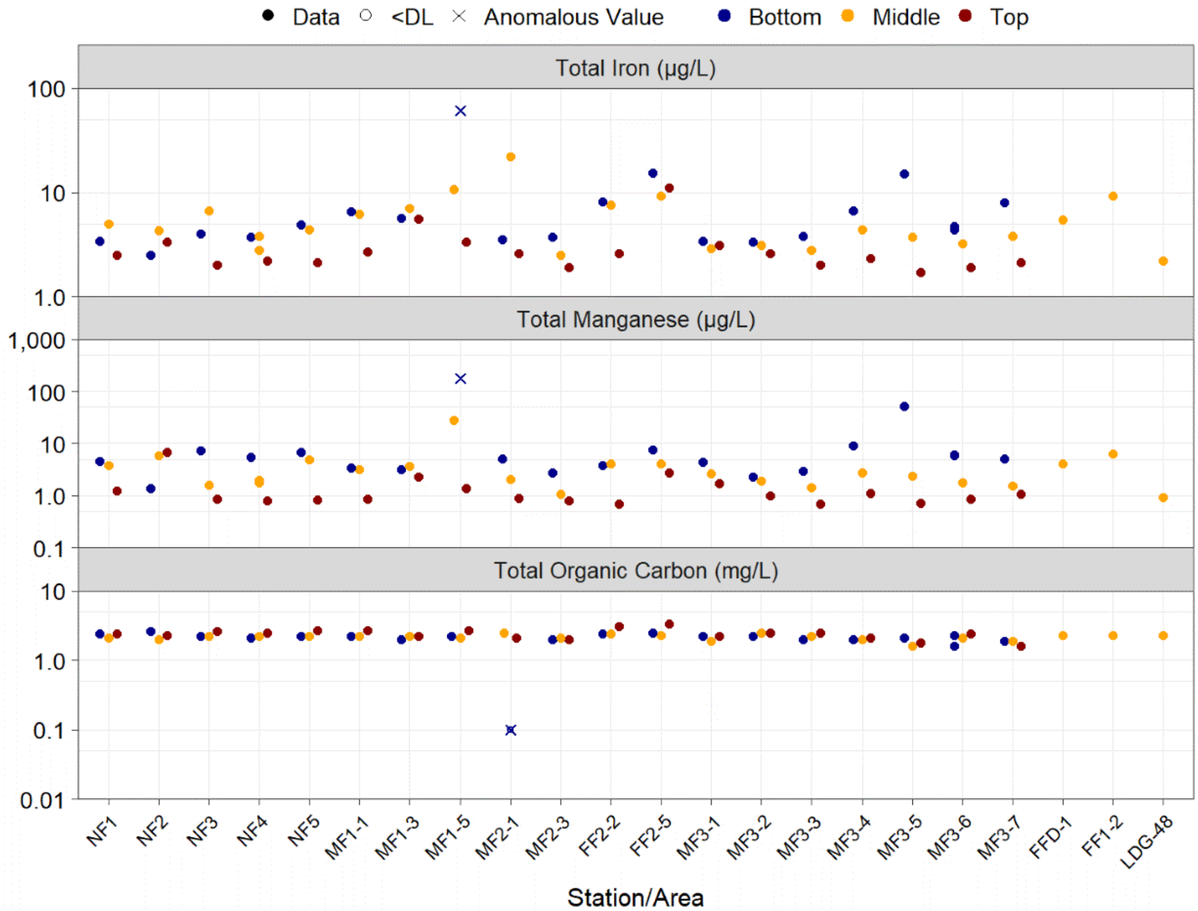
µg/L = micrograms per litre; DL= detection limit.

Figure C-7 Anomalous Data Removed from AEMP Analyses Completed for Total Cobalt, Total Dissolved Ammonia, and Total Dissolved Phosphorus, Ice-Cover Season, 2021



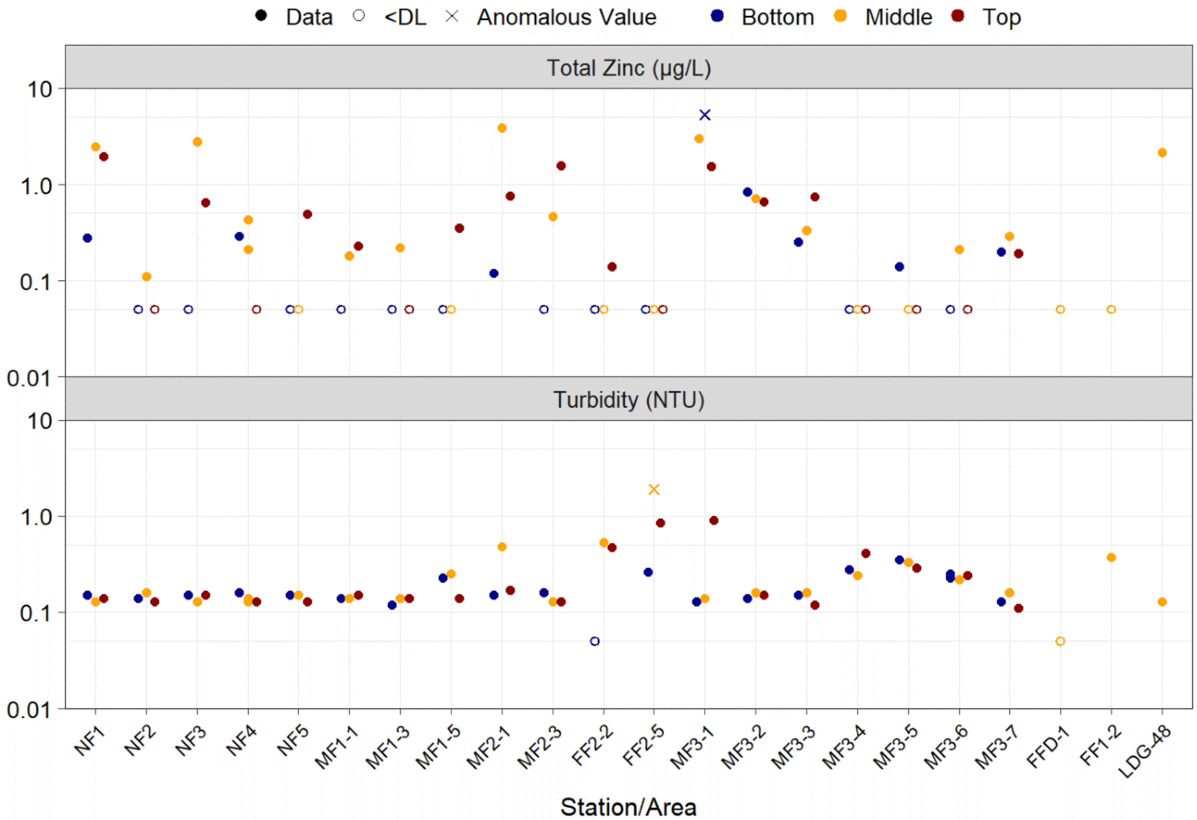
µg/L = micrograms per litre; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; DL= detection limit.

Figure C-8 Anomalous Data Removed from AEMP Analyses Completed for Total Iron, Total Manganese, and Total Organic Carbon, Ice-Cover Season, 2021



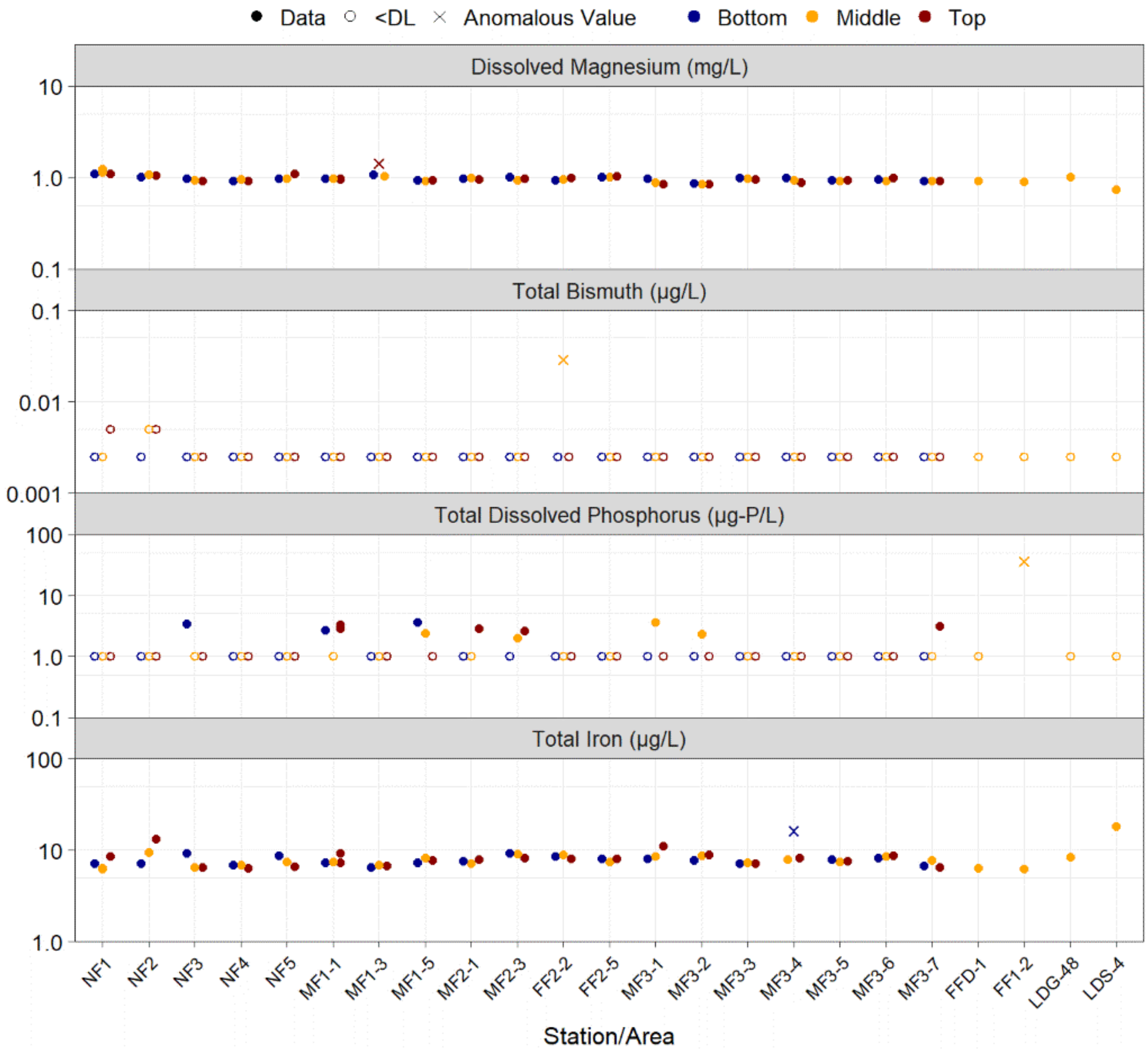
µg/L = micrograms per litre; DL= detection limit.

Figure C-9 Anomalous Data Removed from AEMP Analyses Completed for Total Zinc and Turbidity, Ice-Cover Season, 2021



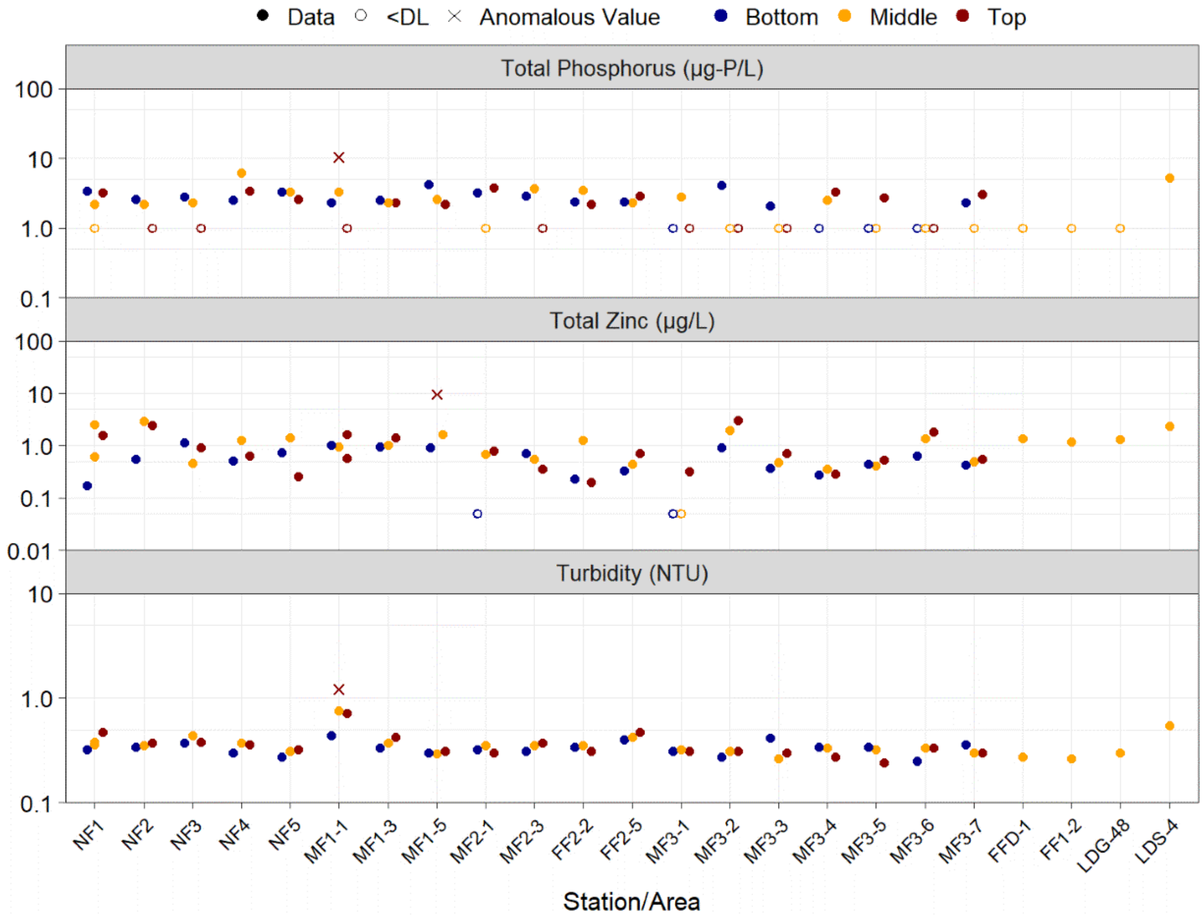
µg/L = micrograms per litre; DL= detection limit.

Figure C-10 Anomalous Data Removed from AEMP Analyses Completed for Dissolved Magnesium, Total Bismuth, Total Dissolved Phosphorus, and Total Iron, Open-Water Season, 2021



µg/L = micrograms per litre; DL= detection limit.

Figure C-11 Anomalous Data Removed from AEMP Analyses Completed for Total Phosphorus, Total Zinc, and Turbidity, Open-Water Season, 2021



µg/L = micrograms per litre; DL= detection limit.

References

Golder (Golder Associates Ltd.). 2017. Diavik Diamond Mine - Aquatic Effects Monitoring Program – Quality Assurance Project Plan (QAPP). Version 3.1. Prepared for Diavik Diamond Mines (2012) Inc., Yellowknife, NT. June 2017.

Golder. 2020. Aquatics Effect Monitoring Program Design Plan Version 5.2. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2020.

Mann PS. 2010. Introductory Statistics. 7th Edition. John Wiley and Sons, Inc. Hoboken, NJ.

ATTACHMENT D

2021 WATER QUALITY RAW DATA – AEMP AND SNP (SNP 1645-18/18B AND SNP 1645-19)

These data are provided electronically as an Excel file.

ATTACHMENT E

2021 TOXICITY TESTING RAW DATA

These data are provided electronically as an Excel file.

APPENDIX III

SEDIMENT QUALITY REPORT

No information was available for this appendix in 2021; this component is only collected during comprehensive years.

APPENDIX IV

BENTHIC INVERTEBRATE REPORT

No information was available for this appendix in 2021; this component is only collected during comprehensive years.

APPENDIX V

FISH REPORT

No information was available for this appendix in 2021; this component is only collected during comprehensive years.

APPENDIX VI

PLUME DELINEATION SURVEY

No information was available for this appendix in 2021 as no plume delineation survey was completed.

APPENDIX VII

DIKE MONITORING STUDY

No information was available for this appendix in 2021 as no dike monitoring study was completed.

APPENDIX VIII

FISH SALVAGE PROGRAM

No information was available for this appendix in 2021 as no fish salvage program was completed.

APPENDIX IX

FISH HABITAT COMPENSATION MONITORING

No information was available for this appendix in 2021 as no fish habitat compensation monitoring was completed.

APPENDIX X

FISH PALATABILITY, FISH HEALTH, AND FISH TISSUE CHEMISTRY SURVEY

No information was available for this appendix in 2021 as no Fisheries Authorization surveys were completed.

APPENDIX XI

PLANKTON REPORT

PLANKTON REPORT
IN SUPPORT OF THE 2021 AEMP ANNUAL REPORT
FOR THE DIAVIK DIAMOND MINE,
NORTHWEST TERRITORIES

Submitted to:

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X1A 2P8, Canada

DISTRIBUTION

1 Copy – Diavik Diamond Mines (2012) Inc., Yellowknife, NT
1 Copy – Golder Associates Ltd., Calgary, AB
1 Copy – Wek'èezhìı Land and Water Board

March 2022
21452119/12000

Doc No. RPT-2206 Ver. 0
PO No. 3104897490

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T: +1 780 483 3499 F: +1 780 483 1574

DDMI acknowledges that unsecured electronic media are susceptible to unauthorized modification, deterioration and incompatibility, and therefore DDMI cannot rely upon the unsecured electronic media versions of this report. In the event of any discrepancy, Golder's native, secured file shall govern.

Executive Summary

In 2021, Diavik Diamond Mines (2012) Inc. (DDMI) completed the field component of an Aquatic Effects Monitoring Program (AEMP) in Lac de Gras, Northwest Territories, as required by Water Licence W2015L2-0001 and according to the *AEMP Design Plan Version 5.2*, approved by the Wek'èezhìı Land and Water Board. This report presents the results of the 2021 plankton sampling program. The objectives of the plankton program were to monitor the potential ecological effects of the Mine on the phytoplankton and zooplankton communities, and assess the plankton community as an indicator of potential toxicological effects of the Mine water discharge and other Mine-related stressors.

Plankton samples were collected and analyzed from twenty-three stations in Lac de Gras during the open-water season in 2021. Overall, the plankton community data suggest that a Mine-related nutrient enrichment effect is occurring in Lac de Gras. The plankton community data do not indicate toxicological impairment. The 2021 phytoplankton results are consistent with a nutrient enrichment effect, showing an increase in total phytoplankton biomass in the near-field (NF) area. Phytoplankton biomass in the NF area was slightly, but not significantly, below the reference condition mean but was still well within the normal range, showing no indication of toxicological impairment in 2021. The zooplankton data suggest that changes are occurring in the NF area of Lac de Gras, potentially related to nutrient enrichment. Zooplankton biomass in the NF area was generally higher relative to other sampling areas, and was above the reference condition mean.

Action Levels for toxicological impairment were not triggered in 2021 and results are consistent with nutrient enrichment, as demonstrated by higher plankton biomass in the NF area compared to other areas, and compared to the reference condition means.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

Acronyms and Abbreviations

AEMP	Aquatic Effects Monitoring Program
AIC	Akaike's information criterion
AICc	Akaike's information criterion corrected for small sample size
Biologica	Biologica Environmental Services, Ltd.
DDMI	Diavik Diamond Mines (2012) Inc.
e.g.	for example
et al.	and more than one additional author
FF	far-field
Golder	Golder Associates Ltd.
i.e.	that is
LDG	Lac de Gras
LDS	Lac du Sauvage
MF	mid-field
Mine	Diavik Diamond Mine
n	sample size/count
NF	near-field
P	probability
QA/QC	quality assurance/quality control
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
r^2	coefficient of determination
R^2	coefficient of multiple determination
RPD	relative percent difference
Salki	Salki Consultants Inc.
SD	standard deviation
SOP	standard operating procedure
sp.	species
spp.	plural of species
WLWB	Wek'èezhìı Land and Water Board

Symbols and Units of Measure

±	plus or minus
%	percent
>	greater than
<	less than
×	times
µm	micrometre
cm	centimetre
cells/L	cells per litre
ind/L	individuals per litre
km	kilometre
m	metre
mg/m^3	milligrams per cubic metre
mL	millilitre

1 INTRODUCTION

1.1 Background

Diavik Diamond Mines (2012) Inc. (DDMI) has been monitoring plankton communities as indicators of change in Lac de Gras water quality since 2007 (Golder 2011, 2016, 2018, 2020a, 2021). In 2013, DDMI revised its Aquatic Effects Monitoring Program (AEMP) for the Diavik Diamond Mine (Mine). Among the revisions to the *AEMP Study Design Version 3.5* (Golder 2014) approved by the Wek'èezhìı Land and Water Board (WLWB) was the addition of plankton as a monitoring component. Plankton monitoring occurs once annually, during the open-water season (between 15 August and 15 September), which is consistent with other AEMP components (Golder 2020b).

In 2021, DDMI completed the field component of its AEMP, as required by Water Licence W2015L2-0001 (WLWB 2021). The assessment of the plankton data collected during the 2021 AEMP field program, which was carried out by DDMI according to the *AEMP Design Plan Version 5.2* (Golder 2020b), is presented herein.

1.2 Objectives

The objective of the plankton component of the AEMP is to monitor the potential ecological effects of the Mine on the phytoplankton and zooplankton communities in Lac de Gras, and to assess whether toxicological changes are occurring in the plankton community.

1.3 Scope and Approach

The plankton component of the AEMP is designed to monitor both spatial and temporal changes in phytoplankton and zooplankton biomass, richness, and community composition. As described in *AEMP Design Plan Version 5.2* (Golder 2020b), the objective of the annual report is to assess whether Mine-related toxicological changes are occurring in the plankton communities in the near-field (NF) and mid-field (MF) areas of Lac de Gras, and to evaluate whether any Action Levels have been triggered. Temporal analyses and an assessment of trends over time are completed at three-year intervals in re-evaluation reports; results of the most recent temporal trend assessment were provided in the *2017 to 2019 Aquatic Effects Re-evaluation Report Version 1.0* (Golder 2021a).

Effects on the plankton communities were evaluated using gradient analysis, and visual and statistical comparisons of plankton biomass, richness, and community composition in the NF and MF areas to the reference condition; the reference condition for each assessed variable was defined in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). Values that were beyond the reference condition were different from what would be considered part of natural variation in Lac de Gras. The importance of effects observed on plankton variables was evaluated according to the Action Level classification defined in the *AEMP Design Plan Version 5.2* (Golder 2020b).

2 METHODS

2.1 Field Sampling

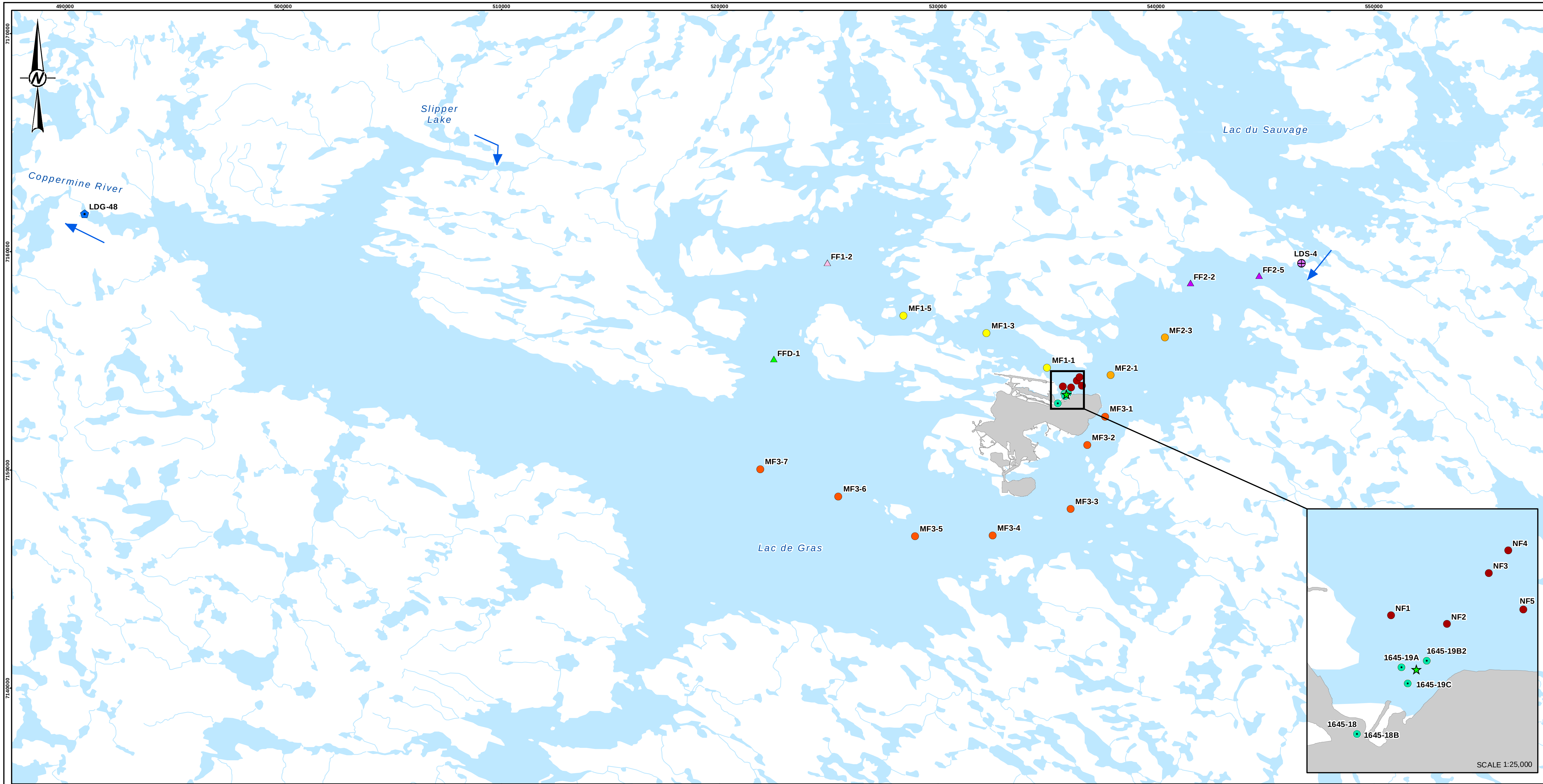
Plankton sampling was conducted by DDMI staff during the open-water season, from 15 August to 14 September 2021, in accordance with *AEMP Design Plan Version 5.2* (Golder 2020b) and the DDMI Standard Operating Procedure (SOP): ENVI-923-0119 "AEMP Combined Open Water and Ice Cover". Water column profile measurements of field parameters, and samples for water chemistry were collected concurrently as part of the Effluent and Water Chemistry Report (Appendix II). No deviations from the SOP occurred during sample collection.

Twenty-three stations located in eight general areas of Lac de Gras were sampled by DDMI during the 2021 AEMP (Table 2-1, Figure 2-1). Sampling areas were selected based on exposure to the Mine effluent (Golder 2020b), and consisted of the NF area, and three MF areas (i.e., MF1, MF2, and MF3). The MF1 transect runs northwest from the NF area, towards the FF1 area. The MF2 transect runs to the northeast, towards the Lac du Sauvage (LDS) inlet. The MF3 transect is located south of the NF area, and extends towards the FFB and FFA areas. In 2020, station FF1-2 was included in interim sampling years, instead of only being sampled in comprehensive years, and station FFD-1 was added to help delineate the extent of effects extending away from the NF area between the MF1 and MF3 transects (Golder 2020b).

Sampling locations, dates, and water depths are provided in Table 2-1. Five stations were sampled in the NF area, three stations were sampled in the MF1 area, four stations were sampled in the MF2 area, seven stations were sampled in the MF3 area, and two additional stations were sampled between the MF1 and MF3 areas (i.e., FF1-2 and FFD-1; Figure 2-1). In addition, single stations were sampled at the outlet of Lac du Sauvage (LDS-4) and the outlet of Lac de Gras (LDG-48) for phytoplankton samples only.

A depth-integrated sampler that collects water from the surface to a depth of 10 m was used to collect phytoplankton samples from the NF, MF1, MF2, MF3 areas and the FF1-2 and FFD-1 stations. Twelve depth-integrated samples were combined from each station and the resulting composite sample was used to fill a sample bottle for phytoplankton taxonomy. Shallow water depths at LDS-4 and LDG-48 resulted in a single water sample being collected from mid-depth using a Beta-bottle.

A 75 µm mesh Wisconsin plankton net with a 30 cm mouth diameter was used to collect duplicate zooplankton samples at each station. Each sample consisted of a composite of three vertical hauls from the entire water column, beginning at a depth of 1 m from the bottom. Zooplankton samples were not collected at the LDG-48 and LDS-4 stations because these stations are characterized by shallow, flowing water that is ecologically dissimilar to the open-water lake habitat represented by other AEMP stations.



LEGEND

DIFFUSERS	FLOW DIRECTION
SURVEILLANCE NETWORK PROGRAM	WATERCOURSE
STATION LOCATIONS	DIAVIK FOOTPRINT
FAR-FIELD 1	WATERBODY
FAR-FIELD 2	
FAR-FIELD D	
LAC DE GRAS OUTLET	
LAC DU SAUVAGE OUTLET	
MID-FIELD 1	
MID-FIELD 2	
MID-FIELD 3	
NEAR-FIELD	

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

TITLE
LOCATIONS OF AEMP PLANKTON SAMPLING STATIONS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	2-1

PATH: I:\CLIENTS\DIAVIK\21452119\Mapping\FigAEMP_2021\Fig2-1_21452119_AEMP_2021PlanktonStations_Rev0.mxd PRINTED ON: 2022-03-28 AT: 2:16:28 PM
25mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Table 2-1 Plankton Sampling Station Locations and Dates, 2021

Area	Station	Date	UTM Coordinates[(a)]		Distance from Diffuser[(b)] (m)	Water Depth (m)
			Easting (m)	Northing (m)		
NF	NF1	01-Sep-21	535740	7153854	394	22.3
	NF2	27-Aug-21	536095	7153784	501	20.6
	NF3	06-Sep-21	536369	7154092	936	18.6
	NF4	06-Sep-21	536512	7154240	1,131	21.1
	NF5	27-Aug-21	536600	7153864	968	20.6
MF1	MF1-1	03-Sep-21	535008	7154699	1,452	19.5
	MF1-3	02-Sep-21	532236	7156276	4,650	18.9
	MF1-5	02-Sep-21	528432	7157066	8,535	18.0
MF2	MF2-1	03-Sep-21	538033	7154371	2,363	18.0
	MF2-3	03-Sep-21	540365	7156045	5,386	20.3
	FF2-2	13-Sep-21	541588	7158561	8,276	19.1
	FF2-5	13-Sep-21	544724	7158879	11,444	20.0
MF3	MF3-1	06-Sep-21	537645	7152432	2,730	19.7
	MF3-2	06-Sep-21	536816	7151126	4,215	22.6
	MF3-3	13-Sep-21	536094	7148215	7,245	20.6
	MF3-4	13-Sep-21	536094	7148215	11,023	20
	MF3-5	10-Sep-21	536094	7148215	14,578	18.6
	MF3-6	10-Sep-21	536094	7148215	18,532	18.0
	MF3-7	14-Sep-21	536094	7148215	22,330	21.5
FF1	FF1-2	11-Sep-21	524932	7159476	12,915	19.0
FFD	FFD-1	14-Sep-21	522495	7155084	17,315	19.5
Outlet of Lac de Gras	LDG-48[(c)]	15-Aug-21	490900	7161750	55,556	2.2
Outlet of Lac du Sauvage	LDS-4[(c)]	15-Aug-21	546797	7159595	-	0.4

a) UTM coordinates are reported as Zone 12, North American Datum (NAD) 83.
b) Approximate distance from the Mine effluent diffusers along the most direct path of effluent flow.
c) Zooplankton samples were not collected at the LDG-48 and LDS-4 stations because these stations are characterized by shallow, flowing water that is ecologically dissimilar to the open-water lake habitat represented by other AEMP stations.
UTM = Universal Transverse Mercator coordinate system; NF = near-field; MF = mid-field; FF = far-field.

2.2 Sample Processing and Taxonomic Identification

2.2.1 Phytoplankton Community

A total of 23 composite phytoplankton samples from the NF, MF, and FF areas in Lac de Gras were submitted to Biologica Environmental Services, Ltd. (Biologica), Victoria, British Columbia, Canada, for analysis of taxonomic composition, abundance, and biomass. No duplicate samples were submitted to the taxonomist in 2021 per *Quality Assurance Project Plan Version 3.1* (Golder 2017b). Two laboratory Quality Control (QC; split) samples were analyzed by the taxonomist, representing approximately 10% of the total samples submitted.

Phytoplankton samples were homogenized by gently shaking sample containers for 60 seconds. Aliquots of 10 to 25 mL were removed, poured into settling chambers, and allowed to settle for a minimum of 24 hours. Quantitative counts were done on a Carl Zeiss Axio Vert.A1 inverted phase-contrast microscope at 400× magnification. Low power scans were performed to confirm a uniform settling of the sample on the bottom of the plate and to evaluate the occurrence of rare species (Utermöhl 1958). A minimum of 250 and a maximum of 300 cells or counting units were enumerated in each sample for statistical accuracy (Lund et al. 1958). Taxonomic identifications were based primarily on Cox (1996), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Hillebrand et al. (1999), Kelly (2000), Komárek (2000), Komárek and Anagnostidis (2000a,b), John et al. (2002), Taylor et al. (2007), Wehr et al. (2015), Guiry and Guiry (2017), and Spaulding and Edlund (2020). Phytoplankton taxa were identified to the genus level, with occasional species level identifications, and abundance was reported as cells per litre (cells/L).

Fresh weight biomass was calculated from recorded abundance and biovolume estimates based on geometric solids (Rott 1981). Biovolumes were estimated from the average dimensions of 10 to 15 individuals; the biovolumes of colonial taxa were based on the number of individuals within each colony. Assuming a specific gravity of one, the biovolume of each species was converted to biomass, reported as milligrams per cubic metre (mg/m^3).

2.2.2 Zooplankton Community

A total of 42 zooplankton samples, consisting of duplicates from the NF and MF areas and two FF stations, were submitted to Salki Consultants Inc. (Salki), Winnipeg, Manitoba, Canada, for analysis of taxonomic composition. Four laboratory QC (split) samples were analyzed by the taxonomist in 2021, representing approximately 10% of the total samples submitted. Samples were analyzed for abundance and biomass of crustaceans and rotifers according to the methods provided by Salki, as summarized below. Each sample underwent three levels of analysis, as follows:

- A 1/40 or 1/80 portion of each sample was examined under a compound microscope at 63× to 160× magnification. All specimens of crustaceans and rotifers were identified to the lowest taxonomic level (typically species) and assigned to size categories as indicated in the species list.
- A second sub-sample, representing 11% of the sample volume, was examined under a stereoscope at 12× magnification for large species (e.g., *Heterocope septentrionales*, *Holopedium gibberum*, *Daphnia middendorffiana*, and *Daphnia longiremis*) and rare species (e.g., *Eubosmina longispina*, *Diaptomus ashlandi*, *Epischura nevadensis, Chydorus sphaericus*, and *Cyclops capillatus*). These were enumerated and assigned to size classes.
- The entire sample was examined under the stereoscope to improve abundance estimates for the largest species (e.g., adult male and female *Heterocope septentrionales*, *Holopedium gibberum*, *Daphnia middendorffiana*, and *Daphnia longiremis*).

Cyclopoida and Calanoida specimens (mature and immature) were identified to species, with the exception of nauplii, which were classified as either Calanoida or Cyclopoida, as appropriate. Cladocera were identified to species. Rotifers were identified to genus. Zooplankton abundance was reported as individuals per litre (ind/L). Taxonomic identifications were based primarily on Brooks (1957), Wilson (1959) and Yeatman (1959).

Biomass estimates for each taxon were obtained using mean adult sizes determined during the analysis of the 2007 zooplankton samples (Golder 2008) and from length-weight regression equations developed by Malley et al. (1989). Additional measurements were made on all newly encountered species. Zooplankton biomass was reported in units of mg/m^3.

2.3 Quality Assurance/Quality Control

The *Quality Assurance Project Plan Version 3.1* (Golder 2017b) outlines the quality assurance/quality control (QA/QC) procedures employed to support the collection of scientifically defensible and relevant data to meet the objectives of the AEMP. The QAPP is designed so that field sampling, laboratory analysis, data entry, data analysis, and report preparation activities produce technically-sound and scientifically defensible results. A description of the QA/QC program is provided in Attachment A.

During review of the 2021 field samples, the zooplankton taxonomist noted two duplicate sample sets (NF4 and FF2-2) in which one of the samples was spoiled as a result of insufficient preservative (i.e., formalin) added to the vials in the field. Insufficient preservative can result in a loss of integrity of the sample and an underestimate of the abundances of soft-bodied crustaceans in the sample. Because only one of the duplicates for each of the samples was affected, the unaffected sample was used in the 2021 zooplankton data analysis.

Data screening of the 2021 phytoplankton and zooplankton community datasets did not identify anomalous values. The remaining duplicate zooplankton sample results were within the expected range of natural variability and the split phytoplankton and zooplankton sample results did not exceed the acceptance criteria. Therefore, the phytoplankton and zooplankton community datasets were deemed acceptable and used to complete the plankton community data analysis in 2021.

2.4 Data Analysis

2.4.1 Data Screening

Initial screening of the 2021 plankton data was completed prior to data analyses to identify anomalous values and decide whether to retain or exclude anomalous data from further analysis. The anomalous data screening approach for AEMP component datasets was approved as part of the *2011 to 2013 Aquatic Effects Re-evaluation Report Version 3.2* (Golder 2016). The 2021 plankton community dataset did not contain any anomalous data (Attachment A).

2.4.2 Plankton Community Analysis

The following methods were used to summarize the 2021 phytoplankton and zooplankton data:

- Abundance and biomass data were divided into the major ecological groups present in the 2016 samples. For phytoplankton, these groups were diatoms, microflagellates, cyanobacteria, dinoflagellates, and chlorophytes, and for zooplankton, they were cladocerans, calanoids, cyclopoids, and rotifers.
- For zooplankton, mean abundance and biomass were calculated for each set of duplicate pairs.

- For phytoplankton, richness was calculated at the genus level for all ecological groups, while for zooplankton, richness was calculated at the lowest taxonomic level: species for cladocerans, cyclopoids, and calanoids; and genus for rotifers.
- The relative abundance and biomass (expressed as a percentage) of each major group was calculated for each sampling area, and summary plots were created using the R statistical environment R v. 4.1.2 (R Core Team 2021).
- Descriptive statistics (i.e., sample size, minimum, maximum, median, mean, and standard deviation) were calculated for total biomass, the biomass of each major ecological group, and taxonomic richness.
- Box-plots showing the mean, median, and range in the 2021 data from the NF, and MF areas of Lac de Gras and Lac du Sauvage (phytoplankton only) for total biomass and the biomasses of the major ecological groups were prepared using the R statistical environment.

Since toxicological impairment is expected to result in declines in most plankton variables relative to the reference condition, one-tailed tests are usually performed to assess if the NF area mean biomass and richness are significantly lower than the reference condition mean. This test was not performed in 2021 for phytoplankton and zooplankton taxonomic richness and zooplankton biomass because they were above the reference condition mean. Phytoplankton biomass was slightly below the reference condition mean in 2021; therefore, a one-tailed test was performed to evaluate whether the difference was significant.

2.4.3 Normal Ranges

The magnitudes of effect on plankton communities were evaluated by comparing plankton variables (i.e., total biomass, richness, and the total biomass of each major ecological group) in the NF area to background values. Background values for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range. Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a) and are summarized in Table 2-2.

Table 2-2 Normal Ranges for Plankton

Variable	Unit	Normal Range	
		Lower Limit	Upper Limit
Phytoplankton			
Total phytoplankton taxonomic richness	number of taxa	19	36
Total phytoplankton biomass	mg/m^3	19	385
Total microflagellate biomass	mg/m^3	13	72
Total diatom biomass	mg/m^3	0	13
Total chlorophyte biomass	mg/m^3	0	309
Total cyanobacteria biomass	mg/m^3	0	48
Total dinoflagellate biomass	mg/m^3	0	40
Zooplankton			
Total zooplankton taxonomic richness	number of taxa	11	17
Total zooplankton biomass	mg/m^3	132	540
Total cladoceran biomass	mg/m^3	8	127

Table 2-2 Normal Ranges for Plankton

Variable	Unit	Normal Range	
		Lower Limit	Upper Limit
Total calanoid biomass	mg/m^3	61	359
Total cyclopoid biomass	mg/m^3	13	105
Total rotifer biomass	mg/m^3	2	7

Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

2.4.4 Statistical Analysis

2.4.4.1 Gradient Analysis

To visually evaluate spatial trends relative to the Mine discharge, total phytoplankton and zooplankton biomass and taxonomic richness at individual stations were plotted against distance from the effluent diffusers. These plots also showed the normal ranges for each variable. Values from Lac du Sauvage outflow (LDS-4) were included on the plots for comparison purposes only; the normal range does not apply to the Lac du Sauvage station.

Spatial gradients in phytoplankton and zooplankton community variables were also evaluated along each of the transects using regression analysis, as described in the *AEMP Design Plan Version 5.2* (Golder 2020b). The NF area data were included in the analysis for each of the three transects (i.e., MF1, MF2, MF3). All stations were included in the analysis, except LDS-4 and LDG-48, which represent the riverine inflow to and outflow from Lac de Gras, respectively. Regression analysis results were considered significant at $\alpha = 0.05$.

Due to the inherent variability in the phytoplankton and zooplankton community datasets, variables often had non-linear patterns with distance from the effluent exposure. Therefore, the analysis method allowed for piecewise regression (also referred to as segmented or broken stick regression). The following approaches were used:

- Model 1: a linear multiplicative model, with main effects of distance from the effluent exposure, gradient (MF1, MF2, MF3 transects), and their interactions
- Piecewise modelling to account for changes in spatial gradients, where individual transects were analyzed separately from one another:
  - Model 2: a linear multiplicative model with main effects of distance from the effluent exposure, gradient (MF1 and MF2 transect) and their interaction
  - Model 3: a linear piecewise (broken stick) model with distance (MF3 only)

For each variable, Model 1 was used to test for the presence of a significant ($P<0.05$) breakpoint using the Davies test (Davies 1987, 2002). If a significant breakpoint was identified, Models 2 and 3 were used. If no significant breakpoint was identified, Model 1 was used.

Following the initial fit of the model, the residuals (of either Model 1 or Model 2, as applicable) were used to examine whether data needed to be transformed to meet regression assumptions. Model 3 was not considered for transformations, because the addition of breakpoint was expected to resolve non-linear patterns. For each response variable, the data underwent Box-Cox transformations (Box and Cox 1964). The Box-Cox transformations are a family of transformations that include the commonly used log and square root transformations. The Box-Cox transformation process tests a series of power values, usually between -2 and +2, and records the log-likelihood of the relationship between the response and the predictor variables under each transformation. The transformation that maximizes the log-likelihood is the one that will best normalize the data. Therefore, the data are transformed using a power value (λ) identified by the transformation process. For a λ of zero, the data are natural log transformed. The transformation rules can be described using the following definitions:

$$\text{Transformed value} = \frac{\text{value}^{\lambda} - 1}{\lambda}\text{ , if } \lambda \neq 0$$

$$\text{Transformed value} = \ln(\text{value})\text{ , if } \lambda = 0$$

The selected transformation was applied to all data (i.e., if piecewise modelling was used, a transformation selected based on Model 2 was also applied to MF3 data used in Model 3).

Following data transformation (if required), the selected models were fitted to the data. Statistical outliers were identified using studentized residuals with absolute values of 3.5 or greater, or due to consideration of leverage (where a single point could strongly influence the overall fit of the model). All values removed from the analysis were retained for plots of model predictions, where they were presented using a different symbol from the rest of the data.

Following removal of outliers, breakpoint significance and data transformation were re-examined. Residuals from the refitted models were examined for normality and heteroscedasticity, and evidence of nonlinear patterns. If non-linearity was evident from residual examination, the analysis was terminated and data were presented qualitatively. If residual assessments did not suggest that assumption of linearity or residual normality were violated, then three models were constructed to assess the effect of heteroscedasticity for each response variable in each season:

- heteroscedasticity by gradient (applied only to Models 1 and 2)
- heteroscedasticity by predicted value (accounting for the classic trumpet shape of heteroscedastic data)
- heteroscedasticity by distance from the effluent exposure

These three models were compared to the original model that did not account for heteroscedasticity, using Akaike's information criterion (AIC), corrected for small sample size (AICc). The model with the lowest AICc score among a set of candidate models was interpreted to have the strongest support, given the set of examined models and the collected data (Burnham and Anderson 2002), and thus was selected for interpretation. When using AIC not corrected for small sample size, models with AIC scores within two units of each other are considered to have similar levels of support (Arnold 2010). Since the small sample size correction was used in the analysis, the cut-off value was adjusted to reflect the higher penalization of model parameters (i.e., the adjustment depended on the number of data points and model parameters).

The constructed models were used to produce the following outputs:

- estimates and significance of slopes (i.e., distance effects) for each gradient; in the case of MF3 data analyzed using piecewise regression, the significance of the first slope, extending from the NF to the breakpoint, was estimated
- the r^2 value of each model, to examine explained variability
- fitted prediction lines and 95% confidence intervals (back-transformed to the original scale of the variable)

Analyses were performed using the R statistical environment, “segmented” package (Muggeo 2008).

2.5 Action Level Evaluation

The importance of effects on phytoplankton and zooplankton was categorized according to the Action Levels in the Response Framework presented in the *AEMP Design Plan Version 5.2* (Golder 2020b). The main goal of the Response Framework is to ensure that significant adverse effects never occur. This is accomplished by requiring proponents to take actions at predefined Action Levels, which are triggered well before significant adverse effects could occur. A significant adverse effect, as it pertains to aquatic biota, was defined in the Environmental Assessment for the Mine as a change in fish population(s) that is greater than 20% (Government of Canada 1999). The effect must have a high probability of being permanent or long-term in nature and must occur throughout Lac de Gras. The Significance Thresholds for all aquatic biota, including plankton are, therefore, related to effects that could result in a change in fish population(s) that is greater than 20%.

The AEMP addresses two broad impact hypotheses for Lac de Gras: the toxicological impairment hypothesis and the nutrient enrichment hypothesis (Golder 2020b). Action Levels for the plankton component address the toxicological impairment hypothesis, while the nutrient enrichment hypothesis is addressed in the Eutrophication Indicators Report (Appendix XIII). Conditions required to trigger Action Levels 1 to 3 for plankton are defined in Table 2-3. Conditions for Action Level 4 would be defined if Action Level 3 was triggered.

Phytoplankton and zooplankton biomass and taxonomic richness are assessed annually, during both interim and comprehensive sampling years. This involves statistically comparing plankton biomass and richness in the NF area (and potentially MF areas) to the reference condition (Table 2-3). Since toxicological impairment is expected to result in declines in most plankton variables relative to the reference condition, Action Level 1 is triggered if the mean value in the NF area is significantly lower than the mean of the reference condition dataset. Action Level 2 is triggered when the effect observed in the NF area expands to the nearest MF stations (i.e., MF1-1, MF2-1, MF3-1), and Action Level 3 is triggered when NF area results are below the normal range.

Table 2-3 Action Levels for Plankton Effects

Action Level	Plankton	Extent	Action
1	Mean biomass or richness significantly less than reference condition mean[(a)]	NF	Confirm effect
2	Mean biomass or richness significantly less than reference condition mean[(a)]	Nearest MF station	Investigate cause
3	Mean biomass or richness less than normal range[(b)]	NF	Examine ecological significance Set Action Level 4 Identify mitigation options
4	TBD[(c)]	TBD[(b)]	Define conditions required for the Significance Threshold
5[(d)]	Decline in biomass or richness likely to cause a >20% change in fish population(s)	FFA	Significance Threshold

a) The reference condition dataset was obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

b) Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

c) To be determined if Action Level 3 is triggered.

d) Although the Significance Threshold is not an Action Level, it is shown as the highest Action Level to demonstrate escalation of effects towards the Significance Threshold.

> = greater than; NF = near-field; MF = mid-field; FF = far-field.

3 RESULTS

The 2021 raw phytoplankton abundance and biomass data, as well as a list of phytoplankton taxa collected in Lac de Gras in 2021, and summary statistics for total phytoplankton biomass and the biomass of the major ecological groups are provided in Attachment B.

The 2021 raw zooplankton abundance and biomass data, as well as a list of zooplankton taxa collected in Lac de Gras in 2021, and summary statistics for total zooplankton biomass and the biomass of the major ecological groups are provided in Attachment C.

3.1 Phytoplankton Community

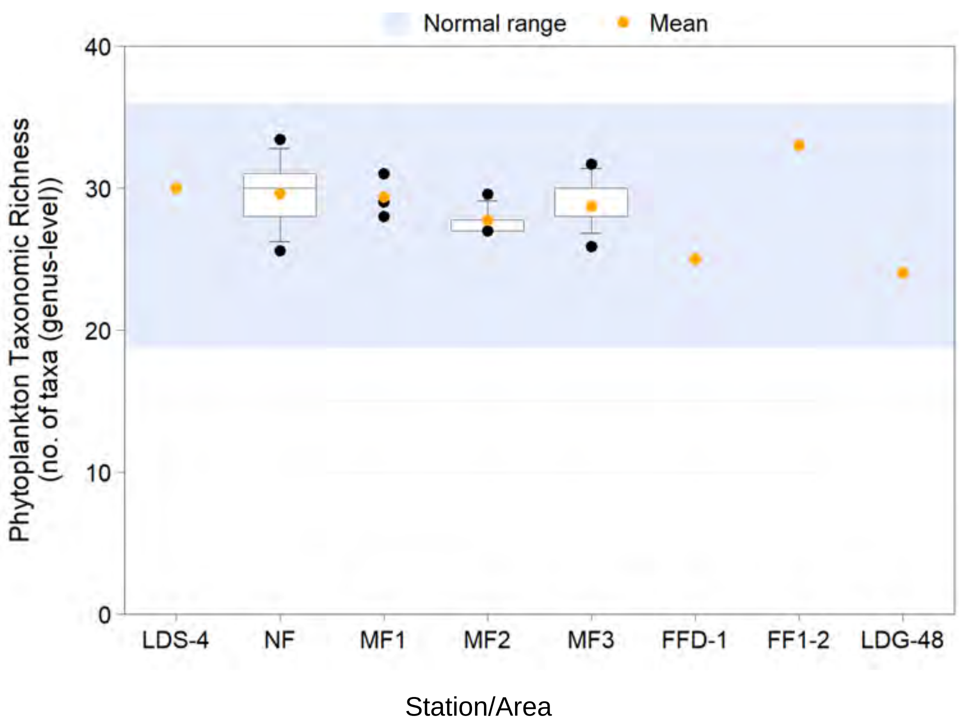
3.1.1 Phytoplankton Taxonomic Richness and Biomass

In total, 56 taxa were identified in the phytoplankton samples collected from Lac de Gras in 2021; 30 taxa were identified at LDS-4 and 24 taxa were identified at LDG-48 (Attachment C, Table C-4). Phytoplankton taxonomic richness was within the normal range in all areas of Lac de Gras in 2021 (Figure 3-1, Table 3-1). Mean taxonomic richness in the NF area was above the reference condition mean in 2021 (Table 3-1).

In 2021, mean phytoplankton biomass in all sampling areas was within or above the normal range (Table 3-1; Figure 3-2). Although mean biomass in the NF area was within the normal range (Figure 3-2), it was slightly below the reference condition mean (Table 3-1). Statistical testing indicated that this difference was not significant. Mean phytoplankton biomass was highest in the MF1 area, but had the greatest variability as well, followed by the LDG-48 station, MF2 and NF areas. Phytoplankton biomass at LDS-4 was similar to that observed at the NF area, while biomass values observed at FFD-1 and FF1-2 were below the means observed in the NF and MF areas.

Different responses were observed in the major ecological groups between the NF area and MF areas in 2021, and between the NF area and reference conditions (Table 3-2; Figure 3-2). Mean microflagellate and diatom biomass values in all areas of Lac de Gras and LDG-48 were either within or above the normal range in 2021. Mean microflagellate biomass followed a similar pattern to that observed in total phytoplankton biomass. Mean diatom biomass was higher at LDS-4 and in the NF area compared to other areas. Mean chlorophyte and dinoflagellate biomass values in all areas of Lac Gras and at LDS-4 were within the normal range, except mean dinoflagellate biomass at LDG-48, which was above the normal range. Mean dinoflagellate biomass in the MF1 and MF3 areas was similar to LDS-4 and higher than those in the NF and MF2 areas. Mean chlorophyte biomass was similar among stations, except at LDG-48, which had higher biomass. Cyanobacteria biomass was above or within the normal range and was similar among the NF and MF areas in 2021.

Figure 3-1 Phytoplankton Taxonomic Richness by Sampling Area in Lac de Gras and Lac du Sauvage, 2021



Note: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the box plots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage; LDG = Lac de Gras.

Table 3-1 Phytoplankton Biomass and Taxonomic Richness in the NF Area of Lac de Gras in 2021 Compared to the Normal Range and Reference Condition Mean, 2021

Variable	Unit	2021 NF		Normal Range[(a)]				Comparison to Reference Condition Mean[(b)]		
								Statistical Test	NF vs. 2013 Mean[(c)]	
		n	Mean ± SD	n	Lower Limit	2013 Mean	Upper Limit		*P*	Magnitude (%)[(d)]
Total phytoplankton taxonomic richness[(e)]	no. of taxa	5	30 ± 3	15	19	27	36	nt		
Total phytoplankton biomass	mg/m³	5	182 ± 35	15	19	186	385	ANOVA[ln]	ns	-2
Microflagellate biomass	mg/m³	5	**105** ± 34	15	13	55	72	na		
Diatom biomass	mg/m³	5	**51** ± 17	15	0	5	13	na		
Chlorophyte biomass	mg/m³	5	18 ± 6	15	0	94	309	na		
Cyanobacteria biomass	mg/m³	5	5 ± 2	15	0	27	48	na		
Dinoflagellate biomass	mg/m³	5	2 ± 1	15	0	10	40	na		

a) Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a); however, the mean is based on the 2013 data.
b) One-tailed comparison to assess toxicological impairment (i.e., lower mean) in the NF area compared to the reference condition mean.
c) Reference area mean based on the 2013 data (Golder 2020a).
d) Percent difference between sampling area means (i.e., NF mean compared to reference condition mean).
e) Taxonomic richness is the number of taxa at the genus level.

Note: **Bolded** NF area means are outside the normal range. Phytoplankton biomass not tested because the 2021 NF mean is greater than or equal to the reference condition mean.

n = number of samples; ± = plus or minus; SD = standard deviation; NF = near-field. ANOVA = analysis of variance (transformation is indicated by superscript); *P* = probability; ns = not significant; na = not applicable, because these variables are not used in the Action Level assessment; nt = not tested.

Table 3-2 Summary Statistics for Phytoplankton Biomass and Taxonomic Richness in the NF and MF Areas of Lac de Gras, 2021

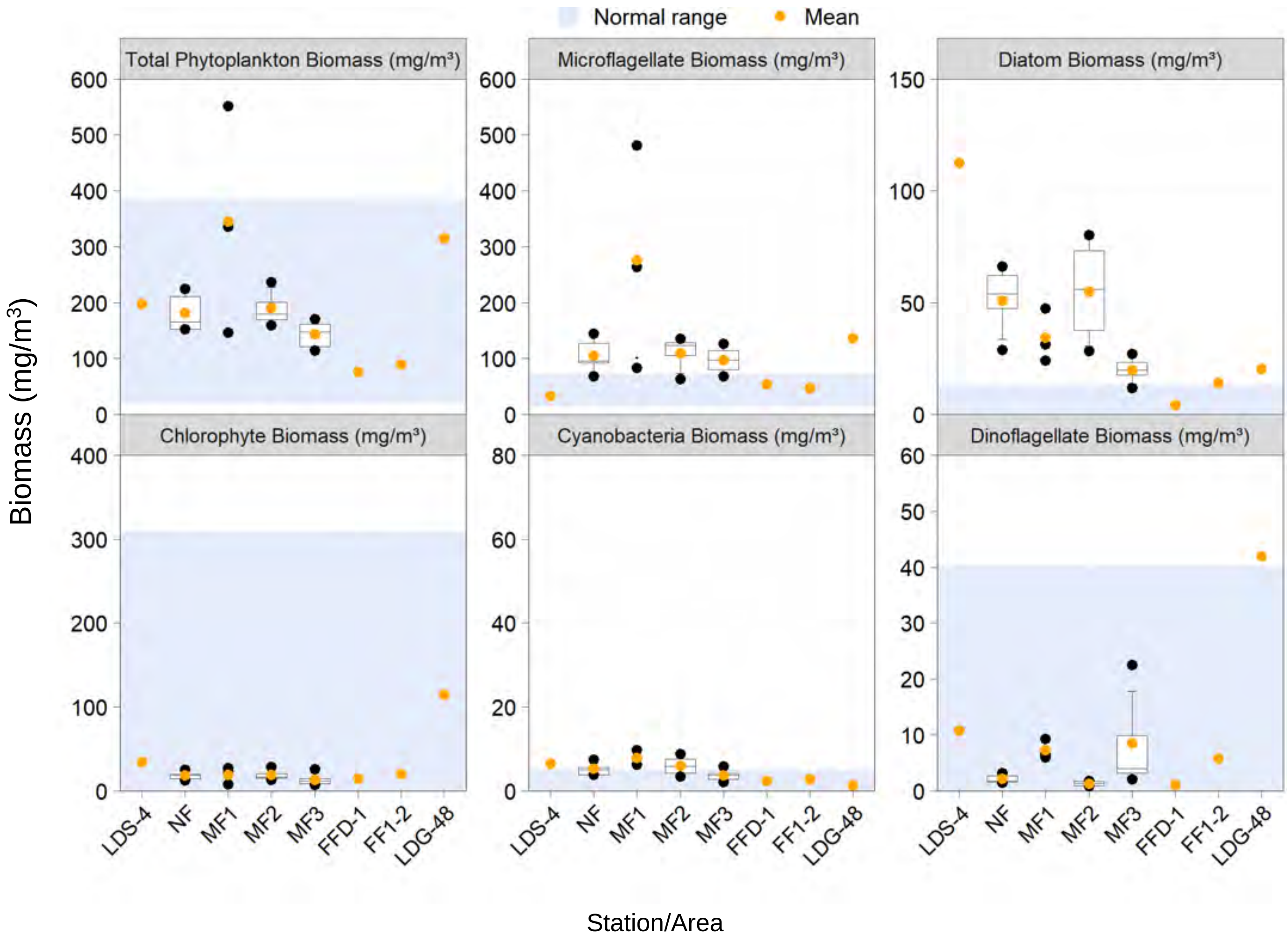
Area		Total Phytoplankton Biomass	Total Phytoplankton Taxonomic Richness[(a)]	Microflagellate Biomass	Diatom Biomass	Cyanobacteria Biomass	Dinoflagellate Biomass	Chlorophyte Biomass
		mg/m^3	No. of taxa	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3
NF	Count	5	5	5	5	5	5	5
	Minimum	152	25	62	24	4	1	12
	Maximum	228	34	149	67	8	3	27
	Median	165	30	95	54	5	2	19
	Mean	182	30	105	51	5	2	18
	Standard Deviation	35	3	34	17	2	1	6
MF1	Count	3	3	3	3	3	3	3
	Minimum	146	28	83	24	6	6	8
	Maximum	551	31	481	47	10	9	27
	Median	336	29	264	31	8	7	22
	Mean	345	29	276	34	8	7	19
	Standard Deviation	202	2	199	12	2	2	10
MF2	Count	4	4	4	4	4	4	4
	Minimum	158	27	52	26	3	1	13
	Maximum	246	30	138	82	9	2	30
	Median	179	27	124	56	6	1	17
	Mean	191	28	109	55	6	1	19
	Standard Deviation	39	2	39	26	3	0	8
MF3	Count	7	7	7	7	7	7	7
	Minimum	113	25	65	10	2	2	6
	Maximum	173	32	131	28	7	27	30
	Median	148	28	98	20	4	4	12
	Mean	143	29	98	20	4	8	13
	Standard Deviation	24	2	24	6	1	9	8

Note: Summary statistics were not calculated for FF1-2, FFD-1, LDG-48 and LDS-4 because only a single station/sample was collected in each area.

a) Taxonomic richness is the number of taxa at the genus level.

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field.

Figure 3-2 Phytoplankton Biomass of Major Ecological Groups by Sampling Area in Lac de Gras and Lac du Sauvage, 2021



Note: boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage; LDG = Lac de Gras.

3.1.2 Gradient Analysis

Gradient analysis of phytoplankton richness, biomass, and the biomass of the major ecological groups indicate that richness significantly decreased along the MF1 and MF3 transects (Table 3-3). Although total richness results were not significant along the MF2 transect according to the linear models applied, visual evaluation indicates that richness also declined with distance from the diffusers (Figure 3-3). Total biomass decreased significantly with increasing distance away from the effluent diffusers along the MF1 transect, but not the MF-2 or MF3 transects (Table 3-3; Figure 3-4). Significant trends were not observed along the MF transects for microflagellate biomass. Diatom biomass significantly decreased with increasing distance from the effluent exposure along the MF1 and MF3 transects (Table 3-3; Figure 3-5). Chlorophyte biomass significantly decreased along the MF3 transect, and cyanobacteria biomass significantly decreased along the MF1 and MF3 transects. Dinoflagellate biomass significantly decreased along the MF2 transect, but increased significantly along the MF3 transect, to a maximum value at approximately 15 km from the diffuser, followed by a significant decreasing trend.

Table 3-3 Gradient Analysis for Phytoplankton Community Variables in Lac de Gras, 2021

Variable	Model	Transformation[(a)]	Gradient	Slope Direction[(b)]	Breakpoint (km)[(c)]	*P*-value	r^2 or R^{2}[(d)]
Total phytoplankton taxonomic richness[(e)]	Model 1	log	MF1	↓	-	**0.003**	0.36
			MF2	↓	-	0.185	
			MF3	↓	-	**0.013**	
Total phytoplankton biomass	Model 1	log	MF1	↓	-	**0.021**	0.14
			MF2	↑	-	0.812	
			MF3	↓	-	0.529	
Microflagellate biomass	Model 1	log	MF1	↓	-	0.113	-0.03
			MF2	↓	-	0.844	
			MF3	↑	-	0.337	
Diatom biomass	Model 1	log	MF1	↓	-	**<0.001**	0.64
			MF2	↑	-	0.58	
			MF3	↓	-	**0.001**	
Chlorophyte[(f)] biomass	Model 2	log	MF1	↓	-	0.907	-0.18
			MF2	↑	-	0.646	
	Model 3		MF3 (1st slope)	↓	5.19	**0.01**	0.59
			MF3 (2nd slope)	↑		-	
Cyanobacteria[(g)] biomass	Model 1	log	MF1	↓	-	**<0.001**	0.76
			MF2	↓	-	0.359	
			MF3	↓	-	**<0.001**	
Dinoflagellate biomass	Model 2	log	MF1	↓	-	0.992	0.48
			MF2	↓	-	**0.011**	
	Model 3		MF3 (1st slope)	↑	14.58	**0.002**	0.69
			MF3 (2nd slope)	↓		-	

Notes: **Bold** indicates *P*-value significant at <0.05

a) Models used and transformation rules are described in Section 2.4.4.

b) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent exposure, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent exposure.

c) The breakpoint is the location from the effluent exposure where the slopes of the linear regressions along the MF3 transect changed values.

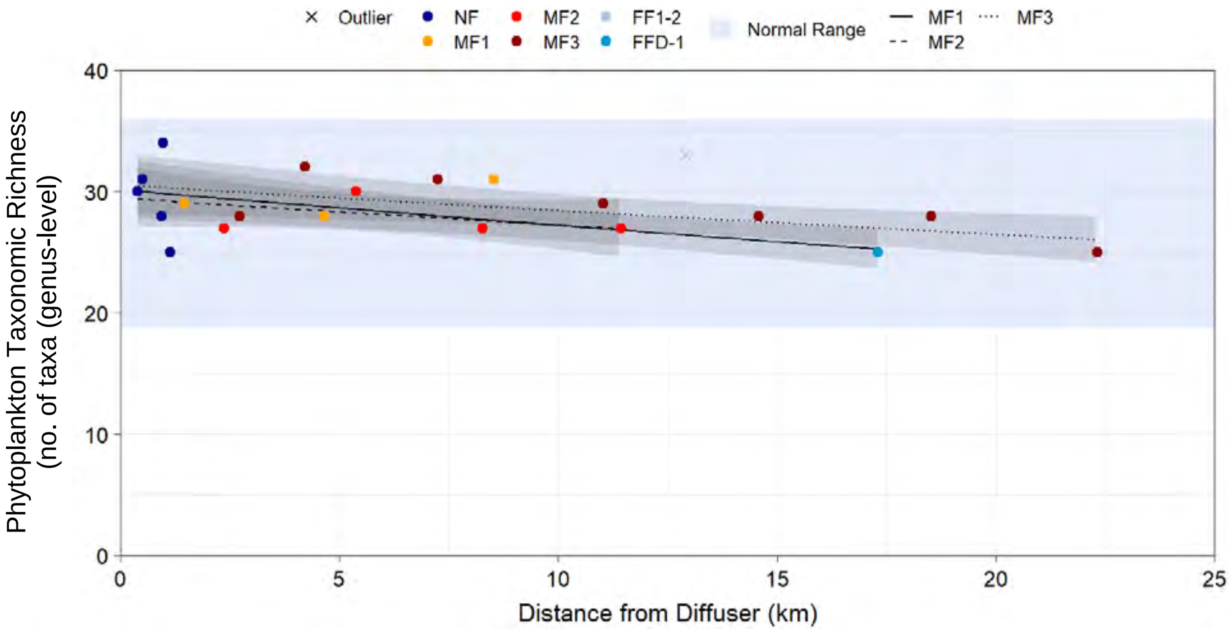
d) For the MF3 broken stick model, r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is used because there is more than one predictor, i.e., distance and gradient.

e) Outlier removed: 33 taxa/sample.

f) Outlier removed: 30 mg/m^3.

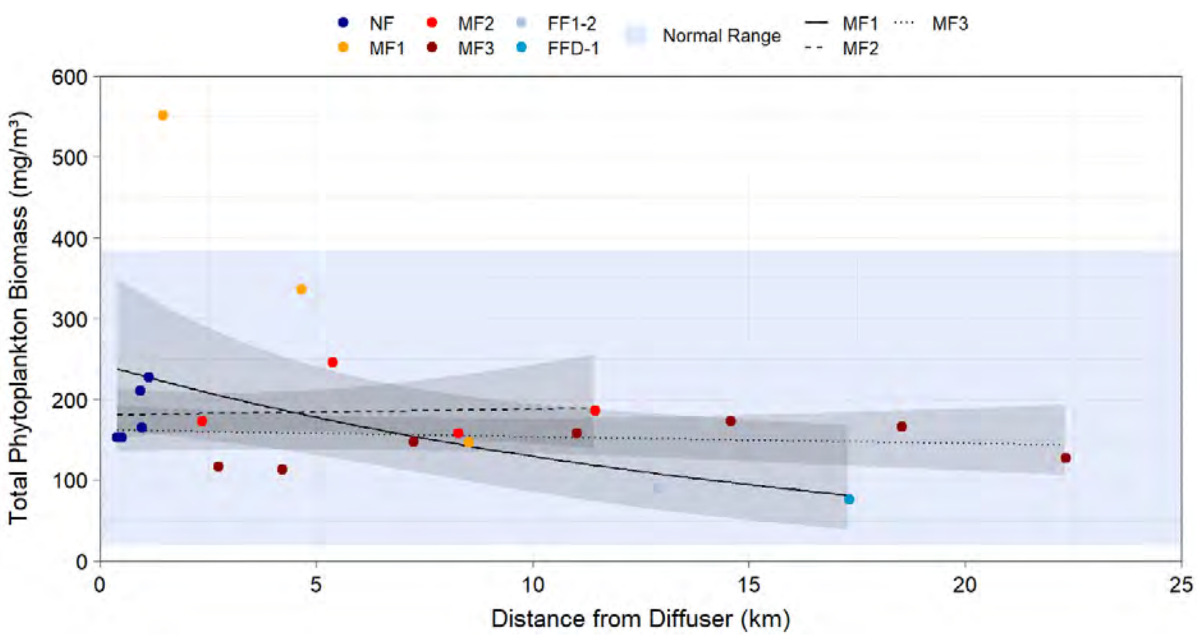
g) Outlier removed: 3.9 mg/m^3.

Figure 3-3 Phytoplankton Taxonomic Richness in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2021



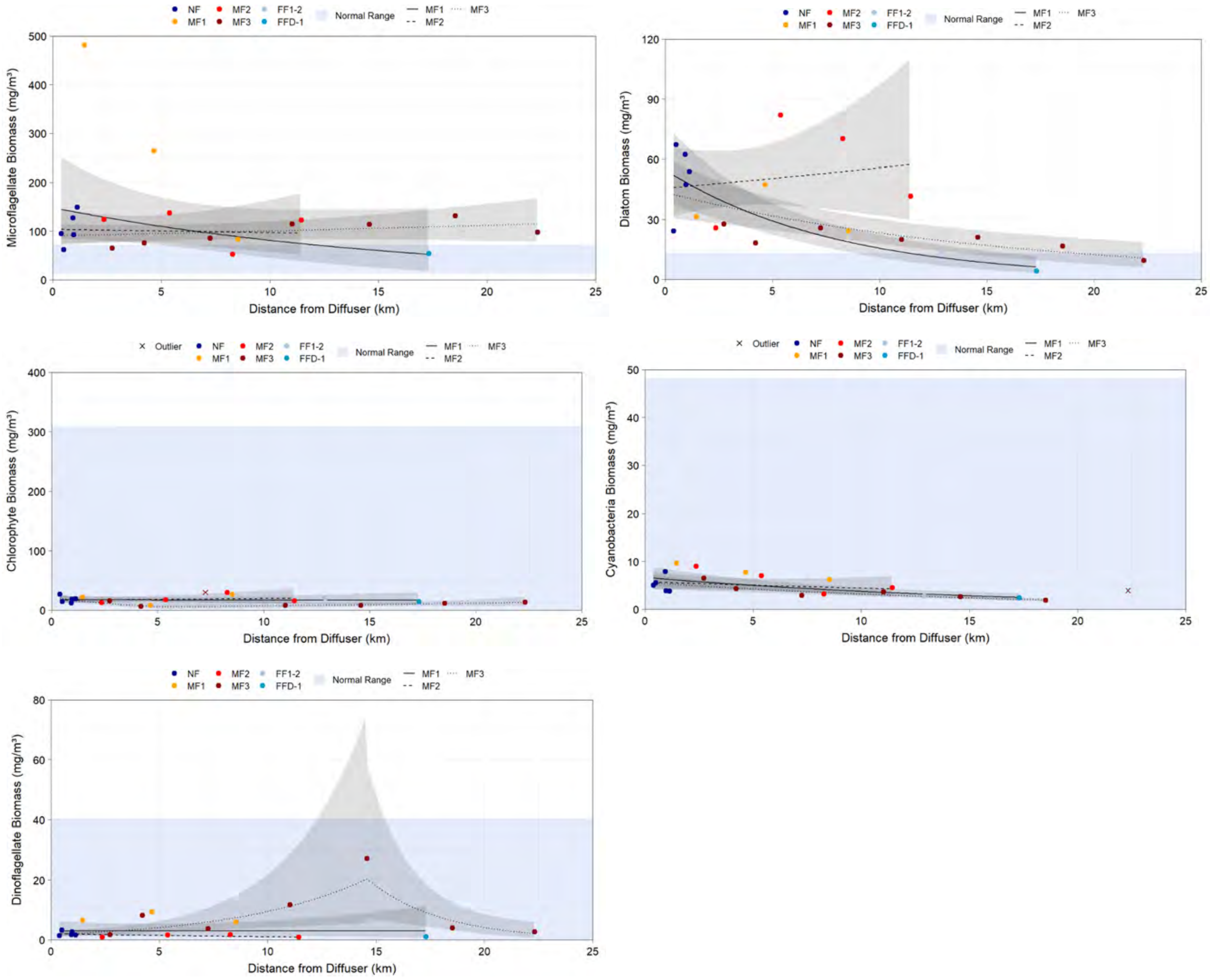
Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras.

Figure 3-4 Phytoplankton Biomass in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2021



Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras..

Figure 3-5 Biomass of Major Phytoplankton Groups in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2021



Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).
NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras.

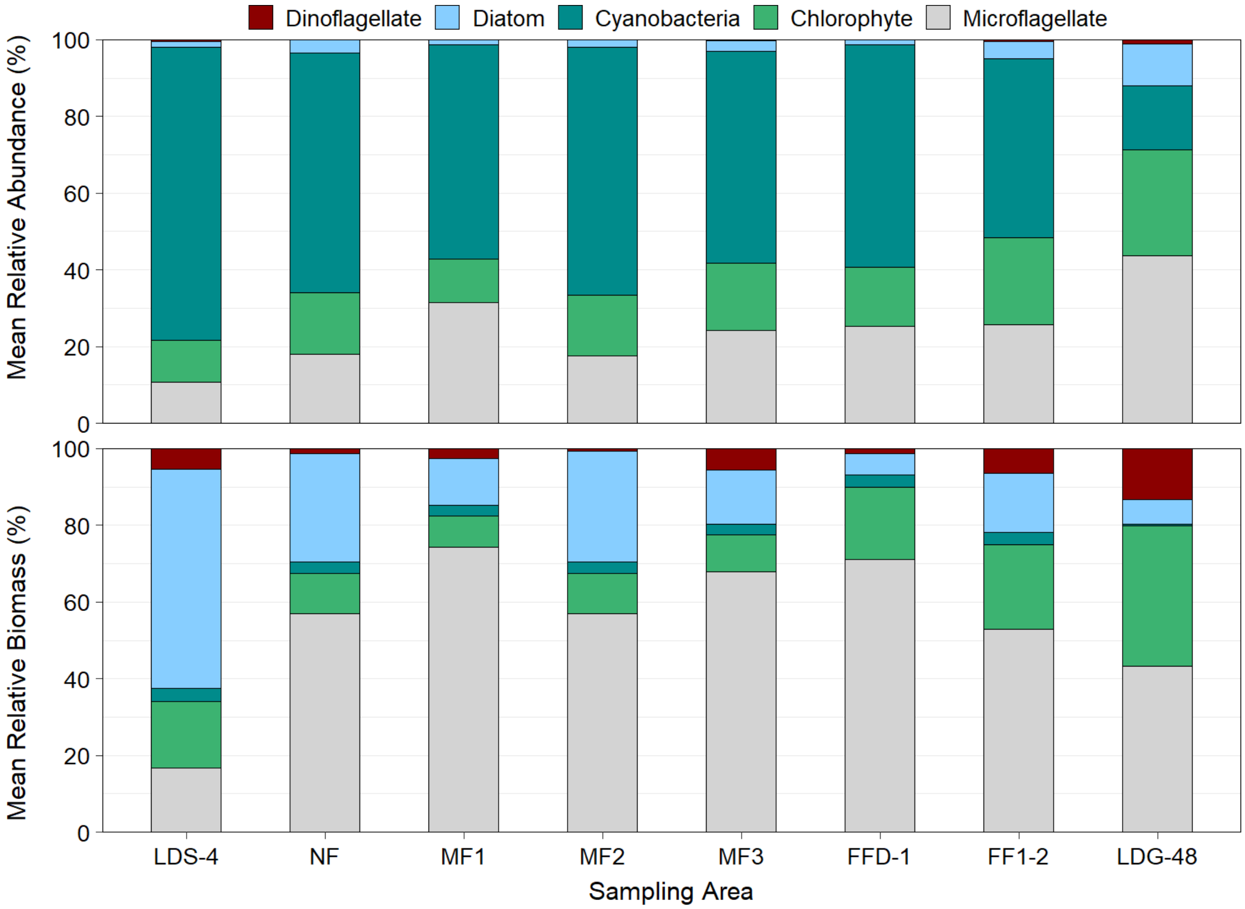
3.1.3 Phytoplankton Community Composition

Phytoplankton community composition in the NF area of Lac de Gras did not substantially differ from the MF areas, in terms of relative abundance or biomass in 2021 (Figure 3-6). The phytoplankton communities in most areas of Lac de Gras and Lac du Sauvage were dominated by cyanobacteria, based on abundance, with microflagellate and chlorophyte sub-dominance, with the exception of LDG-48. Station LDG-48 was dominated by microflagellates, based on abundance, followed by chlorophytes and cyanobacteria. The phytoplankton communities in Lac de Gras were dominated by microflagellates and diatoms, by biomass, while diatoms dominated the community at LDS-4. The

The abundance and biomass results for dominant groups suggest a general east-west gradient in community composition (Figure 3-6). For abundance, mean relative abundance of cyanobacteria was greater in the NF area and at LDS-4, followed by the MF areas and FFD-1 compared to FF1-2 and LDG-48. For biomass, mean relative biomass of microflagellates was greater in the NF and MF areas and at FFD-1 compared to stations FF1-2 and LDG-48. A higher proportion of chlorophyte, microflagellate, diatom, and dinoflagellate abundance was observed at the LDG-48 station, while a higher proportion of diatom biomass was observed at LDS-4 compared to other stations in 2021. The apparent gradual change in community composition from LDS-4, which primarily reflects the phytoplankton community of Lac du Sauvage, to the west through the MF2, NF and other MF areas to LDG-48, implies a potentially large influence of the inflow from Lac du Sauvage on the Lac de Gras phytoplankton community.

Despite accounting for a relatively large proportion of the total phytoplankton abundance, cyanobacteria accounted for a small proportion of the total biomass (i.e., approximately 3% in the NF area and MF areas), reflective of the small size of their cells. In contrast, diatoms and dinoflagellates accounted for a relatively small proportion of the phytoplankton community in terms of abundance (i.e., 2% on average in the NF area and MF areas), but contributed a relatively large proportion of total phytoplankton biomass (i.e., 15% on average in the NF area and 11% on average in the MF areas) because of the comparatively large size of their cells.

Figure 3-6 Mean Relative Phytoplankton Abundance and Biomass in Lac de Gras and Lac du Sauvage, 2021



NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage; LDG = Lac de Gras.

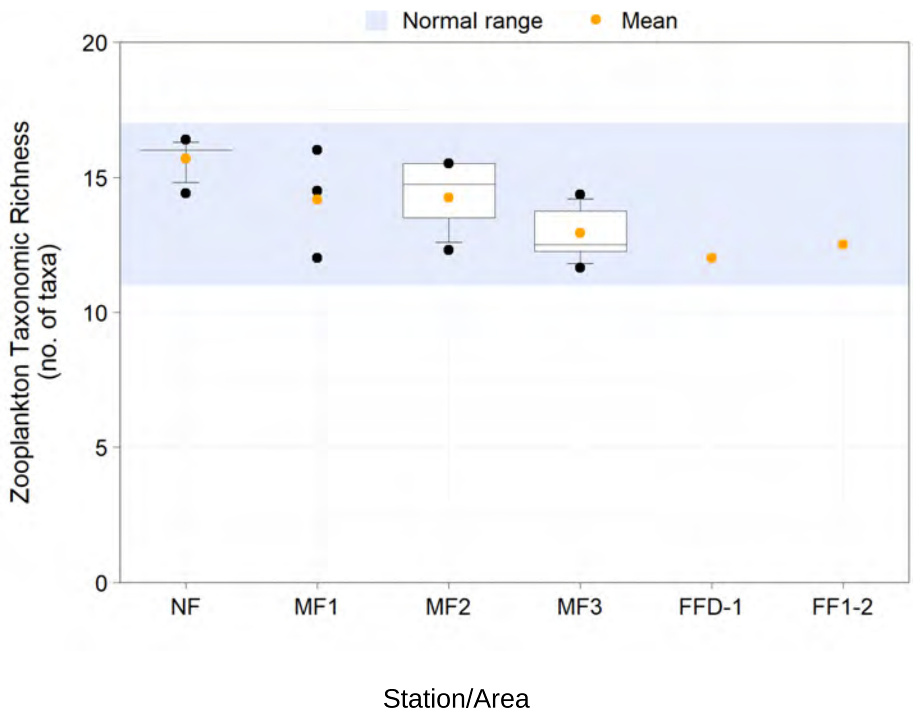
3.2 Zooplankton Community

3.2.1 Zooplankton Taxonomic Richness and Biomass

In total, 20 zooplankton taxa were identified in the zooplankton samples collected in 2021 (Attachment D, Table D-4). Mean zooplankton taxonomic richness in all areas of Lac de Gras was within the normal range and was greater in the NF area compared to the MF areas in 2021 (Figure 3-7; Table 3-4). Mean zooplankton taxonomic richness in the NF area was above the reference condition mean in 2021 (Table 3-4).

In 2021, mean total zooplankton biomass, and the biomass of cladocerans and calanoid and cyclopoid copepods were above the normal range in the NF area, and total biomass and the biomass of cladocerans and calanoid copepods were greater than in other areas (Figure 3-8). Mean biomass of rotifers was within the normal range in the NF area but mean biomass of cyclopoid copepods and rotifers were above the normal range in the MF1 area and greater than in other areas. Mean zooplankton biomass in the NF area was above the reference condition mean in 2021, showing no indication of toxicological impairment (Table 3-4). Mean zooplankton biomass and biomass of calanoid copepods and cladocerans were just above or within the normal range in the MF areas and at stations FFD-1 and FF1-2.

Figure 3-7 Zooplankton Taxonomic Richness by Sampling Area in Lac de Gras, 2021



Note: boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field.

Table 3-4 Zooplankton Biomass and Taxonomic Richness in the NF Area of Lac de Gras in 2021 Compared to the Normal Range

Variable	Unit	2021 NF		Normal Range(a)			
		n	Mean ± SD	n	Lower Limit	2008-2010 Reference Area Mean	Upper Limit
Total zooplankton taxonomic richness	no. of taxa	5	16 ± 1	103	11	14	17
Total zooplankton biomass	mg/m^3	5	**1,426** ± 1003	103	132	288	540
Cladocera biomass	mg/m^3	5	**426** ± 490	100	8	50	127
Calanoida biomass	mg/m^3	5	**877** ± 742	98	61	165	359
Cyclopoida biomass	mg/m^3	5	**116** ± 56	101	13	55	105
Rotifera biomass	mg/m^3	5	6 ± 2	96	2	4	7

a) Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

Note: **Bolded** NF area means are outside the normal range.

n = number of samples; SD = standard deviation; ± = plus or minus; NF = near-field.

Table 3-5 Summary Statistics for Zooplankton Biomass and Taxonomic Richness in the NF and MF Areas of Lac de Gras, 2021

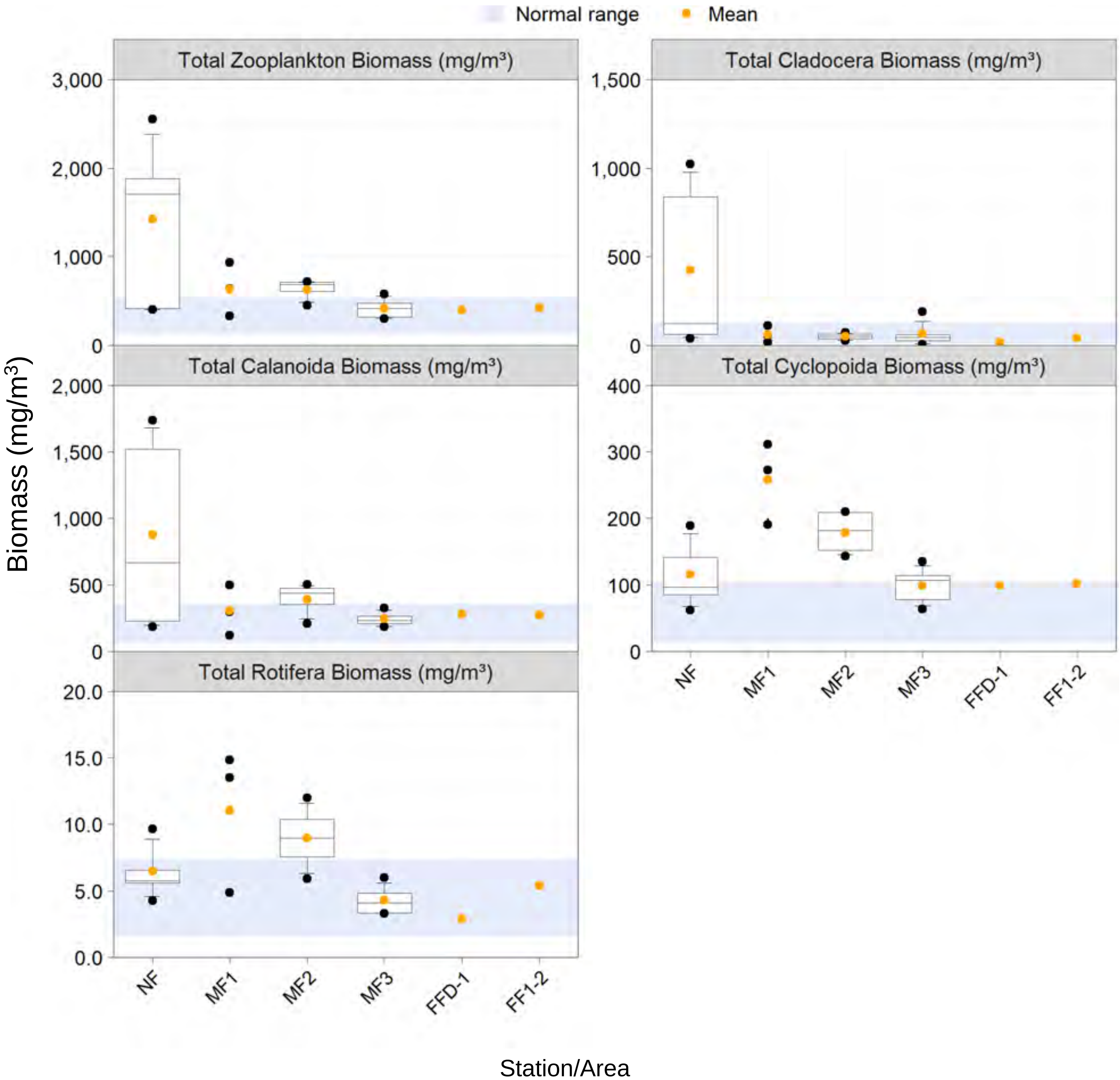
Area		Total zooplankton biomass	Total zooplankton taxonomic richness[(a)]	Cladocera biomass	Cyclopoida biomass	Calanoida biomass	Rotifera biomass
		mg/m³	No. of taxa	mg/m³	mg/m³	mg/m³	mg/m³
NF	Count	5	5	5	5	5	5
	Minimum	400	14	35.09	56	176	4
	Maximum	2,718	17	1,071	200	1,789	10
	Median	1,708	16	124	96	668	6
	Mean	1,426	16	426	116	877	6
	Standard Deviation	1,003	1	490	56	742	2
MF1	Count	3	3	3	3	3	3
	Minimum	333	12	18	191	120	5
	Maximum	938	16	111	311	501	15
	Median	637	15	54	273	297	14
	Mean	636	15	61	258	306	11
	Standard Deviation	302	2	47	62	191	5
MF2	Count	4	4	4	4	4	4
	Minimum	413	12	24	141	173	5
	Maximum	720	16	74	210	511	12
	Median	691	15	52	182	439	9
	Mean	629	14	51	179	390	9
	Standard Deviation	145	2	22	36	150	3
MF3	Count	7	7	7	7	7	7
	Minimum	291	12	5	58	182	3
	Maximum	597	15	247	141	342	6
	Median	416	13	45	107	235	4
	Mean	414	13	67	99	244	4
	Standard Deviation	115	1	82	29	55	1

Note: Summary statistics were not calculated for FF1-2, FFD-1, LDG-48 and LDS-4 because only a single station/sample was collected in each area.

a) Taxonomic richness is the number of species or genera.

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; LDG = Lac de Gras.

Figure 3-8 Zooplankton Biomass of Major Ecological Groups by Sampling Area in Lac de Gras and Lac du Sauvage, 2021



Note: boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field.

3.2.2 Gradient Analysis

Gradient analysis results for zooplankton richness, total biomass and biomass of major ecological groups indicated that these variables have generally decreased with increasing distance away from the effluent diffusers (Table 3-6; Figures 3-9, 3-10 and 3-11). Along the MF1 transect, zooplankton richness and biomass, rotifer biomass and cyclopoid copepod biomass significantly decreased, with increasing distance from the diffusers (Table 3-6). Along the MF2 transect, only taxonomic richness decreased significantly with increasing distance from the diffusers. Along the MF3 transect, taxonomic richness, biomass and rotifer biomass decreased significantly with increasing distance from the diffusers.

Table 3-6 Trend Analysis for Zooplankton Community Variables in Lac de Gras, 2021

Variable	Model	Transformation[a]	Gradient	Slope Direction [b]	Breakpoint (km)[c]	*P*-value	r^2 or R^2[d]
Total zooplankton taxonomic richness[e]	Model 2	log	MF1	↓	-	**<0.001**	0.72
			MF2	↓	-	**0.001**	
	Model 3		MF3 (1st slope)	↓	10.18	**<0.001**	0.90
			MF3 (2nd slope)	↑		-	
Total zooplankton biomass	Model 1	log	MF1	↓	-	**0.037**	0.32
			MF2	↓	-	0.275	
			MF3	↓	-	**0.021**	
Cladoceran biomass	Model 1	log	MF1	↓	-	0.060	0.05
			MF2	↓	-	0.482	
			MF3	↓	-	0.985	
Cyclopoid biomass	Model 1	log	MF1	↓	-	**0.020**	0.47
			MF2	↑	-	0.062	
			MF3	↓	-	0.235	
Calanoid biomass	Model 1	log	MF1	↓	-	0.462	0.12
			MF2	↓	-	0.285	
			MF3	↓	-	0.070	
Rotifer biomass	Model 1	log	MF1	↓	-	**0.001**	0.47
			MF2	↑	-	0.740	
			MF3	↓	-	**0.008**	

Notes: **Bold** indicates *P*-value significant at <0.05

a) Models used and transformation rules are described in Section 2.4.4.

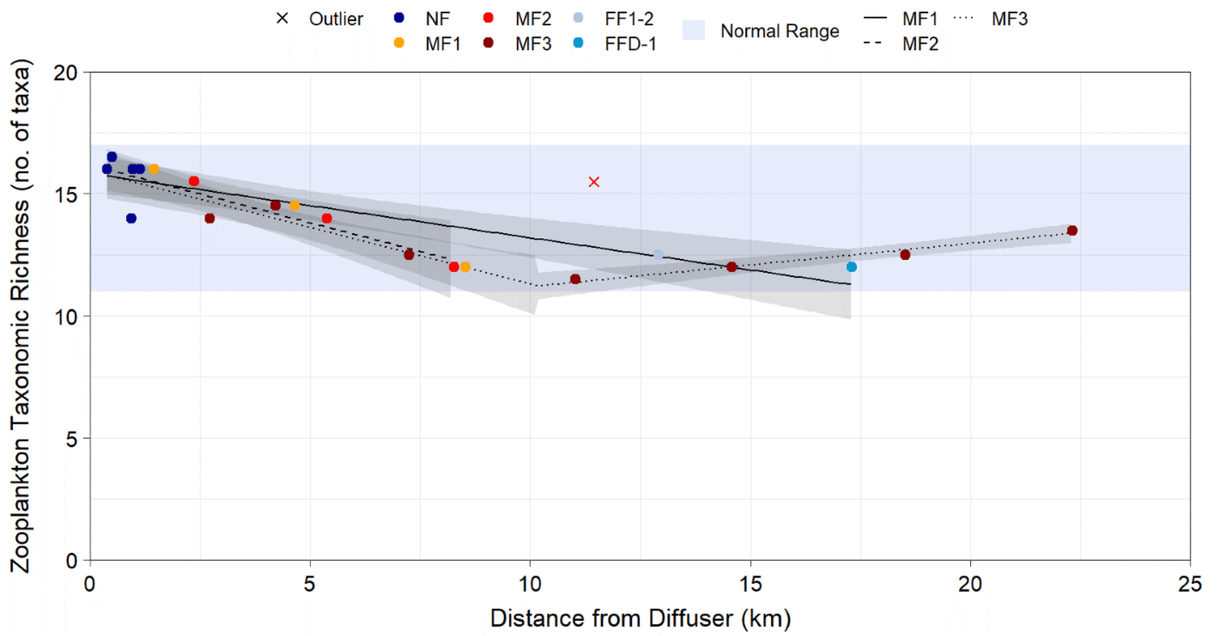
b) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent exposure, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent exposure.

c) The breakpoint is the location from the effluent exposure where the slopes of the linear regressions along the MF3 transect changed values.

d) For the MF3 broken stick model, r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is used because there is more than one predictor, i.e., distance and gradient.

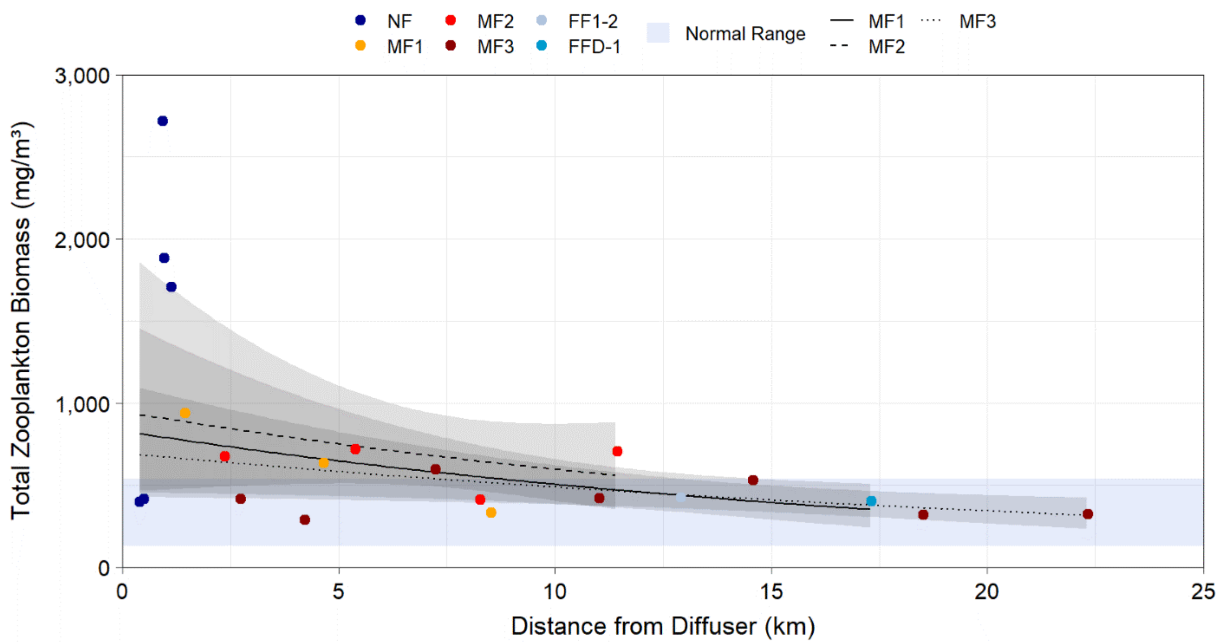
e) Outlier removed: 16 taxa/sample.

Figure 3-9 Zooplankton Taxonomic Richness in Lac de Gras Relative to Distance from the Effluent Discharge, 2021



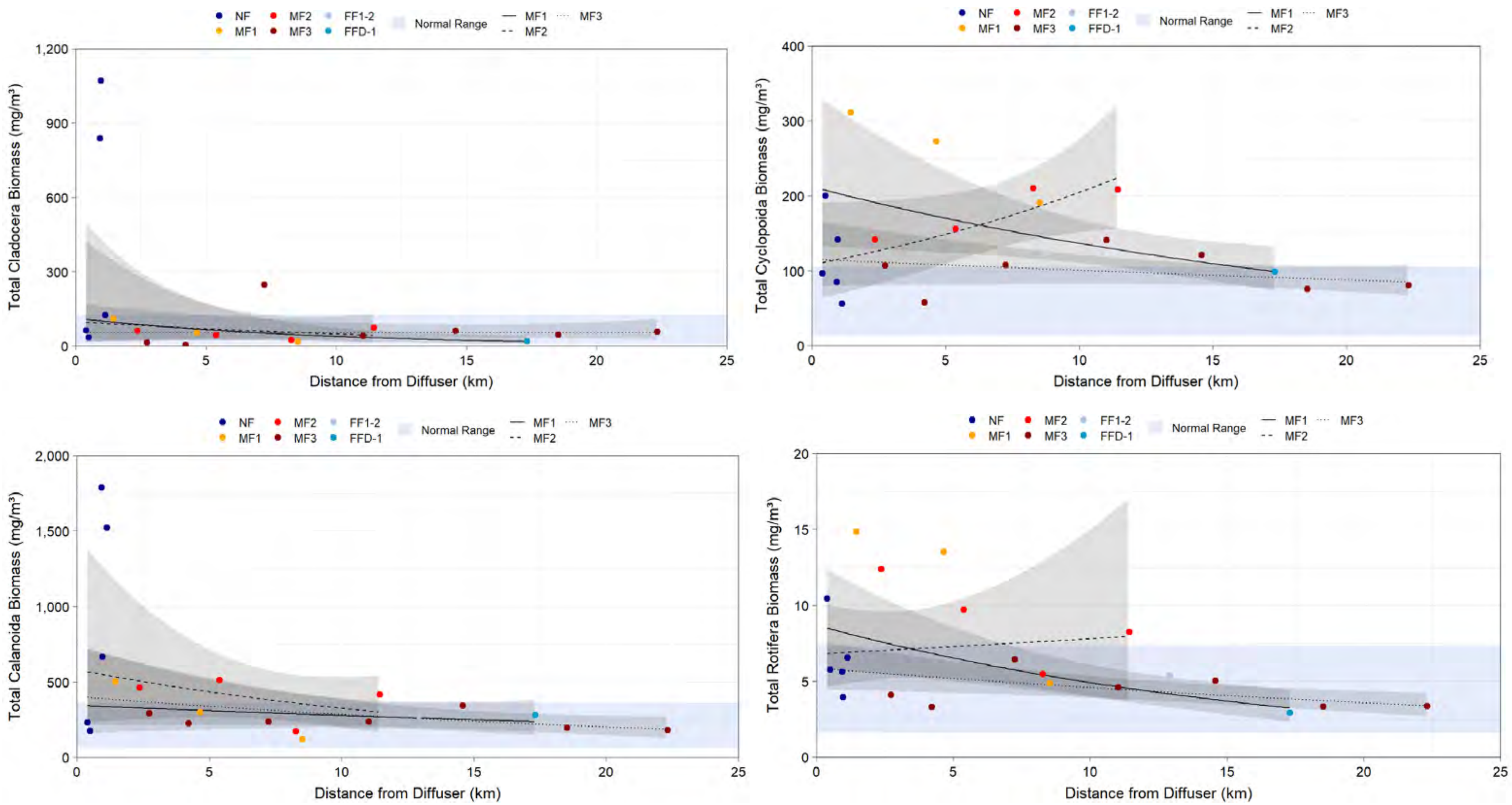
Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field.

Figure 3-10 Zooplankton Biomass in Lac de Gras Relative to Distance from the Effluent Discharge, 2021



Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field.

Figure 3-11 Biomass of Major Zooplankton Groups in Lac de Gras Relative to Distance from the Effluent Discharge, 2021



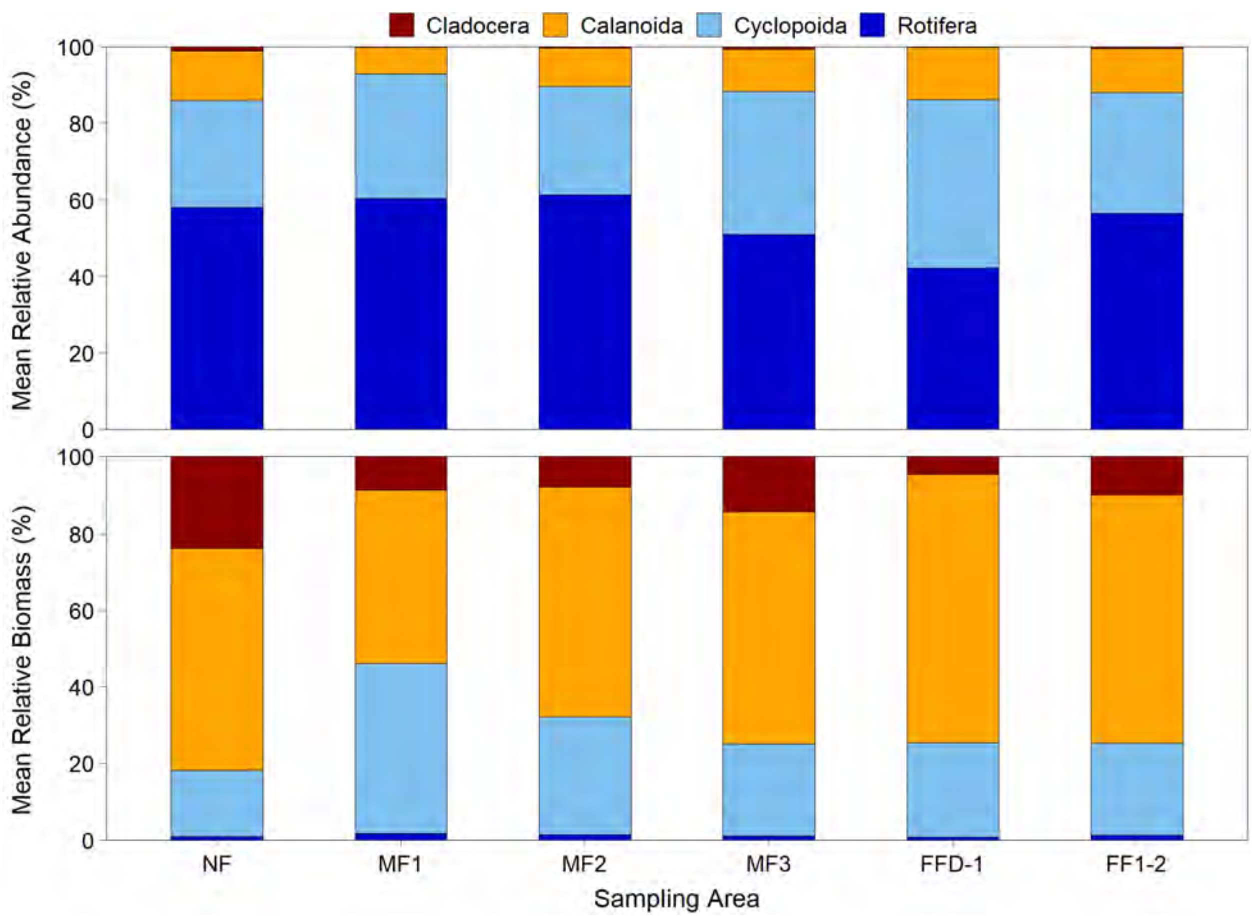
Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).
NF = near-field; MF = mid-field; FF = far-field.

3.2.3 Zooplankton Community Composition

Zooplankton communities, based on abundance, in Lac de Gras were co-dominated by rotifers and cyclopoid copepods in 2021 (Figure 3-12). In terms of mean relative biomass, the zooplankton communities in Lac de Gras were dominated by calanoid copepods, with cyclopoid copepod sub-dominance. There were more cladocerans in the NF area in 2021 compared to the other areas, in terms of both abundance and biomass.

Despite accounting for a large proportion of total abundance, rotifers accounted for a small proportion of the total biomass (i.e., less than 1% in the NF area and 1% in the MF areas), reflective of their small body size (Figure 3-12). In contrast, calanoid copepods and cladocerans accounted for a small proportion of zooplankton community relative abundance (i.e., 10% in the NF area and less than 10 % in the MF areas), but contributed a large proportion of total zooplankton biomass (i.e., 55% in the NF area and between 53% and 72% in the MF areas) because of their relatively large body size.

Figure 3-12 Mean Relative Zooplankton Abundance and Biomass in Lac de Gras, 2021



NF = near-field; MF = mid-field; FF = far-field.

3.3 Action Level Evaluation

The Action Levels for plankton effects address the toxicological impairment hypothesis. Action Level 1 is triggered when biomass or richness in the NF exposure area is significantly lower than the reference condition mean (Table 2-3). In 2021, the NF area mean values for total phytoplankton and zooplankton biomass and taxonomic richness were above the reference condition mean (Tables 3-1 and 3-4). Mean phytoplankton biomass in the NF area was below the reference condition mean but this difference was not significant (Table 3-1). Phytoplankton biomass was also well within the normal range, showing no indication of toxicological impairment in 2021 (Figure 3-2). Therefore, no Action Levels were triggered.

4 SUMMARY AND DISCUSSION

4.1 Phytoplankton Community

Phytoplankton taxonomic richness and biomass were within or above the normal range in all areas of Lac de Gras in 2021. Mean taxonomic richness in the NF area was above the reference condition mean, while mean phytoplankton biomass in the NF area was slightly, but not significantly, below the reference condition mean. Phytoplankton biomass was well within the normal range, showing no indication of toxicological impairment in 2021. Gradient analysis demonstrated that phytoplankton richness, biomass, and the biomass of the major ecological groups decreased with distance from the diffusers, and that stations close to the effluent diffuser (i.e., stations in the NF area) generally had higher richness and biomass than the more distant stations in 2021. These results are consistent with a Mine-related nutrient enrichment effect.

Phytoplankton community composition in the NF area of Lac de Gras did not substantially differ from the MF areas in terms of relative abundance or biomass in 2021. The phytoplankton communities in all areas of Lac de Gras, and in the Lac du Sauvage inflow, were dominated by cyanobacteria based on abundance, with the exception of Station LDG-48 near the lake outflow, which was dominated by microflagellates. In terms of biomass, the phytoplankton communities in all areas of Lac de Gras were dominated by microflagellates and diatoms, while diatoms dominated the community in the Lac du Sauvage inflow.

Overall, the 2021 phytoplankton results did not provide evidence of toxicological impairment, and Action Level 1 for toxicological impairment was not triggered based on phytoplankton taxonomic richness or biomass.

4.2 Zooplankton Community

Mean zooplankton taxonomic richness in all areas of Lac de Gras was within the normal range, was greater in the NF area compared to the MF areas, and was above the reference condition mean in 2021. Mean total zooplankton biomass in the NF area was above the normal range and above the reference condition mean in 2021. In the NF area, mean biomass values of cladocerans, and calanoid and cyclopoid copepods were above the normal range, while the mean biomass of rotifers was within the normal range.

The gradient analysis of zooplankton richness, total biomass and biomass of the major ecological groups indicated that the zooplankton variables have generally not shown a decrease close to the effluent diffusers; rather, richness, total biomass, and biomass of the major ecological groups have generally decreased with distance away from the effluent diffusers, consistent with nutrient enrichment.

Zooplankton communities, based on abundance, in Lac de Gras were dominated by rotifers, with cyclopoid copepod sub-dominance in 2021. In terms of mean relative biomass, the zooplankton communities in Lac de Gras were dominated by calanoid copepods, with cyclopoid copepod sub-dominance. Cladoceran abundance was greater in the NF area in 2021 compared to the other areas, in terms of both abundance and biomass.

The 2021 zooplankton community did not show a response consistent with toxicological impairment and Action Level 1 for toxicological impairment was not triggered. Rather, results were consistent with Mine-related nutrient enrichment, as demonstrated by greater zooplankton biomass in the NF area compared to the other sampling areas, and compared to the reference condition mean. Results reported in the Eutrophication Indicators Report (Appendix XIII) also indicate that nutrient enrichment is occurring in Lac de Gras.

5 RESPONSE FRAMEWORK

In 2021, the NF area mean values for total phytoplankton richness and zooplankton taxonomic richness and biomass were above the reference condition mean. Mean phytoplankton biomass in the NF area was below the reference condition mean but this difference was not significant (Table 3-1). Phytoplankton biomass was also well within the normal range, showing no indication of toxicological impairment in 2021; therefore, Action Level 1 was not triggered.

6 CONCLUSIONS

This report presents the analysis of the phytoplankton and zooplankton data collected during the 2021 AEMP field program. It addresses the objectives of the interim plankton program, which are to evaluate the current year's plankton community data according to the AEMP Response Framework, to evaluate whether Mine-related toxicological changes are occurring in the plankton community in the NF area of Lac de Gras, and to assess the spatial extent of Mine-related effects within the NF and MF areas.

Overall, the 2021 plankton data indicate that a toxicological effect is not occurring in Lac de Gras. Rather, results continue to be consistent with nutrient enrichment[1] originating from nutrients discharged by Mine effluent, as demonstrated by generally greater plankton biomass in the NF area compared to the MF areas and the normal range. The NF area mean values for total phytoplankton and zooplankton taxonomic richness and zooplankton biomass were greater than the reference condition mean[2], indicating that Action Level 1 for toxicological impairment was not triggered.

[1] This is consistent with observations reported in previous AEMP years, as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2021a) and subsequent AEMP annual reports (Golder 2018, 2019b, 2020a, 2021).

[2] This is consistent with observations reported in the 2018,2019, and 2020 AEMP, annual reports (Golder 2019b, 2020a, Golder 2021b).

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8 CLOSURE

We trust the information in this report meets your requirements at this time. If you have any questions relating to the information contained in this report, please do not hesitate to contact the undersigned.

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ATTACHMENT A

QUALITY ASSURANCE AND QUALITY CONTROL

QUALITY ASSURANCE AND QUALITY CONTROL

Introduction

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting, and are described for the Mine Aquatic Effects Monitoring Program (AEMP) in the *Quality Assurance Project Plan Version 3.1* (Golder 2017). Quality assurance (QA) encompasses management and technical practices designed to generate data of appropriate quality. Quality control (QC) is an aspect of QA and includes the techniques used to assess data quality and the corrective actions to be taken when the data quality objectives are not met. This appendix describes QA/QC practices applied during the 2021 plankton component of the AEMP, evaluates QC data, and describes the implications of QC results to the interpretation of study results.

Quality Assurance

Field Staff Training and Operations

Diavik Diamond Mines (2012) Inc. (DDMI) field staff are trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality and plankton sampling. Field work was completed according to specific instructions provided to field crews and Standard Operating Procedures (SOPs). The procedures are described in:

- ENVI-923-0119: “AEMP Combined Open Water and Ice Cover”
- ENVI-902-0119: “Quality Assurance/Quality Control”
- ENVI-900-0119: “Chain of Custody”

These SOPs include guidelines for field record-keeping and sample tracking, guidance for use of sampling equipment, sampling procedures, and sample labelling, shipping and tracking protocols.

Office Operations

A data management system was in place to facilitate an organized system of data control, analysis, and filing. Relevant elements of this system are as follows:

- pre-field meetings to discuss specific work instructions with field crews
- field crew check-ins with task managers every 24 to 48 hours to discuss work completed, and upcoming tasks
- designating two crew members as responsible for:
  - collecting all required samples
  - immediate download and storage of electronic data
  - completing chain-of-custody and analytical request forms; labelling and documentation
  - processing, where required, and delivering samples to the analytical laboratory in a timely manner

- cross-checking chain-of-custody forms and analysis request forms by the task manager to verify that the correct analysis packages were requested
- review of field data sheets by the task manager for completeness and accuracy
- reviewing taxonomy data immediately after receipt from the taxonomist
- creating backup files before data analysis
- completing appropriate logic checks for accuracy of calculations

Quality Control

Methods

Quality control is a specific aspect of QA that includes the techniques used to assess data quality. The field QC program consisted of the collection of duplicate samples to assess within-station variation and sampling precision. Duplicate samples consisted of two samples collected from the same station at the same time, using the same sampling and sample handling procedures. They were labelled and preserved individually and were submitted separately to the taxonomist for identical analyses. In 2021, duplicate zooplankton samples were collected from each station and submitted to Salki Consultants Inc. for analysis of taxonomic composition. Duplicate phytoplankton samples were not collected in 2021 per the *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017). The zooplankton and phytoplankton laboratory QC program consisted of the collection of four and two split samples, respectively, which were analyzed by the same taxonomist to verify counting precision. The data were entered into electronic format by the taxonomist and were double-checked upon entry; errors were corrected as necessary before transferring the electronic files to DDMI.

Initial screening of the 2021 AEMP dataset was completed using the method specified in the QAPP (Golder 2020). If anomalous values were identified during the screening process, the data were plotted with the corresponding 2007 to 2020 data for a range comparison. If the data were also outside the corresponding 2007 to 2020 range, laboratory re-analysis was requested. If laboratory re-analysis confirmed the results, the anomalous values were retained in the final dataset, unless there was a technically defensible reason to exclude them.

The inherent variability associated with the plankton samples makes the establishment of a QC threshold value difficult. For the purposes of the plankton QC program, samples were flagged and assessed further if there was a greater than 50% difference in total abundance or total biomass between the original and duplicate samples, calculated as the relative percent difference (RPD). Similarly, samples were flagged and assessed further if there was a greater than 50% difference in total abundance or biomass between the taxonomist’s split samples.

The RPD was calculated using the following formula:

$$RPD = (|difference\ in\ abundance\ or\ biomass\ between\ duplicate\ samples| / mean\ abundance\ or\ biomass) x 100$$

In addition, the Bray-Curtis dissimilarity index, which is a measure of ecological distance between two communities, was used to assess the overall similarity between the taxonomist's split samples. The value of the Bray-Curtis dissimilarity index ranges from zero (identical communities) to one (very dissimilar communities) and is calculated using the following formula:

$$b = \frac{\sum_{k=1}^{n} \left| x_{ik} - x_{jk} \right|}{\sum_{k=1}^{n} \left(x_{ik} + x_{jk} \right)}$$

In this formula, *b* is the Bray-Curtis dissimilarity index, *n* is the number of taxa in the sample, x_{ik} and x_{jk} are abundance or biomass of taxon *(i)* in the original *(j)* and re-counted *(k)* samples, respectively. Bray-Curtis comparisons were performed on data grouped at the major ecological group level for the phytoplankton community (i.e., diatoms, chlorophytes, microflagellates, cyanobacteria, and dinoflagellates) and zooplankton community (i.e., cladocerans, cyclopoids, calanoids, and rotifers). Index values greater than 0.5 were flagged and follow-up discussions with the taxonomist were initiated.

Duplicate data were not automatically rejected because of an exceedance of the acceptance criterion; rather, they were evaluated on a case-by-case basis, because some level of within-station variability is expected for duplicate samples. If there were departures from the acceptance criterion, the samples were flagged, and a variety of follow-up assessments were performed. These assessments included plotting the data for visual identification of anomalous duplicate sample data. If there were values in the duplicate pairs that were visually anomalous, the data were plotted with the corresponding 2007 to 2020 data for a range comparison. If the data were outside the corresponding 2007 to 2020 range, laboratory re-analysis was requested. If laboratory re-analysis confirmed the results, the anomalous duplicate values were retained in the final dataset, unless there was a technically defensible reason to exclude them.

Results

Sample Integrity

No issues were identified by the taxonomist related to phytoplankton sample integrity. During review of the 2021 field samples, the zooplankton taxonomist noted two samples, NF4 and FF2-2, for which one of the duplicate samples was spoiled as a result of insufficient preservative (i.e., formalin) added to the vials in the field. A lack of preservative can result in a loss of integrity of the sample and an underestimate of soft-bodied crustaceans within the sample. Because only one of the duplicates for each of the samples was affected, the unaffected sample was used in the 2021 zooplankton data analysis.

Duplicate Samples

Phytoplankton field QC duplicate samples were not collected in 2021 per the *Quality Assurance Project Plan Version 3.1* (Golder 2017).

Duplicate zooplankton field QC samples were collected at all stations in 2021. Several of the stations had RPDs that exceeded 50% for one or more of the dominant groups for zooplankton abundance: NF3, MF1-1, MF1-3, MF1-5, MF2-1, MF2-3, FF2-5, MF3-1, MF3-2, MF3-3, MF3-7, and FFD-1 (Table A-1). In most cases this was found for the minor taxa (typically Cladocera), where the absolute difference between duplicates was small. However, no samples had RPDs greater than 50% for total zooplankton abundance and none of the samples had Bray-Curtis dissimilarity values greater than 0.5. Excluding the two stations with one duplicate due to spoiled samples (i.e., NF4 and FF2-2), comparison of duplicate zooplankton samples for total abundance and the abundances of the dominant groups indicated an acceptable level of overall similarity between duplicate samples based on the RPD for total zooplankton abundance and the Bray-Curtis dissimilarity index (Table A-1). Therefore, the duplicate zooplankton abundance data were deemed acceptable for the purposes of this study.

Several stations had RPDs that exceeded 50% for one or more of the dominant groups for zooplankton biomass: NF3, NF5, MF1-1, MF1-3, MF1-5, MF2-1, FF2-5, MF3-1, MF3-3, MF3-4, MF3-7, and FFD-1 (Table A-2). Two stations had RPDs that exceeded 50% based on total biomass: MF3-1 and MF3-3. Despite these exceedances, the overall sample dissimilarity did not exceed the acceptance criterion (i.e., none of the samples had Bray-Curtis dissimilarity values greater than 0.5). Comparison of duplicate zooplankton samples for total biomass and biomass of the dominant groups indicated an overall similarity between duplicate samples based on the Bray-Curtis dissimilarity index (Table A-2). Therefore, the duplicate zooplankton biomass data were deemed acceptable for the purposes of this study.

Table A-1 Results for Field QC (Duplicate) Zooplankton Abundance Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Abundance (Ind/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
NF	NF1	Calanoida	4.84	4.30	12	0.11
		Cyclopoida	6.28	9.18	38	
		Cladocera	0.08	0.08	3.0	
		Rotifera	36.02	44.75	22	
		Total abundance	47.22	58.31	21	
	NF2	Calanoida	2.98	3.67	21	0.02
		Cyclopoida	18.57	18.11	2.5	
		Cladocera	0.05	0.08	47	
		Rotifera	22.53	21.12	6.5	
		Total abundance	44.13	42.98	2.6	
	NF3	Calanoida	9.47	9.06	4.5	0.10
		Cyclopoida	8.35	8.59	2.8	
		Cladocera	0.42	1.00	**81**	
		Rotifera	17.67	24.76	33	
		Total abundance	35.91	43.40	19	
	NF4	Calanoida	5.81	-	-	n/a
		Cyclopoida	6.66	-	-	
		Cladocera	0.12	-	-	
		Rotifera	25.31	-	-	
		Total abundance	37.91	-	-	
	NF5	Calanoida	3.75	3.23	15	0.06
		Cyclopoida	14.79	17.59	17	
		Cladocera	1.27	0.80	45	
		Rotifers	15.21	16.79	9.9	
		Total abundance	35.01	38.41	9.3	
MF1	MF1-1	Calanoida	9.96	7.07	34	0.05
		Cyclopoida	11.49	13.39	15	
		Cladocera	0.25	0.07	**116**	
		Rotifera	60.13	55.22	8.5	
		Total abundance	81.83	75.75	7.7	
	MF1-3	Calanoida	5.11	3.87	28	0.02
		Cyclopoida	14.65	13.81	6.0	
		Cladocera	0.10	0.05	**63**	
		Rotifers	46.75	46.75	0.0	
		Total abundance	66.60	64.48	3.2	
	MF1-5	Calanoida	1.73	1.46	17	0.04
		Cyclopoida	30.64	27.06	12	
		Cladocera	0.05	0.02	**79**	
		Rotifera	15.97	19.43	**20**	
		Total abundance	48.39	47.97	0.9	
MF2	MF2-1	Calanoida	8.83	7.17	21	0.05
		Cyclopoida	11.26	10.34	8.5	
		Cladocera	0.02	0.19	**164**	
		Rotifera	52.18	48.21	7.9	
		Total abundance	72.28	65.91	9.2	
	MF2-3	Calanoida	7.15	8.58	18	0.05
		Cyclopoida	16.08	14.62	9.5	
		Cladocera	0.19	0.07	**93**	
		Rotifera	40.05	36.15	10	
		Total abundance	63.48	59.42	6.6	
	FF2-2	Calanoida	-	2.86	-	n/a
		Cyclopoida	-	17.29	-	
		Cladocera	-	0.23	-	
		Rotifera	-	24.18	-	
		Total abundance	-	44.56	-	
	FF2-5	Calanoida	5.77	5.23	9.7	0.03
		Cyclopoida	19.71	18.05	8.8	
		Cladocera	0.14	0.06	**84**	
		Rotifera	32.91	31.49	4.4	
		Total abundance	58.53	54.84	6.5	
MF3	MF3-1	Calanoida	5.78	2.43	**82**	0.10
		Cyclopoida	10.58	15.56	38	
		Cladocera	0.04	0.02	**63**	
		Rotifera	15.79	17.65	11	
		Total abundance	32.20	35.67	10	
	MF3-2	Calanoida	3.56	3.50	1.5	0.09
		Cyclopoida	5.84	4.49	26	
		Cladocera	0.01	0.03	**100**	
		Rotifera	11.06	14.72	28	
		Total abundance	20.47	22.74	11	
	MF3-3	Calanoida	5.10	2.25	**78**	0.08
		Cyclopoida	18.20	15.50	16	
		Cladocera	1.64	0.14	**169**	
		Rotifera	25.25	25.14	0.4	
		Total abundance	50.19	43.02	15	
	MF3-4	Calanoida	3.83	2.54	41	0.09
		Cyclopoida	18.89	14.92	24	
		Cladocera	0.13	0.08	43	
		Rotifera	18.89	17.32	8.7	
		Total abundance	41.74	34.86	18	
	MF3-5	Calanoida	4.75	4.14	14	0.04
		Cyclopoida	14.32	14.65	2.3	
		Cladocera	0.18	0.16	8.7	
		Rotifera	17.13	20.06	16	
		Total abundance	36.37	39.01	7.0	
	MF3-6	Calanoida	2.45	3.11	24	0.05
		Cyclopoida	9.11	10.59	15	
		Cladocera	0.12	0.13	2.0	
		Rotifera	12.73	13.13	3.1	
		Total abundance	24.42	26.95	9.9	
	MF3-7	Calanoida	3.60	1.61	**76**	0.10
		Cyclopoida	8.97	11.75	27	
		Cladocera	0.21	0.09	**85**	
		Rotifera	10.78	12.83	17	
		Total abundance	23.57	26.28	11	

Table A-1 Results for Field QC (Duplicate) Zooplankton Abundance Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Abundance (Ind/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
FF1/FFD	FF1-2	Calanoida	3.67	3.65	0.6	0.04
		Cyclopoida	9.20	10.78	16	
		Cladocera	0.15	0.11	28	
		Rotifera	17.44	18.41	5.4	
		Total abundance	30.47	32.95	7.8	
	FFD-1	Calanoida	3.09	4.15	29	0.05
		Cyclopoida	12.28	11.09	10	
		Cladocera	0.04	0.02	**57**	
		Rotifera	10.49	11.92	13	
		Total abundance	25.91	27.17	4.8	

Note: **Bolded** values indicate RPD values greater than 50%.
QC = quality control; Ind/L = individuals per litre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.
Grey-shaded cells identify samples that were noted as being spoiled by the taxonomist as a result of insufficient preservative added to the vials in the field.

Table A-2 Results for Field QC (Duplicate) Zooplankton Biomass Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Biomass (mg/m³)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
NF	NF1	Calanoida	231.03	227.85	1.4	0.06
		Cyclopoida	73.69	119.04	47	
		Cladocera	62.44	65.23	4.4	
		Rotifera	9.38	11.49	20	
		Total biomass	376.54	423.61	12	
	NF2	Calanoida	154.14	198.64	25	0.08
		Cyclopoida	193.74	207.08	6.7	
		Cladocera	30.59	39.58	26	
		Rotifera	6.54	5.01	27	
		Total biomass	385.01	450.31	16	
	NF3	Calanoida	1406.65	2171.91	43	0.24
		Cyclopoida	90.05	79.98	12	
		Cladocera	565.98	1109.60	**65**	
		Rotifera	4.88	6.34	26	
		Total biomass	2067.54	3367.82	48	
	NF4	Calanoida	1521.64	-	-	n/a
		Cyclopoida	56.04	-	-	
		Cladocera	123.77	-	-	
		Rotifera	6.56	-	-	
		Total biomass	1708.00	-	-	
	NF5	Calanoida	497.09	839.00	**51**	0.19
		Cyclopoida	117.35	166.18	34	
		Cladocera	1427.68	713.73	**67**	
		Rotifers	3.70	4.17	12	
		Total biomass	2045.82	1723.08	17	
MF1	MF1-1	Calanoida	569.94	431.34	28	0.15
		Cyclopoida	324.25	298.35	8.3	
		Cladocera	169.83	52.11	**106**	
		Rotifera	15.75	13.93	12	
		Total biomass	1079.77	795.72	30	
	MF1-3	Calanoida	384.09	209.38	**59**	0.18
		Cyclopoida	262.57	283.35	7.6	
		Cladocera	78.87	29.08	**92**	
		Rotifers	14.03	13.02	7.5	
		Total biomass	739.56	534.83	32	
	MF1-5	Calanoida	127.61	112.28	13	0.09
		Cyclopoida	161.23	220.31	31	
		Cladocera	28.41	7.04	**121**	
		Rotifera	4.13	5.58	30	
		Total biomass	321.39	345.21	7.1	
MF2	MF2-1	Calanoida	506.77	416.57	20	0.09
		Cyclopoida	122.32	160.43	27	
		Cladocera	16.70	104.11	**145**	
		Rotifera	13.19	11.55	13	
		Total biomass	658.97	692.66	5.0	
	MF2-3	Calanoida	434.59	586.43	30	0.13
		Cyclopoida	147.23	163.63	11	
		Cladocera	37.28	51.49	32	
		Rotifera	9.39	10.00	6.3	
		Total biomass	628.49	811.55	25	
	FF2-2	Calanoida	-	173.27	-	n/a
		Cyclopoida	-	210.04	-	
		Cladocera	-	23.82	-	
		Rotifera	-	5.48	-	
		Total biomass	-	412.61	-	
	FF2-5	Calanoida	426.24	406.14	4.8	0.12
		Cyclopoida	235.67	181.06	26	
		Cladocera	121.00	27.11	**127**	
		Rotifera	8.25	8.27	0.2	
		Total biomass	791.16	622.57	24	
MF3	MF3-1	Calanoida	410.36	173.36	**81**	0.29
		Cyclopoida	101.05	113.60	12	
		Cladocera	12.45	13.68	9.5	
		Rotifera	3.77	4.41	16	
		Total biomass	527.63	305.05	**54**	
	MF3-2	Calanoida	218.08	232.11	6.2	0.05
		Cyclopoida	71.33	44.83	46	
		Cladocera	4.10	5.53	30	
		Rotifera	3.02	3.61	18	
		Total biomass	296.53	286.07	3.6	
	MF3-3	Calanoida	295.67	177.18	**50**	0.45
		Cyclopoida	111.04	104.24	6.3	
		Cladocera	454.59	39.20	**168**	
		Rotifera	7.05	5.82	19	
		Total biomass	868.35	326.44	**91**	
	MF3-4	Calanoida	305.72	165.24	**60**	0.22
		Cyclopoida	161.12	120.64	29	
		Cladocera	34.89	45.54	27	
		Rotifera	4.67	4.51	3.5	
		Total biomass	506.40	335.93	41	
	MF3-5	Calanoida	358.63	325.00	9.8	0.07
		Cyclopoida	139.92	102.26	31	
		Cladocera	56.45	65.94	16	
		Rotifera	5.23	4.86	7.4	
		Total biomass	560.23	498.05	12	
	MF3-6	Calanoida	178.75	214.24	18	0.07
		Cyclopoida	71.17	79.75	11	
		Cladocera	44.79	45.77	2.2	
		Rotifera	3.49	3.17	9.6	
		Total biomass	298.19	342.93	14	
	MF3-7	Calanoida	232.64	132.34	**55**	0.22
		Cyclopoida	81.77	79.37	3.0	
		Cladocera	76.61	39.93	**63**	
		Rotifera	2.60	4.14	46	
		Total biomass	393.62	255.78	43	

Table A-2 Results for Field QC (Duplicate) Zooplankton Biomass Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Biomass (mg/m^3)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
FF1/FFD	FF1-2	Calanoida	269.94	280.68	3.9	0.03
		Cyclopoida	96.18	107.51	11	
		Cladocera	50.67	32.13	45	
		Rotifera	6.09	4.67	26	
		Total biomass	422.88	425.00	0.5	
	FFD-1	Calanoida	255.12	306.99	19	0.07
		Cyclopoida	116.95	81.14	36	
		Cladocera	28.74	8.65	**107**	
		Rotifera	2.89	2.94	1.6	
		Total biomass	403.70	399.72	1.0	

Note: **Bolded** values are RPD values greater than 50%.
QC = quality control; mg/m^3 = milligrams per cubic metre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.
Grey-shaded cells identify samples that were noted as being spoiled by the taxonomist as a result of insufficient preservative added to the vials in the field.

Split Samples

The laboratory QC program consisted of two phytoplankton and four zooplankton split samples in 2021.

The phytoplankton laboratory QC data indicated that the occurrence of dominant groups was consistent between the split samples (Table A-3 and Table A-4). The phytoplankton split sample results did not exceed an RPD of 50% for total abundance. However, an RPD of 50% was exceeded for dinoflagellate abundance (i.e., the least abundant group) in the NF2 sample. The phytoplankton split sample results exceeded an RPD of 50% for total biomass and microflagellate biomass in one sample (NF2) but did not exceed an RPD of 50% for total biomass or biomasses of other dominant groups in the other sample (MF2-3). Despite these exceedances, the overall sample dissimilarity did not exceed the acceptance criterion (i.e., none of the sample pairs had Bray-Curtis dissimilarity values greater than 0.5). Therefore, based on the split phytoplankton abundance and biomass results, samples were deemed acceptable for the purposes of this study.

The zooplankton laboratory QC data indicated that the occurrence of dominant groups was generally consistent between the split samples (Table A-5 and Table A-6). An RPD of 50% was exceeded for cladoceran abundance in the MF3-1 sample, and for calanoid copepod abundance in the FFD-1 sample. Total cladoceran biomass exceeded an RPD of 50% in the MF3-1 sample. Despite these exceedances, the overall sample dissimilarity did not exceed the acceptance criterion (i.e., none of the samples had Bray-Curtis dissimilarity values greater than 0.5). Therefore, based on the split zooplankton abundance and biomass results, the samples were deemed acceptable for the purposes of this study.

Table A-3 Results for Laboratory QC (Split) Phytoplankton Abundance Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Abundance (cells/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
NF	NF2	Microflagellates	373,533	378,261	1	0.15
		Diatoms	207,179	187,713	10	
		Chlorophytes	563,223	506,204	11	
		Cyanobacteria	2,610,002	1,734,843	40	
		Dinoflagellates	4,768	160	**187**	
		Total abundance	3,758,706	2,807,182	29	
MF2	MF2-3	Microflagellates	921,150	689,420	29	0.13
		Diatoms	60,529	40,174	40	
		Chlorophytes	643,964	529,299	20	
		Cyanobacteria	2,444,692	3,605,002	38	
		Dinoflagellates	120	120	0	
		Total abundance	4,070,455	4,864,014	18	

Note: **Bolded** values indicate RPD values greater than 50%.

QC = quality control; cells/L = cells per litre; RPD = relative percent difference; NF = near-field; MF = mid-field.

Table A-4 Results for Laboratory QC (Split) Phytoplankton Biomass Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Biomass (mg/m^3)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
NF	NF2	Microflagellates	62.1	121.5	**65**	0.26
		Diatoms	67.2	108.2	47	
		Chlorophytes	14.4	18.7	26	
		Cyanobacteria	5.5	4.8	14	
		Dinoflagellates	3.3	3.2	3	
		Total biomass	152.5	256.4	**51**	
MF2	MF2-3	Microflagellates	137.6	91.1	41	0.11
		Diatoms	82.0	86.8	6	
		Chlorophytes	17.4	15.8	10	
		Cyanobacteria	7.0	9.2	27	
		Dinoflagellates	1.6	1.6	0	
		Total biomass	245.7	204.4	18	

Note: **Bolded** values indicate RPD values greater than 50%.

QC = quality control; mg/m^3 = milligrams per cubic metre; RPD = relative percent difference; NF = near-field; MF = mid-field.

Table A-5 Results for Laboratory QC (Split) Zooplankton Abundance Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Abundance (Ind/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Split Sample		
NF	NF2	Calanoida	3.67	3.90	6.2	0.03
		Cyclopoida	18.11	19.74	8.6	
		Cladocera	0.08	0.07	18.1	
		Rotifera	21.12	21.94	3.8	
		Total abundance	42.98	45.65	6.0	
MF3	MF3-1	Calanoida	5.78	4.40	27.2	0.03
		Cyclopoida	10.58	10.10	4.6	
		Cladocera	0.04	0.18	**119.3**	
		Rotifera	15.79	16.38	3.6	
		Total abundance	32.20	31.05	3.6	
MF2	MF3-6	Calanoida	2.45	1.92	24.2	0.07
		Cyclopoida	9.11	9.78	7.1	
		Cladocera	0.12	0.10	22.3	
		Rotifera	12.73	15.41	19.0	
		Total abundance	24.42	27.21	10.8	
FFD	FFD-1	Calanoida	4.15	2.46	**51.0**	0.05
		Cyclopoida	11.09	10.37	6.7	
		Cladocera	0.02	0.02	3.3	
		Rotifera	11.92	13.95	15.7	
		Total abundance	27.17	26.80	1.4	

Note: **Bolded** values are RPD values greater than 50%.

QC = quality control; Ind/L = Individuals per litre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Table A-6 Results for Laboratory QC (Split) Zooplankton Biomass Samples Collected from Lac de Gras, 2021

Area	Station	Major Taxonomic Group	Total Biomass (mg/m³)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Split Sample		
NF	NF2	Calanoida	198.64	217.14	8.9	0.04
		Cyclopoida	207.08	222.11	7.0	
		Cladocera	39.58	35.32	11.4	
		Rotifera	5.01	5.20	3.8	
		Total biomass	450.31	479.77	6.3	
MF3	MF3-1	Calanoida	410.36	305.23	29.4	0.11
		Cyclopoida	101.05	139.71	32.1	
		Cladocera	12.45	26.11	**70.9**	
		Rotifera	3.77	4.41	15.7	
		Total biomass	527.63	475.47	10.4	
MF3	MF3-6	Calanoida	178.75	148.04	18.8	0.05
		Cyclopoida	71.17	74.11	4.0	
		Cladocera	44.79	45.39	1.3	
		Rotifera	3.49	4.10	16.3	
		Total biomass	298.19	271.64	9.3	
FFD	FFD-1	Calanoida	302.23	201.37	40.1	0.15
		Cyclopoida	81.14	77.60	4.5	
		Cladocera	8.65	9.52	9.6	
		Rotifera	2.94	3.33	12.4	
		Total biomass	394.96	291.82	30.0	

Note: **Bolded** values are RPD values greater than 50%.

QC = quality control; mg/m³ = milligrams per cubic metre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Summary

During review of the 2021 field samples, the zooplankton taxonomist noted two samples (i.e., NF4 and FF2-2) for which one of the duplicate samples was spoiled as a result of insufficient preservative (i.e., formalin) added to the vials in the field. Because only one of the duplicates for each of the samples was affected, the unaffected sample was used in the 2021 zooplankton data analysis.

Data screening of 2021 phytoplankton and zooplankton community datasets did not identify anomalous values. Results for several stations in the duplicate zooplankton dataset exceeded an RPD of 50%; however, no samples had RPDs greater than 50% for total zooplankton abundance and none of the samples had Bray-Curtis dissimilarity values greater than 0.5; based on this, the duplicate zooplankton samples were considered to be within the expected range of natural variability. The split phytoplankton and zooplankton samples generally did not exceed the acceptance criteria, with the exception of one phytoplankton split sample, and two zooplankton split samples. But neither the phytoplankton nor zooplankton split samples had Bray-Curtis dissimilarity values greater than 0.5. Therefore, the phytoplankton and zooplankton community datasets were deemed acceptable and used to complete the plankton community analysis in 2021.

References

Golder (Golder Associates Ltd.). 2017. Diavik Diamond Mine – Aquatic Effects Monitoring Program – Quality Assurance Project Plan (QAPP). Version 3.1. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. June 2017.

ATTACHMENT B

2021 PHYTOPLANKTON COMMUNITY DATA

These data are provided electronically in an Excel file.

ATTACHMENT C

2021 ZOOPLANKTON COMMUNITY DATA

These data are provided electronically in an Excel file.

APPENDIX XII

SPECIAL EFFECTS STUDY REPORTS

No information was available for this appendix in 2021 as no Special Effects Studies were completed.

APPENDIX XIII

EUTROPHICATION INDICATORS REPORT

EUTROPHICATION INDICATORS REPORT
IN SUPPORT OF THE 2021 AEMP ANNUAL REPORT
FOR THE DIAVIK DIAMOND MINE,
NORTHWEST TERRITORIES

Submitted to:

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PO Box 2498
300 - 5201 50th Avenue
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DISTRIBUTION

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1 Copy – Golder Associates Ltd., Calgary, AB
1 Copy – Wek'èezhìı Land and Water Board

March 2022
21452119/12000

Doc No. RPT-2206 Ver. 0
PO No. 3104897490

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Executive Summary

In 2021, Diavik Diamond Mines (2012) Inc. (DDMI) completed the field component of the Aquatic Effects Monitoring Program (AEMP) for the Diavik Diamond Mine (Mine) in Lac de Gras, Northwest Territories, as required by Water Licence W2015L2-0001, according to the *AEMP Design Plan Version 5.2*, as approved by the Wek'èezhìı Land and Water Board (WLWB). This report presents the assessment of eutrophication indicators data collected during the 2021 AEMP. The objective of this component of the AEMP was to evaluate whether Mine-related activities are having an effect on concentrations of nutrients, chlorophyll *a*, and phytoplankton and zooplankton biomass in Lac de Gras. In 2021, Mine-related inputs that had the potential to affect Lac de Gras included effluent discharge and dust deposition. No dike construction or dewatering activities occurred in 2021.

To evaluate whether effluent from the Mine is causing nutrient enrichment in Lac de Gras, indicators of eutrophication were measured in the near-field (NF) and mid-field (MF) areas of the lake and at two stations (FF1-2 and FFD-1) that have recently been added to the annual monitoring program. In addition, the outlet of Lac de Gras to the Coppermine River (LDG-48) and the narrows between Lac de Gras and Lac du Sauvage (LDS-4) were also monitored. Eutrophication indicators evaluated by the AEMP were total and dissolved phosphorus (TP and TDP), soluble reactive phosphorus (SRP), total and dissolved nitrogen (TN and TDN), total ammonia, nitrate, nitrite, nitrate + nitrite, total and dissolved Kjeldahl nitrogen (TKN and DKN), soluble reactive silica (SRSi), chlorophyll *a*, phytoplankton biomass as biovolume, and zooplankton biomass as ash-free dry mass (AFDM). Secchi depth was also included in the analysis as supporting information for the interpretation of the results for phytoplankton biomass and chlorophyll *a*. The analysis of potential effects focused on spatial trends in Lac de Gras using a gradient approach.

The assessment of the 2021 eutrophication indicators dataset concluded that the Mine is having a nutrient enrichment effect in Lac de Gras. The annual load of phosphorus to Lac de Gras in 2021 was similar to the 2020 annual load and below the Water Licence limit. During the ice-cover season, TP concentrations were within or below the normal range at most stations with the exceptions of some depths at two NF and two MF2 stations. Concentrations were variable, but higher concentrations were observed at stations within 5 km of the diffuser and declined with distance from the diffuser. During the open-water season, TP concentrations were within or below the normal range, and there was no apparent trend with distance from the diffuser. Therefore, the extent of effect on TP was estimated as 0% of Lac de Gras during the open-water season and <20% during the ice-cover season. The monthly loads of nitrogen parameters to Lac de Gras, and concentrations in AEMP sampling areas, were on average greater during the open-water season than in the ice-cover season. Concentrations of TN were above the normal range in the NF area and up to 15 km from the diffuser in the MF areas of Lac de Gras, and decreased with distance from the diffuser. The extent of effect on TN was 20% of lake area during the open-water season and 41% during the ice-cover season. Significant decreasing trends in SRSi concentration were observed with distance from the diffusers, and concentrations were greater during the ice-cover season than in the open-water season.

Chlorophyll *a* concentrations and zooplankton biomass decreased with distance from the diffuser and were above the normal range across the entire sampled part of the lake for chlorophyll *a* and in the NF and MF areas for zooplankton biomass. Total phytoplankton biomass decreased with distance from the diffuser; however, most results were within the normal range. The 2021 chlorophyll *a* concentrations in Lac de Gras were consistently about double the concentrations measured in 2020, despite a similar TP load from the Mine in both years (2020: 289 kg, 2021: 297 kg) and lower phytoplankton biomass measured in 2021 compared to 2020. It is not clear why chlorophyll *a* concentrations would be elevated without at least some

corresponding increase in phytoplankton biomass, suggesting a potential data quality issue associated with the chlorophyll *a* dataset. Field procedures were reviewed, and the analytical laboratory was contacted to verify the 2021 chlorophyll *a* results; this review identified no data quality issues. Overall, the 2021 chlorophyll *a*, total phytoplankton biomass, and zooplankton biomass displayed a response consistent with nutrient enrichment. The extent of effects on chlorophyll *a*, phytoplankton biomass, and zooplankton biomass were 100%, 0%, and greater than or equal to 58% of Lac de Gras, respectively.

The concentration of chlorophyll *a* in the NF and MF areas was above the normal range in an area representing more than 20% of the lake. Based on these results, Action Level 2 was triggered for nutrient enrichment. According to the Response Framework, exceedance of Action Level 2 requires an action to establish an Effects Benchmark; however, as previous AEMP reports have triggered Action Level 2, the Effects Benchmark has been previously established. Therefore, no further action is required.

Total phosphorus was added to the eutrophication indicators Response Framework in 2021. The concentration of TP at some NF and MF2 stations was above the normal range in an area representing less than 20% of the lake. Based on these results, Action Level 1 was triggered. According to the Response Framework, Action Level 1 is an early-warning change and no further action is required.

The 2021 results are consistent with the Environmental Assessment prediction of elevated concentrations of nutrients in lake water, particularly phosphorus, resulting from the minewater discharge, and an associated increase in primary productivity. Although a clear effect on phosphorus concentrations in lake water was not detected, likely due to rapid utilization of this nutrient, Mine-related phosphorus loading is the most likely factor accounting for the observed biological effects. The combined results of nutrient-productivity indicator relationships, year-to-year variation in affected areas for nutrients and productivity indicators, and nutrient ratios calculated previously, suggest at most a limited influence of nitrogen loading from the Mine effluent on primary producers in Lac de Gras.

The 2021 AEMP provided no evidence that dust deposition had an additional measurable effect on concentrations of TP or chlorophyll *a* in Lac de Gras, beyond the effect apparent from the Mine effluent discharge.

Overall, the results of the 2021 AEMP are consistent with those reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* and subsequent AEMP annual reports (i.e., 2020).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

Acronyms and Abbreviations

AEMP	Aquatic Effects Monitoring Program
AFDM	ash-free dry mass
AIC	Akaike's information criterion
AICc	Akaike's information criterion corrected for small sample size
ALS	ALS Laboratories
Biologica	Biologica Environmental Services, Ltd.
BV Labs	Bureau Veritas Laboratories (formerly Maxxam Analytics)
CALA	Canadian Association of Laboratory Accreditation
DDMI	Diavik Diamond Mines (2012) Inc.
DKN	dissolved Kjeldahl nitrogen
DL	detection limit
DQO	data quality objectives
EA	environmental assessment
e.g.	for example
et al.	and more than one additional author
EQC	effluent quality criteria
FF	far-field
Golder	Golder Associates Ltd.
i.e.	that is
LDG	Lac de Gras
LDS	Lac du Sauvage
MF	mid-field
Mine	Diavik Diamond Mine
Mine centroid	geographic centre of the Mine
n	sample size/count
NIWTP	North Inlet Water Treatment Plant
NF	near-field
QA/QC	quality assurance/quality control
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
r	Pearson correlation coefficient
r^2 or R^2	coefficient of determination
RPD	relative percent difference
SES	special effects study
SNP	surveillance network program
SOP	standard operating procedure
SRSi	soluble reactive silica
SRP	soluble reactive phosphorus

TKN	total Kjeldahl nitrogen
TN	total nitrogen
TP	total phosphorus
TDN	total dissolved nitrogen
TDP	total dissolved phosphorus
WLWB	Wek’èezhìı Land and Water Board
ZOI	zone of influence

Symbols and Units of Measure

%	percent
<	less than
>	greater than
≥	greater than or equal to
×	times
µm	micrometre
cm	centimetre
dm^{2}	square decimetre
kg	kilogram
kg/mo	kilograms per month
kg/yr	kilograms per year
km	kilometre
km^{2}	square kilometre
L	litre
m	metre
mg/dm^{2}/yr	milligrams per square decimetre per year
mg/L	milligrams per litre
mg/m^{3}	milligrams per cubic metre
mL	millilitre
mo	month
P	probability
t	tonne
t/yr	tonnes per year
yr	year
µg/L	micrograms per litre
µg-N/L	micrograms nitrogen per litre
µg-P/L	micrograms phosphorus per litre

1 INTRODUCTION

1.1 Background

As required by Water Licence W2015L2-0001 (WLWB 2021) issued by the Wek'èezhìı Land and Water Board (WLWB), Diavik Diamond Mines (2012) Inc. (DDMI) has been monitoring indicators of eutrophication in Lac de Gras (LDG) as a component of the Aquatic Effects Monitoring Program (AEMP) since 2007. Eutrophication indicators are a key component of the AEMP, because the Environmental Assessment (EA) predicted that the discharge of effluent from the Diavik Diamond Mine (Mine) would cause a change in trophic status (which is a classification of the level of primary productivity) in up to 20% of Lac de Gras as a result of nutrient enrichment (Government of Canada 1999).

This report presents the assessment of eutrophication indicators data collected during the 2021 AEMP field program. Data collection and analysis followed *AEMP Design Plan Version 5.2* (Golder 2020a). Mine-related sources on lake productivity, such as dust deposition, are also considered herein.

1.2 Objectives

The primary objective of the eutrophication indicators assessment is to determine if effluent discharged from the Mine is having an effect on concentrations of nutrients, chlorophyll *a*, and phytoplankton and zooplankton biomass in Lac de Gras.

1.3 Scope and Approach

The Eutrophication Indicators component is designed to monitor both spatial and temporal changes in nutrients, chlorophyll *a*, and phytoplankton and zooplankton biomass. Eutrophication indicators selected for this AEMP component are total and dissolved phosphorus (TP and TDP), soluble reactive phosphorus (SRP), total and dissolved nitrogen (TN and TDN[1]), total ammonia, nitrate, nitrite, nitrate + nitrite, total and dissolved Kjeldahl nitrogen (TKN and DKN), soluble reactive silica (SRSi), chlorophyll *a*, phytoplankton biomass as biovolume, and zooplankton biomass as ash-free dry mass (AFDM). Secchi depth is also included in the analysis and used, as appropriate, in the interpretation of results for phytoplankton biomass and chlorophyll *a*. The spatial extent of effects is established by estimating the surface area of the lake that demonstrates concentrations or biomass greater than background values. Background values for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range, as described in Section 1.2 of the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). The magnitude of effects is assessed by comparing eutrophication indicator endpoints in the near-field (NF) and mid-field (MF) areas to background values. Values above the normal range exceed what would be considered natural levels for Lac de Gras. The importance of effects observed on eutrophication endpoints is assessed according to the Action Level classification defined by Golder (2020a).

The AEMP measures and evaluates the effects of Mine-related activities on the aquatic environment of Lac de Gras. Mine-related activities in 2021 that had the potential to affect Lac de Gras include effluent discharge and dust deposition from vehicular and heavy equipment operations within the Mine footprint. No dyke construction or dewatering activities occurred in 2021.

[1] TN and TDN are calculated based on measured variables according to the following equations: TN = TKN + (nitrate + nitrite) and TDN = DKN + (nitrate + nitrite).

2 METHODS

2.1 Field Sampling

2.1.1 Effluent and Mixing Zone

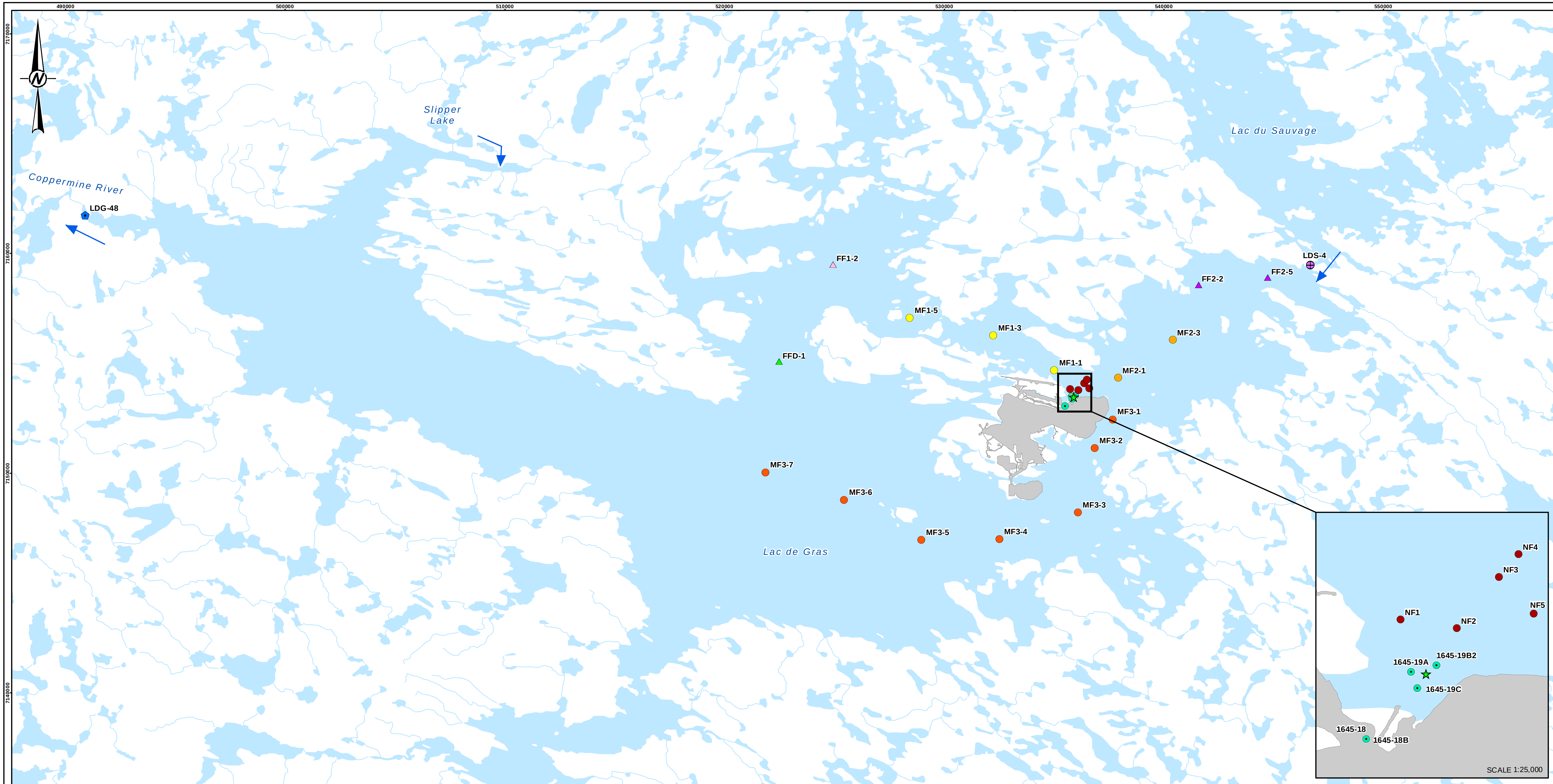
Effluent and water quality data collected in support of the Mine's Surveillance Network Program (SNP) were incorporated herein. Treated effluent from the North Inlet Water Treatment Plant (NIWTP) was sampled from within the NIWTP (Figure 2-1), prior to discharge at SNP 1645-18 (the original diffuser, which has discharged continuously to Lac de Gras since 2002) and Station SNP 1645-18B (the second diffuser, which became operational in September 2009). In addition, water quality samples were collected at the mixing zone boundary in Lac de Gras at three stations (i.e., SNP 1645-19A, SNP 1645-19B2, and SNP 1645-19C), which are located along a semicircle, at 60 m from the effluent diffusers. These stations represent the edge of the mixing zone, which covers an area of approximately 0.01 km^2. Station SNP 1645-19B2 was established in 2009 to replace Station SNP 1645-19B, after the second diffuser became active in Lac de Gras.

Effluent samples were collected approximately every six days. At the mixing zone boundary, samples were collected monthly at each station at the lake water surface and at 5 m depth intervals. Samples were not collected during ice-off (June) at the mixing zone stations due to unsafe ice conditions that prevented access.

2.1.2 Lac de Gras

Twenty-one stations located in six general areas of Lac de Gras were sampled by DDMI during the 2021 AEMP (Figure 2-1, Table 2-1). Sampling areas were selected based on exposure to the Mine effluent (Golder 2020a) and consisted of the NF area and three MF areas. In addition, FF1-2 and FFD-1 were sampled. Sampling stations in the MF areas follow transect lines that run from the NF area towards the far-field (FF) areas (i.e., FF1, FFA, and FFB [although the latter two FF areas are not sampled in interim years and, therefore, are not shown on Figure 2-1]). The MF1 transect is located northwest of the NF area and runs towards the FF1 area. The MF2 transect is located to the northeast and includes the FF2 stations near the Lac du Sauvage (LDS) inlet. The MF3 transect is located south of the NF area, and runs towards the FFB and FFA areas. In 2020, station FF1-2 was included in interim sampling years, instead of only being sampled in comprehensive years, and station, FFD-1, was added to help delineate the extent of effects extending away from the NF area between the MF1 and MF3 transects (Golder 2020a).

In addition to the 21 stations in Lac de Gras, stations located at the outlet of Lac de Gras to the Coppermine River (LDG-48) and at the narrows between Lac de Gras and Lac du Sauvage (LDS-4) were also sampled.



LEGEND

★	DIFFUSERS	→	FLOW DIRECTION
●	SURVEILLANCE NETWORK PROGRAM	—	WATERCOURSE
		▭	DIAVIK FOOTPRINT
		▭	WATERBODY

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

RioTinto

PROJECT

DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT

WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

TITLE

LOCATIONS OF AEMP EUTROPHICATION INDICATORS SAMPLING STATIONS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	2-1

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Table 2-1 Eutrophication Indicators Sampling Station Locations, 2021

Area	Station	UTM Coordinates[a]		Distance from Diffuser[b] (m)	Water Depth (m)
		Easting (m)	Northing (m)		
NF	NF1	535740	7153854	394	22.3
	NF2	536095	7153784	501	20.6
	NF3	536369	7154092	936	18.6
	NF4	536512	7154240	1,131	21.1
	NF5	536600	7153864	968	20.6
MF1	MF1-1	535008	7154699	1,452	19.5
	MF1-3	532236	7156276	4,650	18.9
	MF1-5	528432	7157066	8,535	18.0
MF2	MF2-1	538033	7154371	2,363	18.0
	MF2-3	540365	7156045	5,386	20.3
	FF2-2	541588	7158561	8,276	19.1
	FF2-5	544724	7158879	11,444	20.0
MF3	MF3-1	537645	7152432	2,730	19.7
	MF3-2	536816	7151126	4,215	22.6
	MF3-3	536094	7148215	7,245	20.6
	MF3-4	532545	7147011	11,023	20.0
	MF3-5	528956	7146972	14,578	18.6
	MF3-6	525427	7148765	18,532	18.0
	MF3-7	521859	7150039	22,330	21.5
FF1	FF1-2	524932	7159476	12,915	19.0
FFD	FFD-1	522495	7155084	17,315	19.5
Outlet of Lac de Gras	LDG-48	490900	7161750	55,556	2.2
Outlet of Lac du Sauvage	LDS-4	546797	7159595	-	0.4

a) UTM coordinates are reported as Zone 12, North American Datum (NAD) 83.
b) Approximate distance from the Mine effluent diffusers along the most direct path of effluent flow.
UTM = Universal Transverse Mercator coordinate system; - = not applicable; NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage.

The field sampling program included the collection of water samples for analysis of nutrients and chlorophyll *a*, phytoplankton and zooplankton samples for biomass analysis, and in situ water quality measurements. Sampling was conducted once during ice-cover season and once during the open-water season (Attachment A):

- ice-cover season sampling period: 19 April to 9 May 2021
- open-water season sampling period: 15 August to 15 September 2021

Nutrient samples were collected in both seasons, while chlorophyll *a*, phytoplankton, and zooplankton samples were collected during the open-water season only. The sampling protocol for nutrients differed between the ice-cover and open-water seasons, according to DDMI Standard Operating Procedure (SOP), ENVI-923-0119 AEMP “Combined Open-Water and Ice-Cover” and as described below. Water samples were handled according to DDMI SOPs, ENVI-902-0119 “Quality Assurance Quality Control” and ENVI-900-0119 “Chain of Custody”.

Because the effluent may not be vertically mixed under ice-cover and water chemistry may differ among depths, samples were collected at three discrete depths during the ice-cover season. Duplicate samples were collected at the top, middle, and bottom depths at each NF, MF, and FF2 station, and at a single depth (i.e., middle) at the FF1-2, FFD-1, and LDG-48 stations. Surface samples were collected at a depth of 2 m from ice surface, and bottom samples were collected 2 m from the lake bottom. Mid-depth samples were collected at the middle of the total water column depth. No sample was collected at LDS-4 during the ice-cover season.

During the open-water season, duplicate depth-integrated water samples were collected at each station for the analysis of nutrients and chlorophyll *a*. Only water quality, nutrients, chlorophyll *a*, and phytoplankton biomass were sampled at LDG-48 and LDS-4. These stations are shallow, which does not allow quantitative zooplankton sampling using a plankton net.

Depth-integrated water samples were collected at deep stations for nutrient analysis to provide an estimate of the concentrations of nutrients to which phytoplankton are exposed. These samples were collected from the top 10 m of the water column using a depth-integrated sampler. A second depth-integrated sample was collected to produce duplicate samples for nutrients and chlorophyll *a* at each station. The phytoplankton biomass (as biovolume) data presented herein were taken from the Plankton Report (Appendix XI); however, samples were collected in the same manner as for nutrients and chlorophyll *a*, with the exception that twelve depth-integrated samples at a station were combined, and the resulting composite sample was used to fill a sample bottle for phytoplankton taxonomy.

Duplicate zooplankton samples were collected using a plankton net (30 cm mouth diameter, 75 µm mesh) for the determination of zooplankton biomass as AFDM. Each sample consisted of a composite of three vertical hauls through the entire water column.

2.2 Laboratory Analysis

Nutrient samples, excluding SRSi, were sent for analysis to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics Inc.) in Edmonton, Alberta (AB), or Calgary, AB, Canada. The SRSi samples were sent to ALS Laboratories (ALS) in Vancouver, British Columbia, Canada. As in recent years, filtering of the dissolved nutrient samples in 2021 was performed at BV Labs. Duplicate samples for total ammonia analysis were also sent to ALS. To be consistent with the dataset used in the Effluent and Water Chemistry Report (Appendix II), total ammonia data from ALS were used in the data analysis of the ice-cover season and total ammonia data from BV Labs were used for the open-water season (see Section 2.3.1 in the Effluent and Water Chemistry Report [Appendix II]).

A list of the nutrients analyzed and the analyte-specific detection limits (DLs) reported in 2021 are provided in Table 2-2. The target DL as stated in the design plan was not achieved for some samples due to insufficient sample volume or other problems with the original sample (e.g., interference by other analytes). Deviations from the target DLs and a discussion of potential effects on data quality are discussed in Attachment B. Raw nutrient data are provided in Attachment F.

Table 2-2 Detection Limits for Nutrient Analysis, 2021

Variable	Unit	Detection Limit
Nutrients		
Total phosphorus	µg-P/L	2
Total dissolved phosphorus	µg-P/L	2
Soluble reactive phosphorus	µg-P/L	1
Total nitrogen	µg-N/L	20
Total dissolved nitrogen	µg-N/L	20
Total Kjeldahl nitrogen	µg-N/L	20
Dissolved Kjeldahl nitrogen	µg-N/L	20
Total ammonia	µg-N/L	5
Nitrate	µg-N/L	2
Nitrite	µg-N/L	1
Nitrate + nitrite	µg-N/L	2 or 2.2[(a)]
Soluble reactive silica	µg/L	10

a) All ice-cover samples met target DL of 2.2 µg/L; all open-water samples had DL of 2 µg/L

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre.

Depth-integrated chlorophyll *a* samples were sent to the Biogeochemical Analytical Service Laboratory at the University of Alberta, Edmonton, AB, Canada. Samples were analyzed for chlorophyll *a* at a DL of 0.04 µg/L. Composite phytoplankton samples were submitted to Biologica Environmental Services, Ltd. (Biologica), Victoria, British Columbia, for analysis of abundance and biomass. Analytical methods are presented in the Plankton Report (Appendix XI). Zooplankton biomass (as AFDM) was measured by BV Labs, Calgary, AB, Canada.

2.3 Quality Assurance/Quality Control

The *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017a) outlines the quality assurance (QA) and quality control (QC) procedures employed to support the collection of scientifically defensible and relevant data required to meet the objectives of the *AEMP Design Plan Version 5.2* (Golder 2020a). The QAPP is designed so that field sampling, laboratory analysis, data entry, data analysis, and report preparation activities produce technically sound and scientifically defensible results. A description of the QA/QC practices applied to the eutrophication indicators component of the 2021 AEMP and an evaluation of the QC data are provided in Attachment B. Nutrient data collected during the 2021 AEMP were considered to be of acceptable quality, with the exception of total ammonia results and five values that had multiple QC failures. Each data quality issue is discussed below.

Data quality issues with total ammonia continue to be a concern, with occasional detections in blank samples, and relatively high variability between duplicate samples. It is difficult to reliably measure low concentrations of total ammonia due to the high potential of sample contamination at the low DLs selected for the AEMP.

As discussed in the Effluent and Water Chemistry Report (Appendix II), BV Labs identified a contamination issue for total ammonia in the ice-cover dataset. BV Labs identified their black capped vials as a likely source of ammonia contamination part-way through the ice-cover season. BV labs switched to the use of septa caps following this discovery. Stations were mostly split between black capped, or septa capped vials, with both container types only used at two stations (i.e., MF3-5 and MF3-6). At the stations where both vials were filled, the septa cap vials had lower concentrations. BV Labs recommended use of its own data from stations sampled with septa cap vials, and use of ALS data from other stations. This recommendation was not accepted because use of a complete dataset is preferred for each season from a single laboratory. Therefore, total ammonia data generated by ALS was used for the ice-cover season in the 2021 AEMP data analysis.

For the open-water season, BV Labs used septa cap vials for all total ammonia samples. An interlaboratory comparison study conducted by BV Labs indicated that the total ammonia data generated by BV Labs had fewer data quality issues than the ALS dataset and should, therefore, be used for the analysis of the open-water dataset. This recommendation was accepted and the total ammonia data generated by BV Labs was used for the open-water season in the 2021 AEMP data analysis.

Five values were removed from the dataset prior to anomalous value screening, generating plots, and statistical analysis because of multiple QC failures. These values and the rationales for their removal are provided below:

- The reported TN and TKN values for MF2-1B-4 collected during the ice-cover season were 33 µg-N/L and <20 µg-N/L, respectively, which were an order of magnitude lower than their duplicates (TN = 320 µg-N/L, TKN = 173 µg-N/L) and failed the data quality objective (DQO) with high RPDs (TN = 163%, TKN = 159%). These values were not consistent with those reported at the mid and top depths. Three lines of evidence suggest that the reported values for MF2-1B-4 were not representative of concentrations at this station: 1) Concentrations were much higher and similar to one another at other depths, 2) dissolved concentrations (TDN and DKN) were higher for the same samples, and 3) concentrations at other depths from these stations were consistent with concentrations measured at nearby stations.
- The reported TDN and DKN values for MF3-3T collected during the ice-cover season were both 32 µg-N/L, which were lower than their duplicates (TDN = 160 µg-N/L, DKN = 149 µg-N/L) and failed the DQO with an RPD of 133% and 129% respectively. The reported TDN and DKN values were not considered representative at this station because the corresponding TN value was much higher (TN = 140 µg-N/L, TKN = 140 µg-N/L) and consistent with other TN and TKN concentrations at nearby stations.
- The reported TDP value for FF1-2 collected during the open-water season was 49.8 µg-P/L, which was higher than its duplicate (2 µg-P/L) and failed the DQO with an RPD of 185%. The value of 49.8 µg-P/L was not considered representative of the station because (1) the corresponding TP value and duplicate were both lower (2 µg-P/L) and consistent with other TP and TDP concentrations at nearby stations and (2) it was an order of magnitude higher than typical concentrations reported from Lac de Gras.

Chlorophyll *a* concentrations were observed to be noticeably higher in 2021 than in 2020, despite a similar TP loading from effluent and no obvious potential increase related to deposition of TP in dust. Further investigation did not identify any other reasons to doubt the reliability of the measured values:

- A review of the field datasheets did not identify any unexpected field conditions or issues that may have affected the chlorophyll *a* samples. The field staff confirmed that collection methods and sample handling followed approved SOPs.
- The analytical laboratory (U of A) confirmed that the correct filtration volumes, as recorded on the Chain of Custody forms, were used to calculate the final chlorophyll *a* concentrations.
- The RPDs for duplicate samples ranged from 0 to 13%, indicating high reproducibility of results within a station.
- No anomalous values were identified in the data screening (Section 2.4.1).
- Similar to previous years, chlorophyll *a* concentrations were elevated in the NF area and decreased with distance from the diffuser. This trend is consistent with an effluent-related, rather than a dust-related effect. The potential total anthropogenic loading of TP from dust was also similar to 2020 (Attachment D).

However, there was a lack of a corresponding response in total phytoplankton biomass. It is not clear why chlorophyll *a* concentrations would be elevated without at least a minor corresponding increase in phytoplankton biomass. This suggests a potential but unidentified data quality issue associated with the chlorophyll *a* dataset.

2.4 Data Analysis

2.4.1 Data Screening

Initial screening of the 2021 nutrient, chlorophyll *a*, and zooplankton biomass (as AFDM) datasets was completed before generating plots and statistical analyses to identify unusually large (or small) values and decide whether to retain or exclude anomalous data from further analysis. The anomalous data screening methods are described in the QAPP (Golder 2017a). This screening was done on the individual sample results (i.e., duplicate data were not averaged).

Data screening for anomalous values identified one potentially anomalous value in the 2021 eutrophication indicators dataset, representing 0.005% of the dataset. The reported TDP value of 6 µg/L for MF1-1T-4 collected during the ice-cover season was higher than its duplicate (2 µg/L for MF1-1T-5), with an RPD of 100% (Table B-4). The TDP value was also higher than its corresponding TP value, with an RPD of 89% (Table B-7). However, the value was not considered a DQO fail because it was not greater than or equal to five times the detection limit (DL). As the TDP value of 6 µg/L is within five times the DL (i.e., the range of analytical uncertainty) and the average concentration of the two duplicates is 3.5 µg/L, which is within the range of TDP values that could reasonably occur at this station, it was retained in the dataset used for analysis.

2.4.2 Censored Data

For the purposes of the AEMP, censored data are concentrations reported below the analytical DL (<DL, referred to as non-detect values). Due to the location of Lac de Gras on the Canadian Shield, concentrations of many water quality variables are low and at or below the DL. A frequently used, simple approach to deal with censored data is the substitution of a surrogate value (e.g., the DL or some fraction of the DL) for non-detect data, which is considered generally acceptable in cases when a relatively small proportion of the data (e.g., <15%) are <DL. Prior to data analyses, non-detect values were substituted with half the DL (i.e., 0.5 times the DL). This approach for handling censored data (US EPA 2000) is consistent with the approved methods applied in the calculation of the normal range in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). Data reported as <DL are presented on plots at half the DL.

2.4.3 Effluent and Mixing Zone

The quantity of nutrients in effluent was evaluated graphically by plotting total monthly loads of nutrients. The daily load from each diffuser was calculated by multiplying the effluent discharge rate by the nutrient concentration at each effluent diffuser station (i.e., SNP 1645-18 and SNP 1645-18B). The total daily load was calculated as the sum of loads from the two diffusers. Total monthly loads represent the sum of the total daily loads for a given month. The period of effluent discharge summarized in this report (i.e., the reporting period) was 1 November 2020 to 31 October 2021.

Time series plots showing the concentrations of nutrients in effluent were generated for the reporting period (Section 3.1). Results for individual grab samples were plotted separately for each effluent diffuser station (i.e., SNP 1645-18 and SNP 1645-18B).

Water was sampled at the mixing zone boundary monthly[2], at five depths (i.e., 2, 5, 10, 15, and 20 m) at each of the three mixing zone stations (i.e., SNP 1645-19A, SNP 1645-19B, SNP 1645-19C). Hence, up to 15 samples were collected each month. Results were summarized as boxplots showing 10th, 25th, 50th (median), 75th, and 90th percentile concentrations, circles represent the 5th and 95th percentile concentrations.

The quality of the effluent was assessed in the Effluent and Water Chemistry Report (Appendix II) by comparing water chemistry results at stations SNP 1645-18 and SNP 1645-18B with the Effluent Quality Criteria (EQC) defined in the Water Licence. Results for key nutrient variables are presented herein, specifically TP, TDP, SRP, TN, total ammonia, nitrate, and nitrite. Total phosphorus has an EQC specified in terms of load, rather than concentration. The Water Licence specifies that the load of TP must not exceed a maximum of 300 kg/mo, an average annual load of 1,000 kg/yr during the life of the Mine, and a maximum load of 2,000 kg/yr in any year during the life of the Mine.

[2] Samples at the mixing zone boundary were not sampled in June 2021 due to unsafe ice conditions.

2.4.4 Lac de Gras

2.4.4.1 Gradient Analysis

The spatial gradients in water quality variables along the three MF transects were analyzed using linear regression, as described in the *AEMP Design Plan Version 5.2* (Golder 2020a). The NF area data were included in the linear regression for each of the three MF transects. Hereafter, the NF-MF1 transect is referred to as MF1, the NF-MF2-FF2 transect is referred to as MF2, and the NF-MF3 transect is referred to as MF3. The stations included in each of the MF transects are described in Section 2.1. A single maximum value of either top, middle or bottom depth samples for the three MF transects was used for each station in the regression analysis. Regression analyses were considered significant at $\alpha = 0.05$.

Due to the length of the MF3 transect, variables often had non-linear patterns with distance from the diffusers. Therefore, the analysis method allowed for piecewise regression (also referred to as segmented, or broken stick regression). Two approaches were used:

- Model 1: a linear multiplicative model, with main effects of distance from diffusers, gradient (MF1, MF2, and MF3 transects), and their interaction
- Piecewise modelling to account for changes in spatial gradients in MF3, where MF1 and MF2 were analyzed separately from MF3:
  - Model 2: a linear multiplicative model, with main effects of distance from diffusers, gradient (MF1 and MF2 transect only), and their interaction
  - Model 3: a linear piecewise (i.e., broken stick) model with distance (MF3 transect only)

For each variable in each season, Model 1 was used to test for presence of a significant (P<0.05) breakpoint using the Davies test (Davies 1987, 2002). If a significant breakpoint was identified, Models 2 and 3 were used for that variable in that season. If no significant breakpoint was identified, Model 1 was used for that variable in that season.

Following the initial fit of the model, the residuals (of either Model 1 or Model 2, as applicable) were used to examine whether data needed to be transformed to meet regression assumptions. Model 3 was not considered for transformations, since the addition of a breakpoint was expected to resolve non-linear patterns. For each response variable in each season, the data underwent Box-Cox transformations (Box and Cox 1964). The Box-Cox transformations are a family of transformations that include the commonly used log and square root transformations. The Box-Cox transformation process tests a series of power values, usually between -2 and +2, and records the log-likelihood of the relationship between the response and the predictor variables under each transformation. The transformation that maximizes the log-likelihood is the one that will best normalize the data. Therefore, the data are transformed using a power value identified by the transformation process. For a power value (λ) of zero, the data are natural log transformed. The transformation rules can be described using the following definitions:

$$\text{Transformed value} = \frac{\text{value}^{\lambda} - 1}{\lambda}\text{ , if } \lambda \neq 0$$

$$\text{Transformed value} = \ln(\text{value})\text{ , if } \lambda = 0$$

The selected transformation was applied to all data (i.e., if piecewise modelling was used, a transformation selected based on Model 2 was also applied to MF3 data used in Model 3).

Following data transformation (if required), the selected models were fitted to the data. Statistical outliers were identified using studentized residuals with absolute values of 3.5 or greater, or due to consideration of leverage (where a single point could strongly influence the overall fit of the model). All values removed from analysis were retained for plots of model predictions, where they were presented using a different symbol from the rest of the data.

Following removal of outliers, breakpoint significance and data transformation were re-examined. Residuals from the refitted models were examined for normality, heteroscedasticity, and evidence of non-linear patterns. If non-linearity was evident from residual examination, the analysis was terminated and data were presented qualitatively. If residual assessments did not suggest that assumptions of linearity or residual normality were violated, then three models were constructed to assess the effect of heteroscedasticity for each response variable in each season:

- heteroscedasticity by gradient (applied only to Models 1 and 2)
- heteroscedasticity by predicted value (accounting for the classic trumpet shape of heteroscedastic data)
- heteroscedasticity by distance from the diffuser

These three models were compared to the original model that did not account for heteroscedasticity, using Akaike's information criterion (AIC), corrected for small sample size (AICc). The model with the lowest AICc score among a set of candidate models was interpreted to have the strongest support, given the set of examined models and the collected data (Burnham and Anderson 2002), and thus was selected for interpretation. When using AIC not corrected for small sample size, models with AIC scores within two units of each other are considered to have similar levels of support (Arnold 2010). Since the small sample size correction was used in the analysis, the cut-off value was adjusted to reflect the higher penalization of model parameters (the adjustment depended on the number of data points and model parameters).

The constructed models were used to produce the following outputs:

- Estimates and significance of slopes (i.e., distance effects) for each gradient. In the case of MF3 data analyzed using piecewise regression, the significance of the first slope, extending from the NF to the breakpoint, was estimated.
- The r^2 value of each model, to examine explained variability.
- Fitted prediction lines and 95% confidence intervals (back-transformed to original scale of the variable).

Based on US EPA (2000) guidance, a screening value of greater than 15% censoring was used to flag datasets that may not be amenable to the linear regression analysis. The decision of whether to analyze the data using linear regression was based on review of the number of values <DL for each variable and season. Because of a large number of values <DL, linear regression analysis was not performed for:

- TP: ice-cover (46% <DL) and open-water (50% <DL)

- TDP: ice-cover (71% <DL) and open-water (89% <DL)
- SRP: ice-cover (58% <DL) and open-water (98% <DL)
- TDN: open-water (50% <DL)
- DKN: open-water (59% <DL)
- nitrite: ice-cover (50% <DL) and open-water (61% <DL)
- nitrate + nitrite: open-water (22% <DL)

Scatterplots of concentrations according to distance from the effluent discharge were included for variables that had large numbers of values that were <DL.

2.4.4.2 Normal Ranges

Magnitude of effects on indicators of eutrophication were evaluated by comparing nutrient concentrations, chlorophyll *a*, and phytoplankton and zooplankton biomass in the NF and MF areas to background values. Background values for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range. Normal ranges were calculated using data from 2007 to 2010 (with some exceptions) and three AEMP FF areas (i.e., FF1, FFA, and FFB). The normal ranges used to evaluate potential effects for indicators of eutrophication were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a) and are summarized in Table 2-3.

Table 2-3 Normal Ranges for Eutrophication Indicators

Variable	Unit	Normal Range			
		Ice-cover		Open-water	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
Total phosphorus	µg-P/L	2.0	5.0	2.0	5.3
Total dissolved phosphorus	µg-P/L	1.1	3.2	0	3.5
Soluble reactive phosphorus	µg-P/L	0	1.5	0	1.0
Total nitrogen	µg-N/L	138	173	122	153
Total dissolved nitrogen	µg-N/L	130	166	105	133
Total ammonia	µg-N/L	11	17	0	6
Nitrate	µg-N/L	0	15.2	0	2.0
Nitrite	µg-N/L	0	2	0	2
Nitrate + nitrite	µg-N/L	5	10	0	1
Chlorophyll *a*	µg/L	-	-	0.31	0.82
Phytoplankton biomass	mg/m^3	-	-	19.1	385
Zooplankton biomass as AFDM	mg/m^3	-	-	16.4	40.5

Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

AFDM = ash-free dry mass; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; mg/m^3 = milligrams per cubic metre; - = not applicable.

2.4.4.3 Extent of Effects

To estimate the extent of effects, the area of the lake with values greater than the normal range was estimated for TP, TN, chlorophyll *a*, and phytoplankton and zooplankton biomass. The extent of effects calculated for 2021 was compared with those estimated in previous years to evaluate whether effects were expanding farther into the lake over time.

Directive 2B from the 25 March 2019 WLWB Decision regarding the *AEMP 2017 Annual Report* (Golder 2018) directed DDMI to present the spatial extent of effects of eutrophication indicators for both the ice-covered and open-water seasons in future AEMP Annual Reports. Therefore, the extent of effects was calculated for both seasons. In addition, the extent of effects was calculated for all three depths (i.e., top, middle, and bottom) for the ice-covered season.

To quantify extent of effects along each transect, a linear interpolation method was used to estimate the distance between the station farthest from the diffuser with a value greater than the normal range, and the adjacent station with a value below the normal range. In cases where concentrations did not decrease uniformly with distance from the diffuser, a conservative approach was taken by assuming that the effect extended to the farthest station with a concentration above the normal range, even if closer stations along the transect had concentrations below the normal range.

For TP, concentrations in the MF areas were above normal range, but the average concentration in the NF area was not. Because the extent of elevated concentrations occurred over two MF stations and there was an apparent trend of decreasing TP concentration with distance along that transect, the lake area affected was calculated by conservatively assuming that the NF area had a mean TP concentration at the upper limit of the normal range. This likely overestimated the lake area affected.

2.4.4.4 Role of Nitrogen in Spatial Extent of Chlorophyll *a*

The 25 March 2019 WLWB Directive regarding the *2014 to 2016 Aquatic Effects Re-evaluation Report* required DDMI to include a spatial analysis of TN across the spatial extent of increased chlorophyll *a* in Lac de Gras. This directive was addressed in Section 5.3.5.3 of the *2014 to 2016 AEMP Re-evaluation Report Version 1.1* (Golder 2019b) and again in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) using data available for all AEMP monitoring years up to 2019. To address this recommendation during an interim sampling year, relationships among these variables were evaluated in the 2021 open-water dataset by calculating Pearson correlation coefficients.

2.4.4.5 Effects from Dust Deposition

Concerns have been raised regarding the potential for dust emissions from the Mine to affect nutrient enrichment in Lac de Gras. To address these concerns, the following analyses have been presented:

- **Calculation of annual TP loads from dust deposition to Lac de Gras**. Consistent with methods in previous AEMP reports (e.g., *AEMP 2020 Annual Report*, Golder 2021), the relative magnitudes of phosphorus delivered to Lac de Gras in 2021 from natural (i.e., background) and anthropogenic (Mine-related) dust deposition were estimated using data from the 2021 dustfall monitoring program. The annual TP load from dust was compared to the TP load from effluent, with the caveat that the dust program was not designed to be as precise as effluent monitoring for measuring TP loads to Lac de

Gras; findings from this analysis should be considered along with the other lines of evidence described below.

- **Visual comparison of open-water TP and chlorophyll *a* concentrations within the estimated zone of influence (ZOI) from dust deposition to results at other nearby stations outside the ZOI, and to reference conditions for Lac de Gras (i.e., normal range)**. Based on the analysis conducted for the last re-evaluation, the dust ZOI is estimated to extend between 3.7 and 4.8 km from the geographic centre of the Mine (i.e., the Mine centroid), or between 0.3 and 4.2 km from the boundary of the Mine footprint (Golder 2020b). These distances were estimated based on gradient analysis of dust deposition relative to distance from the Mine site and encompass the area of the lake where potential effects would be expected to be measurable (Golder 2020b). Beyond this estimated zone, dust deposition levels are similar to background levels. The AEMP sampling stations that fall within the expected zone of influence (ZOI) from dust deposition include the five stations in the NF area and stations MF1-1, MF3-1, MF3-2 and MF3-3[3].
- **Summary of the Special Effects Study – Dust Deposition (Dust SES; Appendix XI to the *AEMP 2019 Annual Report* [Golder 2020c])**. The Dust SES sampled stations that were located closer to the potentially high dust generating areas than the AEMP stations noted above that are within the dust ZOI. Also, the Dust SES identified the geochemical signatures of Mine effluent and dustfall and evaluated the fate of dust-related phosphorus in lake water.
- **Summary of the spatial-temporal analysis and comparison of phosphorus deposition rates and phosphorus concentrations in Lac de Gras at the end of the ice-cover season from the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b)**. During spring break-up, the entire winter dust load that accumulated on lake ice is delivered to lake water over a short period, resulting in the maximum potential dust-related increase in phosphorus concentration in lake water within a typical year. The re-evaluation analysis provided estimated increases in TP and SRP concentrations in lake water at spring break-up within and outside the dust ZOI, using dust deposition estimates and lake water chemistry data accumulated over the last decade of monitoring.

2.5 Action Level Evaluation

The magnitude of effects on selected assessment endpoints was categorized according to the Action Level framework described for indicators of eutrophication in the *AEMP Design Plan Version 5.2* (Golder 2020a). The Action Level classifications were developed to meet the goals of the draft Guidelines for Adaptive Management (WLWB 2010) and Racher et al. (2011). The main goal of the Response Framework is to ensure that significant adverse effects never occur. This is accomplished by requiring proponents to take actions at predefined Action Levels, which are triggered well before significant adverse effects could occur.

[3] Formerly, Station MF2-1 was considered within the dust ZOI; with the revised dust ZOI delineated in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b), this station is no longer expected to be measurably affected by dust. Station MF3-3 is now within the dust ZOI.

The Significance Threshold for the indicators of eutrophication is a concentration of chlorophyll *a* and TP that exceeds the Effects Threshold by more than 20% in the FFA area of Lac de Gras (Table 5.2-3; Golder 2020a). In contrast to linking toxicological impairment responses to water chemistry (e.g., from elevated concentrations of metals), eutrophication responses are difficult to link to nutrient concentrations. As demonstrated by years of monitoring in Lac de Gras, concentrations of TP do not predict the actual biological response to nutrient enrichment. Rather, the increase in the biomass of algae as measured by chlorophyll *a* has been a more useful measure of the effects of nutrient enrichment.

Elevated concentrations of nutrients were predicted in Lac de Gras (Government of Canada 1999). Specifically, up to 20% (i.e., 116 km^2) of the surface area of Lac de Gras was expected to exceed the EA Benchmark for phosphorus during peak operations during the open-water season, and up to 11% (i.e., 64 km^2) of the lake during the ice-cover season. Outside these areas, TP concentration was predicted to increase relative to baseline in parts of Lac de Gras, but concentrations would remain below the EA Benchmark. The “extent of effect” for the chlorophyll *a* and TP Action Levels reflects this prediction (Table 2-4).

Table 2-4 Action Levels for Chlorophyll *a* and Total Phosphorus

Action Level	Magnitude of Effect	Extent of Effect	Action/Notes
1	95th percentile of MF values greater than normal range[(a)]	MF station	Early warning.
2	NF and MF values greater than normal range[(a)]	20% of lake area or more	Establish Effects Benchmark.
3	NF and MF values greater than normal range plus 25% of Effects Benchmark[(b)]	20% of lake area or more	Confirm site-specific relevance of existing benchmark. Establish Effects Threshold.
4	NF and MF values greater than normal range plus 50% of Effects Threshold[(c)]	20% of lake area or more	Investigate mitigation options.
5	NF and MF values greater than Effects Threshold	20% of lake area or more	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
6	NF and MF values greater than Effects Threshold +20%	20% of lake area or more	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
7	95th percentile of MF values greater than Effects Threshold +20%	All MF stations	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
8	95th percentile of FFB values greater than Effects Threshold +20%	FFB	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
9[(d)]	95th percentile of FFA values greater than Effects Threshold+20%	FFA	Significance Threshold[(d)].

a) The normal ranges for chlorophyll *a* and total phosphorus were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).
b) Indicates 25% of the difference between the Effects Benchmark and the top of the normal range.
c) Indicates 50% of the difference between the Effects Threshold and the top of the normal range.
d) Although the Significance Threshold is not an Action Level, it is shown as the highest Action Level to demonstrate escalation of effects towards the Significance Threshold.
NF = near-field; MF = mid-field; FF = far-field; WLWB = Wek'èezhìı Land and Water Board; EQC = Effluent Quality Criteria.

Given that Action Level 2 for chlorophyll *a* has been triggered in previous years (Golder 2016a,b, 2017b), an Effects Benchmark for chlorophyll *a* was developed as part of *AEMP Study Design Version 3.5* (Golder 2014). The chlorophyll *a* Effects Benchmark concentration of 4.5 µg/L is appropriate in terms of both the aesthetic quality and food web functionality in Lac de Gras. Aesthetic qualities are likely to be preserved at chlorophyll *a* concentrations up to 10 µg/L, while a benchmark of 4.5 µg/L maintains the trophic classification of the lake as oligotrophic (Golder 2020a).

Although an Effects Benchmark does not need to be established until Action Level 2 has been triggered, an Effects Benchmark was developed for TP in AEMP Design Version 5.1, which has been carried forward to Version 5.2. In their decision regarding Version 5.1 of the AEMP design, the WLWB provided direction that the effects benchmark for TP was to be set at 7.5 µg/L.

3 RESULTS

3.1 Effluent and Mixing Zone

Monthly loads of TP generally followed the same pattern as concentrations in effluent with larger loads in April, May, June, and September, while effluent concentrations were highest between April and May (Figure 3-1). During the open-water season, the magnitude of the monthly loads continued to follow the effluent concentrations and generally followed effluent volume, with the exception of September. Concentrations at the mixing zone boundary also largely followed effluent concentrations, with greater concentrations in April and May; June samples at the mixing zone boundary could not be collected due to hazardous ice conditions.

The monthly TP load did not exceed the 300 kg/mo loading criterion, with the highest monthly load of TP (38 kg) occurring in April 2021. The annual TP load in 2021 (297 kg) was below the average annual loading criterion of 1,000 kg defined in the Water Licence, and much lower than the maximum annual loading criterion of 2,000 kg. The annual TP load in 2021 was comparable to the annual TP load in 2020 (289 kg).

Loads of TDP were more similar among months, with larger loads in January, February, and April (Figure 3-2). However, lower TDP loads generally occurred in the open-water season compared to the ice-cover season, which followed the magnitude of TDP in effluent (i.e., concentrations in effluent were generally lower during the open-water season; Figure 3-2). Concentrations of TDP at the mixing zone boundary were generally at the DL or close to the DL, with more detectable concentrations measured during April, July, and October. The concentrations of TDP at the mixing zone did not follow the same pattern as the effluent concentrations in that TDP was detected more during the open-water season than in the ice-cover season, when effluent concentrations were generally higher.

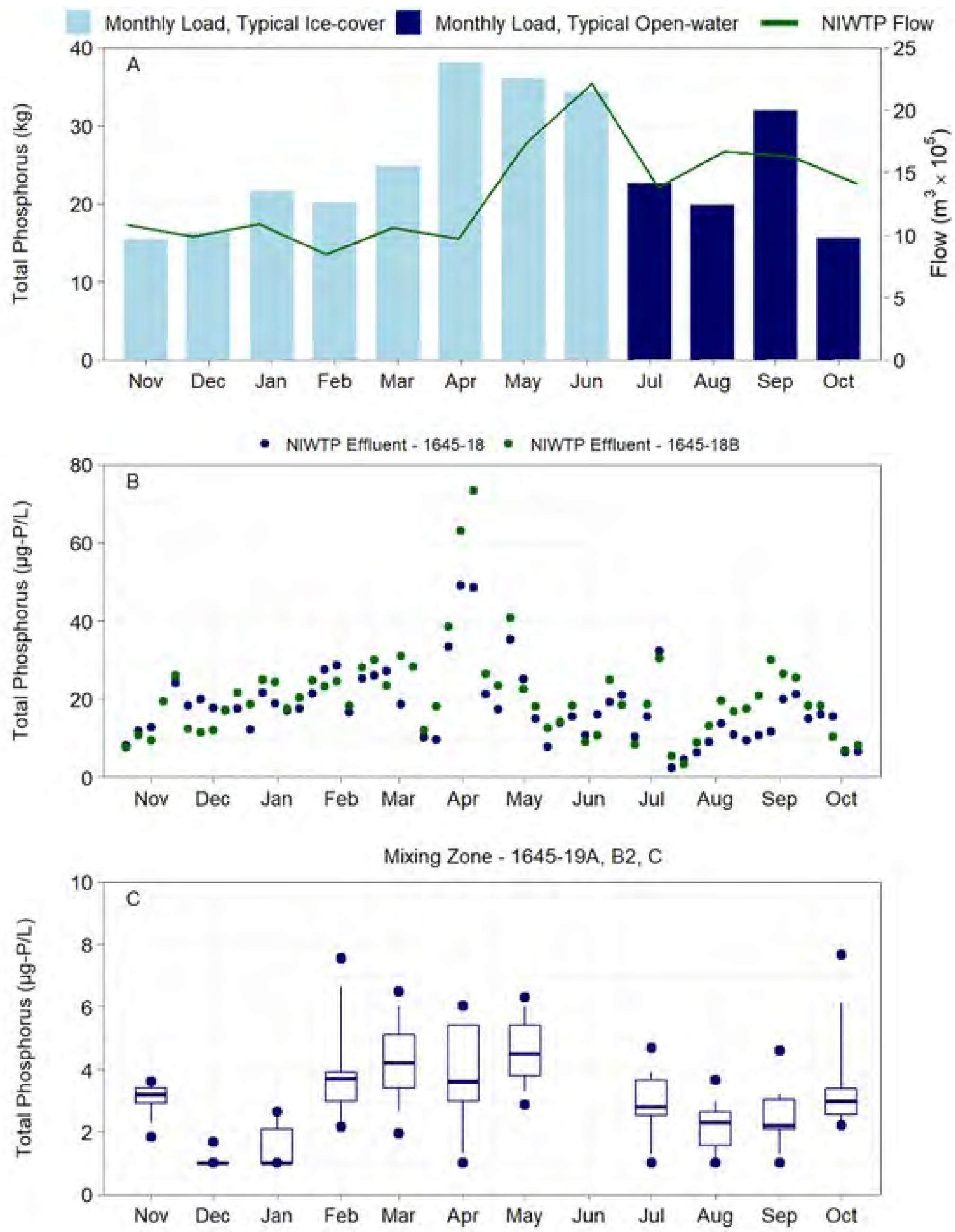
For SRP, monthly loads were higher during the ice-cover season and lower in the open-water season, and a similar pattern was observed in effluent and mixing zone concentrations (Figure 3-3).

All species of nitrogen had concentrations and loads in effluent that tracked closely together and followed a similar trend to effluent volume (Figure 3-4 to Figure 3-7). Monthly loads and effluent concentrations declined from November to April, then rose to a peak in June. This peak corresponded to a peak in effluent volume. Loads and effluent concentrations were greater during the open-water season compared to late winter (e.g., April). Most of the TN was present as nitrate in the effluent (Figure 3-5). Concentrations at the mixing zone boundary generally followed the same pattern as that of the effluent, with lower concentrations during the late open-water season (Figure 3-4 to Figure 3-6).

Total ammonia monthly loads and concentrations in effluent followed a similar pattern as the other nitrogen species during the ice-cover season, but not in the open-water season. Loads generally followed effluent volume for most months (Figure 3-7). Concentrations in effluent were highest in November to December and May to June, with lowest concentrations in April, July, and October. The smallest monthly load occurred in October and matched the lowest observed effluent concentrations. Concentrations at the mixing zone boundary generally followed those in effluent, with the exception of a lack of peak concentrations in May.

The decreases in concentrations of nitrate and total ammonia between May and July at the mixing zone boundary (Figure 3-4 to Figure 3-7) reflects quick assimilation by algae and bacterial nitrification (Wetzel 2001) during the shift between the seasons.

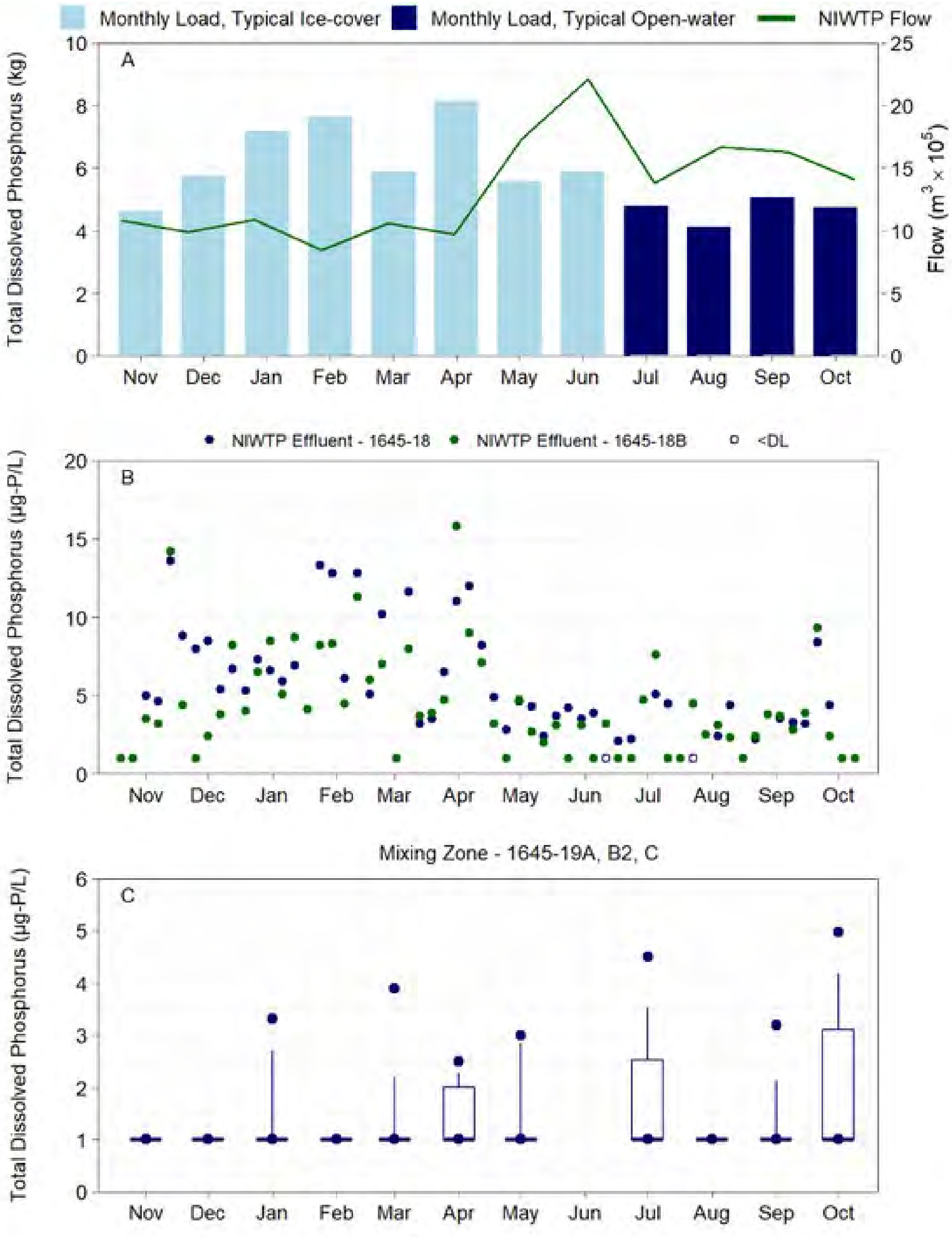
Figure 3-1 Total Phosphorus: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2020 to October 2021



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2021 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The filled symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-P/L = micrograms phosphorus per litre; NIWTP = North Inlet Water Treatment Plant.

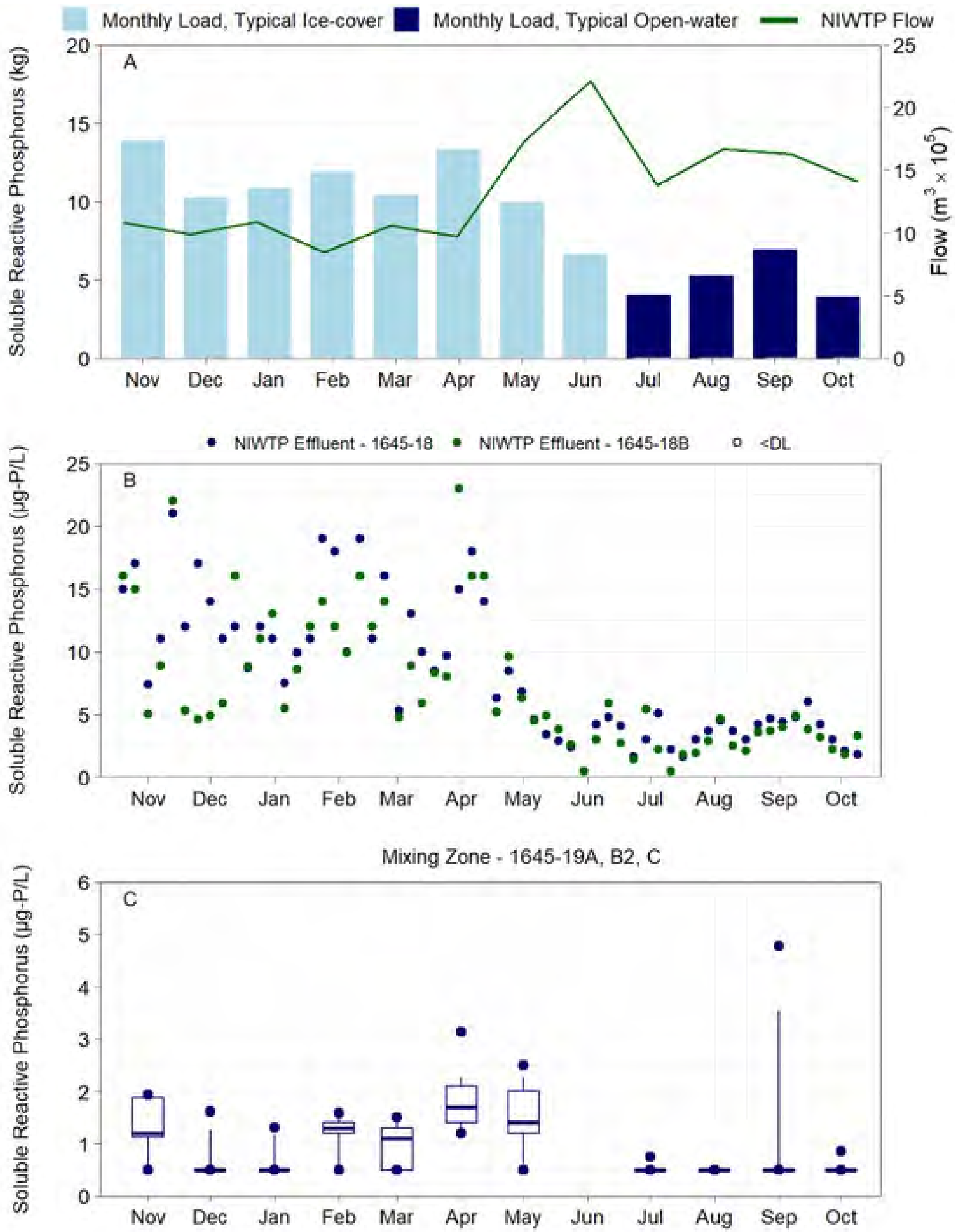
Figure 3-2 Total Dissolved Phosphorus: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2020 to October 2021



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2021 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The filled symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-P/L = micrograms phosphorus per litre; NIWTP = North Inlet Water Treatment Plant; <DL = less than detection limit.

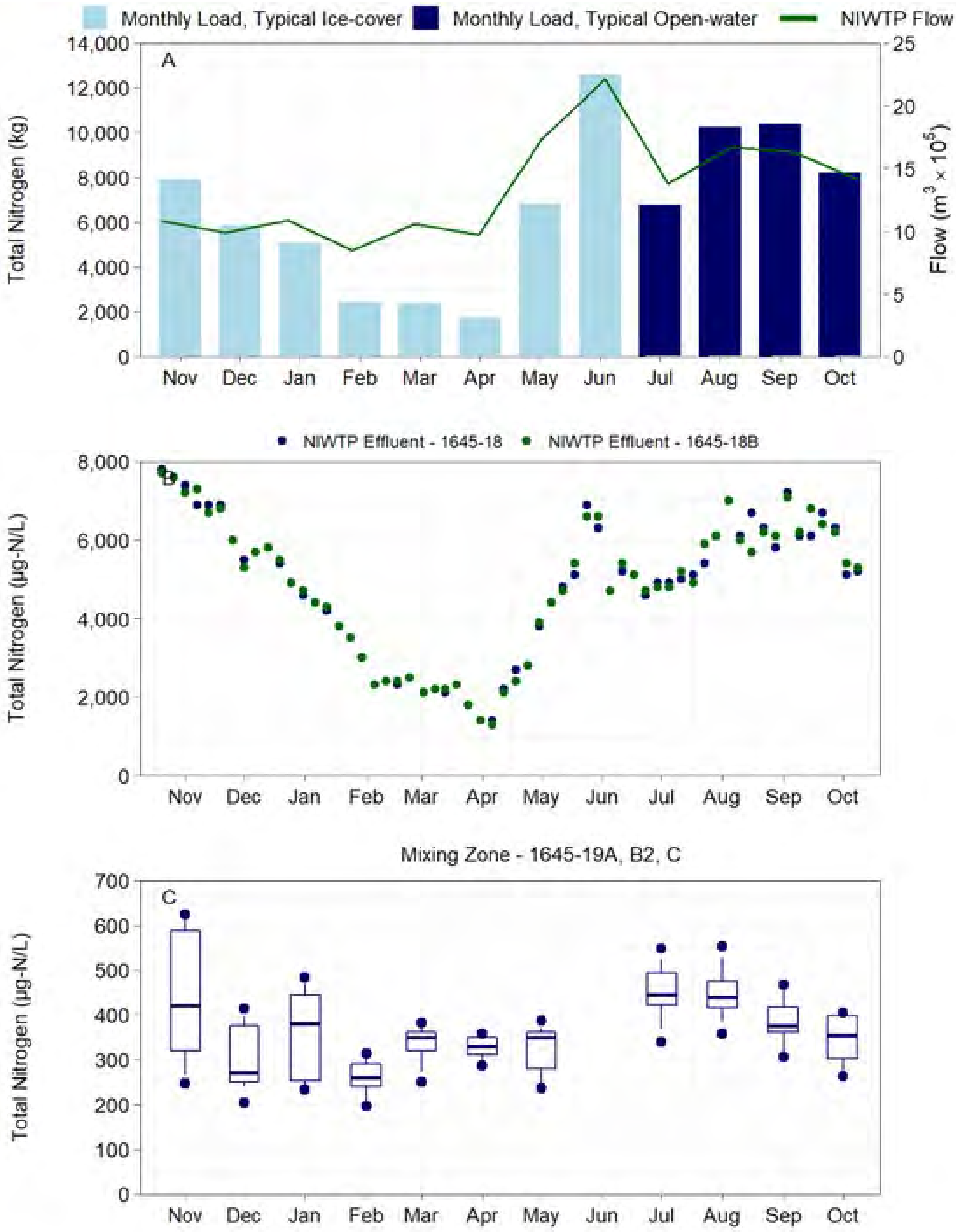
Figure 3-3 Soluble Reactive Phosphorus: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2020 to October 2021



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2019 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The filled symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-P/L = micrograms phosphorus per litre; NIWTP = North Inlet Water Treatment Plant; <DL = less than detection limit.

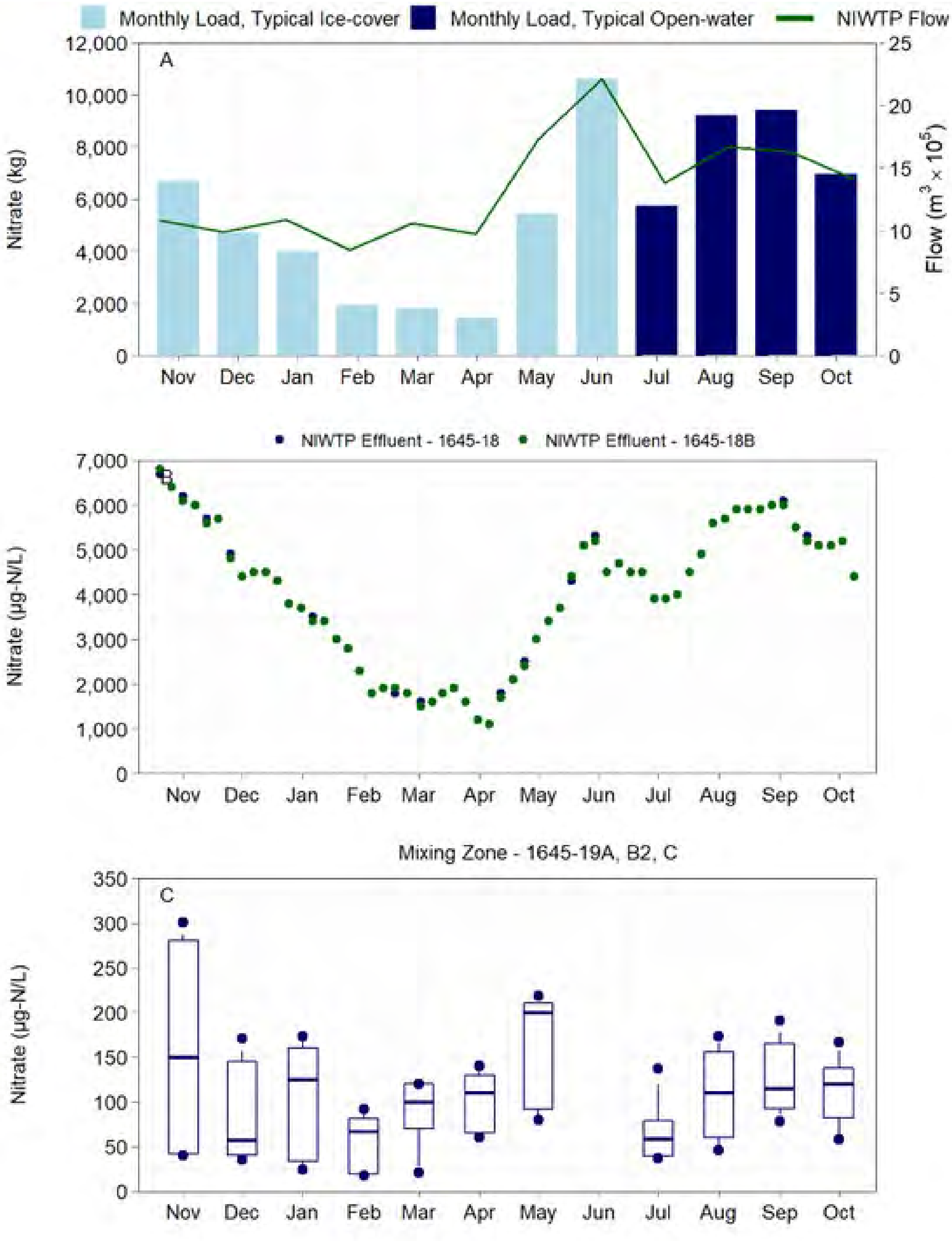
Figure 3-4 Total Nitrogen: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2020 to October 2021



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2021 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The filled symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant.

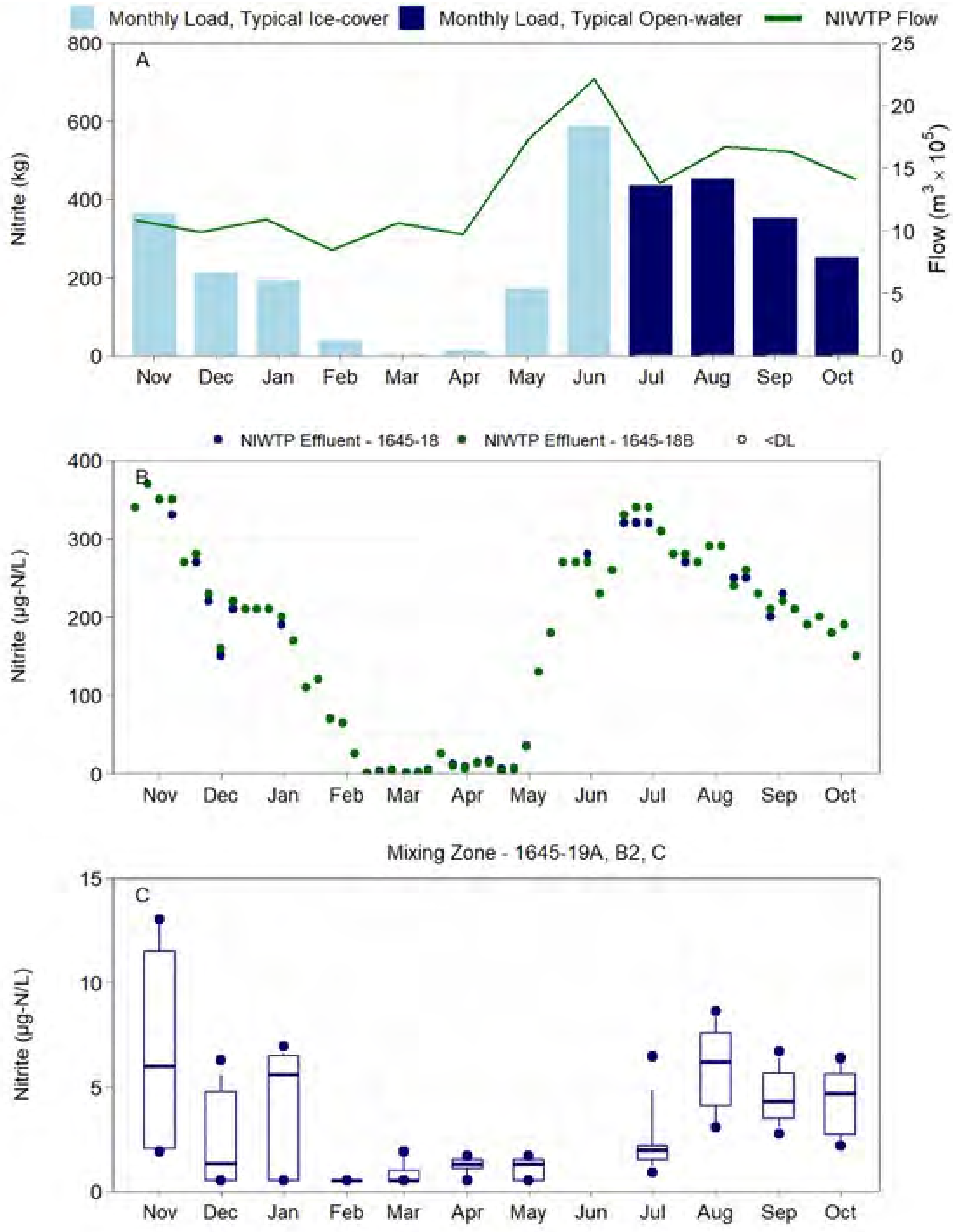
Figure 3-5 Nitrate: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2020 to October 2021



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2021 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The filled symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant.

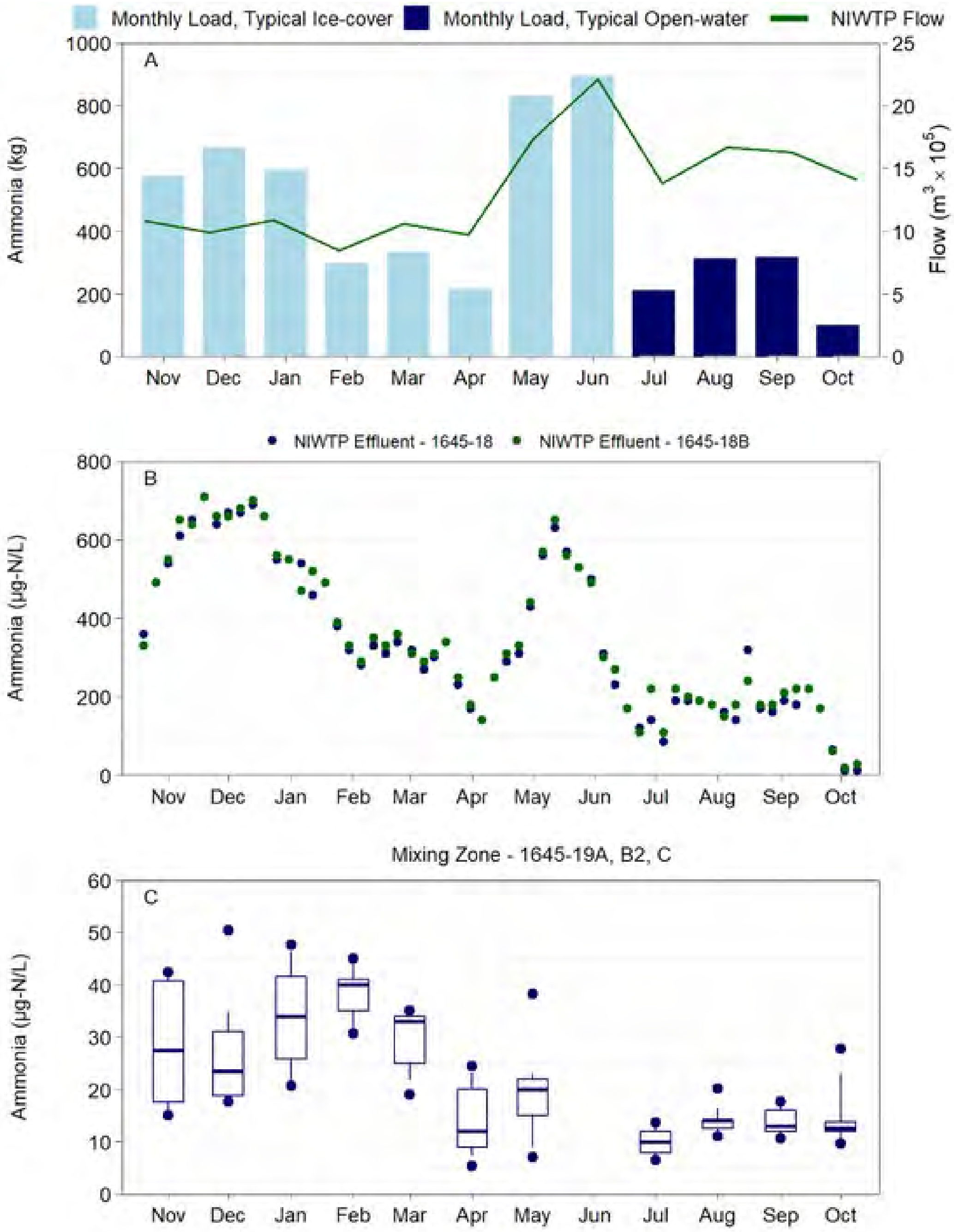
Figure 3-6 Nitrite: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2020 to October 2021



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2021 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The filled symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant; <DL = less than detection limit.

Figure 3-7 Total Ammonia: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2020 to October 2021



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2021 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The filled symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant.

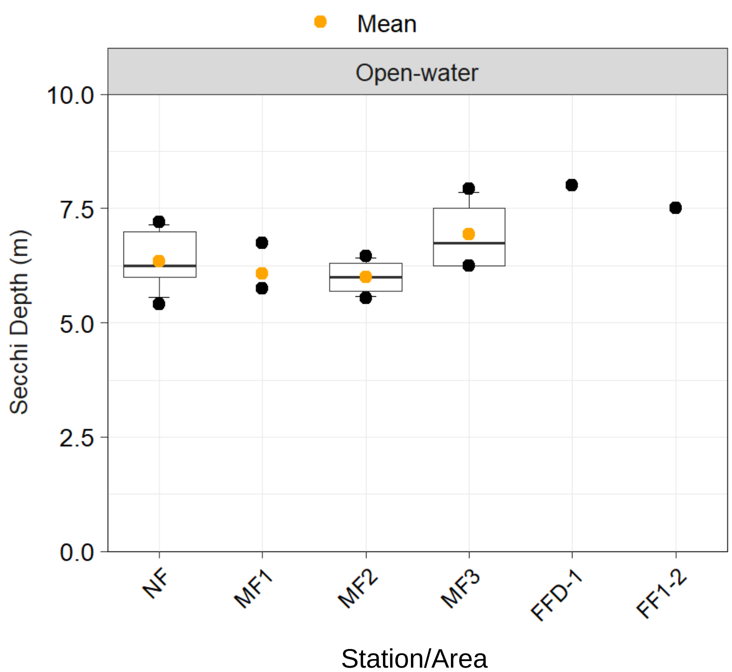
3.2 Lac de Gras

3.2.1 Secchi Depth

The Secchi depth corresponds to the depth at which approximately 10% of surface light remains (Dodds and Whiles 2010). The euphotic zone extends to a depth where approximately 1% of surface light remains, often estimated as twice the Secchi depth (Dodds and Whiles 2010). In less productive (i.e., oligotrophic) waterbodies like Lac de Gras, with low amounts of suspended or dissolved material, light is transmitted to greater depths. Secchi depth data are useful to estimate the extent of the euphotic zone where sufficient light is available for phytoplankton, and provide an indirect measure of algal biomass in the water column.

Secchi depth measurements indicated good light penetration throughout Lac de Gras. Secchi depth was between 5.25 and 8.0 m during the open-water season in 2021 (Figure 3-8). Mean Secchi depth was highest in the MF3 area (6.9 m) and was lowest in the MF2 area (6.0 m). The highest measurement was recorded at FFD-1 (8.0 m). These results were inconsistent with the expectation that Secchi depth would be lowest at NF stations, indicating greater algal turbidity in this area due to nutrient enrichment. Given the Secchi depths measured in Lac de Gras, a large proportion of the total volume of this lake is within the euphotic zone and can support phytoplankton growth.

Figure 3-8 Secchi Depth in Lac de Gras during the Open-Water Season, 2021



Notes: Secchi depth was not measured at LDS-4 and LDG-48, which are too shallow for this measurement. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

NF = near-field; MF = mid-field; FF = far-field; LDS-4 = Lac du Sauvage outlet (the Narrows); LDG-48 = Lac de Gras outlet.

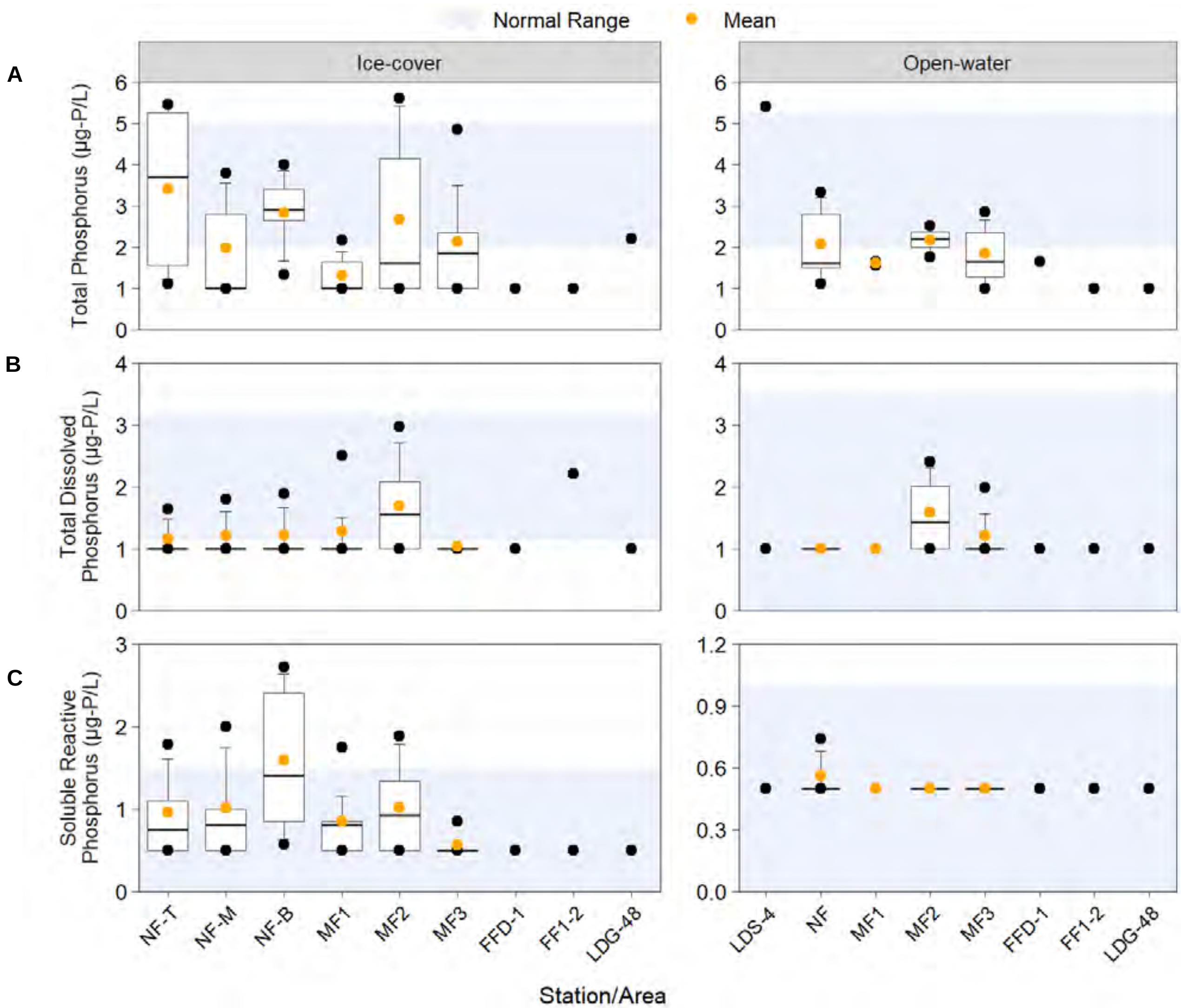
3.2.2 Nutrients

Concentrations of TP varied at all stations during the ice-cover and open-water seasons, with most concentrations generally within and below normal range (Figure 3-9A). During the ice-cover season, TP concentrations were highest, on average, at the NF top depths, and lowest, on average, in the MF-1 area. Detection frequency was low (i.e., 52% of samples had concentrations above the DL of 2 µg/L) and TP was not detected at FFD-1 and FF1-2. Concentration of TP at LDS-48 during the ice-cover season was similar to the mean TP concentration in the MF3 area. During the open-water season, station LDS-4 (outflow from Lac du Sauvage) had the highest TP concentration of 5.4 µg/L, which is greater than the normal range developed for Lac de Gras. Concentrations at other areas were below or within the normal range, and below DL at FF1-2 and LDG-48. Detection frequency was also low in the open-water season (50%).

Concentrations of TDP were infrequently detected during both the ice-cover and open-water seasons. During the ice-cover season, all detected concentrations were within or below the normal range with the exception of MF1-1 and MF-2-3 at the top depth (Figure 3-9B). TDP was not detected at FFD-1 or LDG-48 in the ice-cover season. During the open-water season, detected TDP concentrations were within the normal range in the MF2 and MF3 areas and not detected in the NF or MF1 areas, or at other stations including LDS-4, FFD-1, FF1-2, or LDG-48 (Figure 3-9B).

In contrast to TP and TDP, concentrations of SRP were more frequently detected during the ice-cover season due to a lower DL (1 µg/L for SRP compared to 2 µg/L for TP and TDP) (Figure 3-9C). However, concentrations were low (i.e., within five times the DL). The average SRP concentrations were generally within the normal range, with the exception of in the NF area at bottom depth. Detection frequency was lower during the open-water season, and detected SRP concentrations in the NF area were all within the normal range. SRP was not detected in the MF areas, or at LDS-4, FFD-1, FF1-2, or LDG-48.

Figure 3-9 Concentrations of Total Phosphorus (A), Total Dissolved Phosphorus (B), and Soluble Reactive Phosphorus (C) in Lac de Gras during the Ice-Cover and Open-Water Season, 2021



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown. Non-detect values are plotted at half the detection limit.

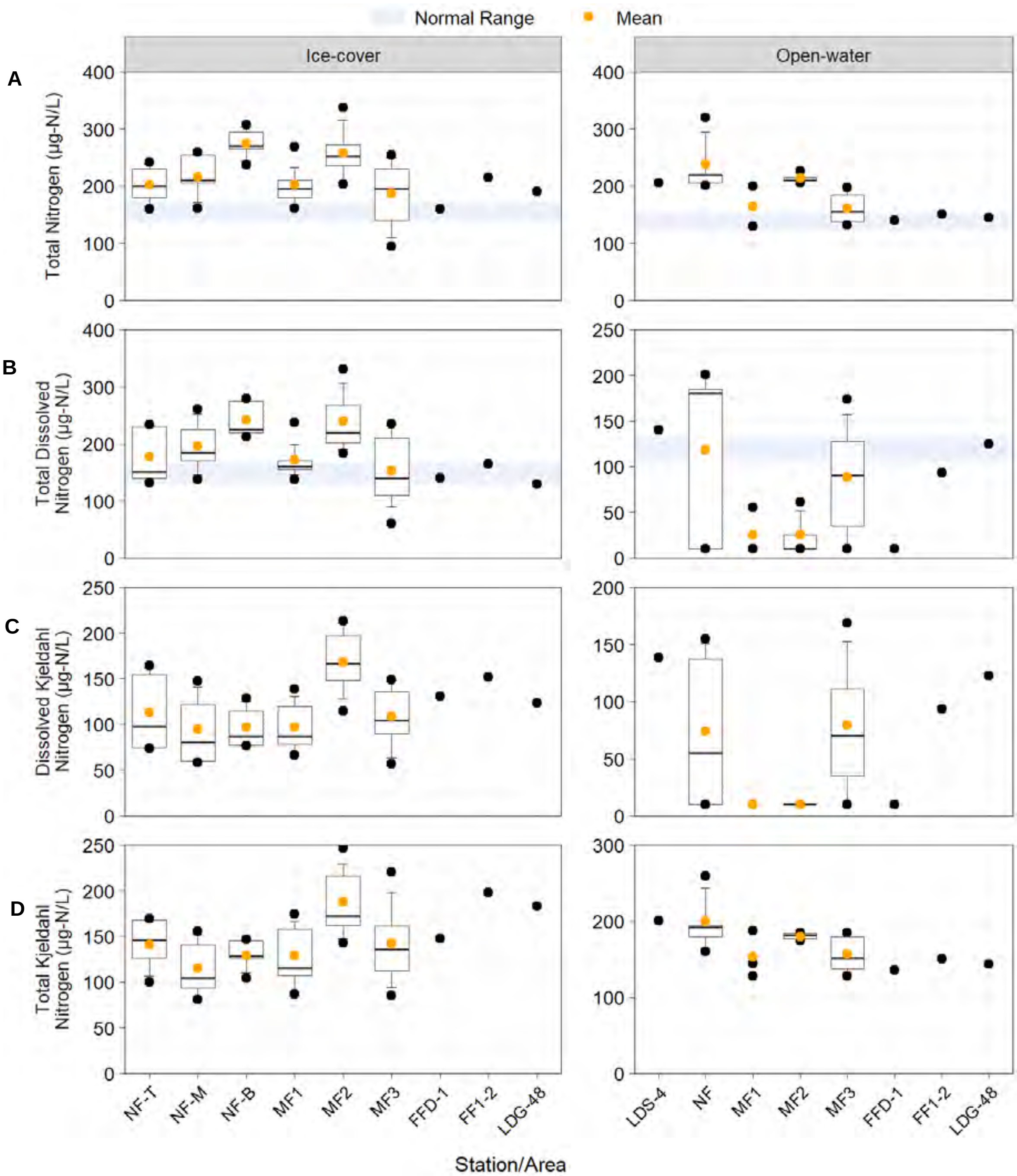
µg-P/L = micrograms phosphorus per litre; NF = near-field; T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Concentrations of TN and TDN in the NF area were generally greater during the ice-cover season than during open-water (Figure 3-10A,B). During the ice-cover season, TN and TDN concentrations increased with depth in the NF area, reflecting the discharge of effluent to the bottom of the water column. Concentrations of TN and TDN were generally at or above the normal range, with the highest concentrations in the NF and MF2 areas. TDN concentrations were lower than TN and more variable, with the highest concentrations observed in the NF and MF3 areas. Concentrations at FFD-1, FF1-2 and LDG-48 were similar to the mean TN and TDN concentrations in MF3, with the exception of TDN in FFD-1.

During the open-water season, mean TN concentrations were above the normal range in the NF and MF areas (Figure 3-10A). Concentrations of TN were highest and similar at the NF and MF2 areas and at LDS-4. Mean TN concentrations were similar at MF1 and MF3 areas, and slightly greater than at FFD-1, FF1-2, and LDS-48, which were similar to each other. Concentrations of TDN were generally lower than TN (Figure 3-10B). The highest TDN concentrations were measured at LDS-4 and LDG-48. Mean concentrations were greater in NF and MF3 areas and at FF1-2 compared to MF1 and MF2 areas and to FFD-1.

Concentrations of TKN and DKN generally followed the same patterns as TN and TDN, respectively, with a less noticeable variation by depth in the NF area during the ice-cover season (Figure 3-10C,D).

Figure 3-10 Concentrations of Total Nitrogen (A), Total Dissolved Nitrogen (B), Dissolved Kjeldahl Nitrogen (C), and Total Kjeldahl Nitrogen (D) in Lac de Gras during the Ice-Cover and Open-Water Season, 2021



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown. Non-detect values are plotted at half the detection limit.

µg-N/L = micrograms nitrogen per litre; NF = near-field; T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Nitrate and nitrate + nitrite concentrations followed the same pattern as TN and TDN, with concentrations increasing with depth in the NF area during the ice-cover season (Figure 3-11A,C). Concentrations generally decreased with distance from the diffuser and were greater than the normal range in the NF and MF areas. Concentrations at FFD-1, FF1-2, and LDG-48 were within or just above the normal range.

During the open-water season, concentrations of nitrate and nitrate + nitrite were generally above normal range (Figure 3-11A,C). Mean concentrations were highest in the NF and MF2 areas, and lower in the MF1 and MF3 areas. Concentrations were not detected during the ice-cover and open-water seasons at LDG-48. Nitrate, nitrite, and nitrate + nitrite concentrations at LDS-4 were either not detected, or slightly above the DL during the open-water season.

Nitrite concentrations were much lower than nitrate concentrations, and did not follow the same pattern (Figure 3-11B). Nitrite concentrations were within five times the DL of 1 µg-N/L and most were within the normal range. Nitrite concentrations during the ice-cover season were similar at bottom and top depths in the NF area, while concentrations in the NF area at mid-depth were comparable to the MF areas. During the open-water season, all nitrite concentrations were at or near the DL and within the normal range except for the NF area, where mean concentrations were above the normal range. Nitrite was not detected in either season at LDG-48.

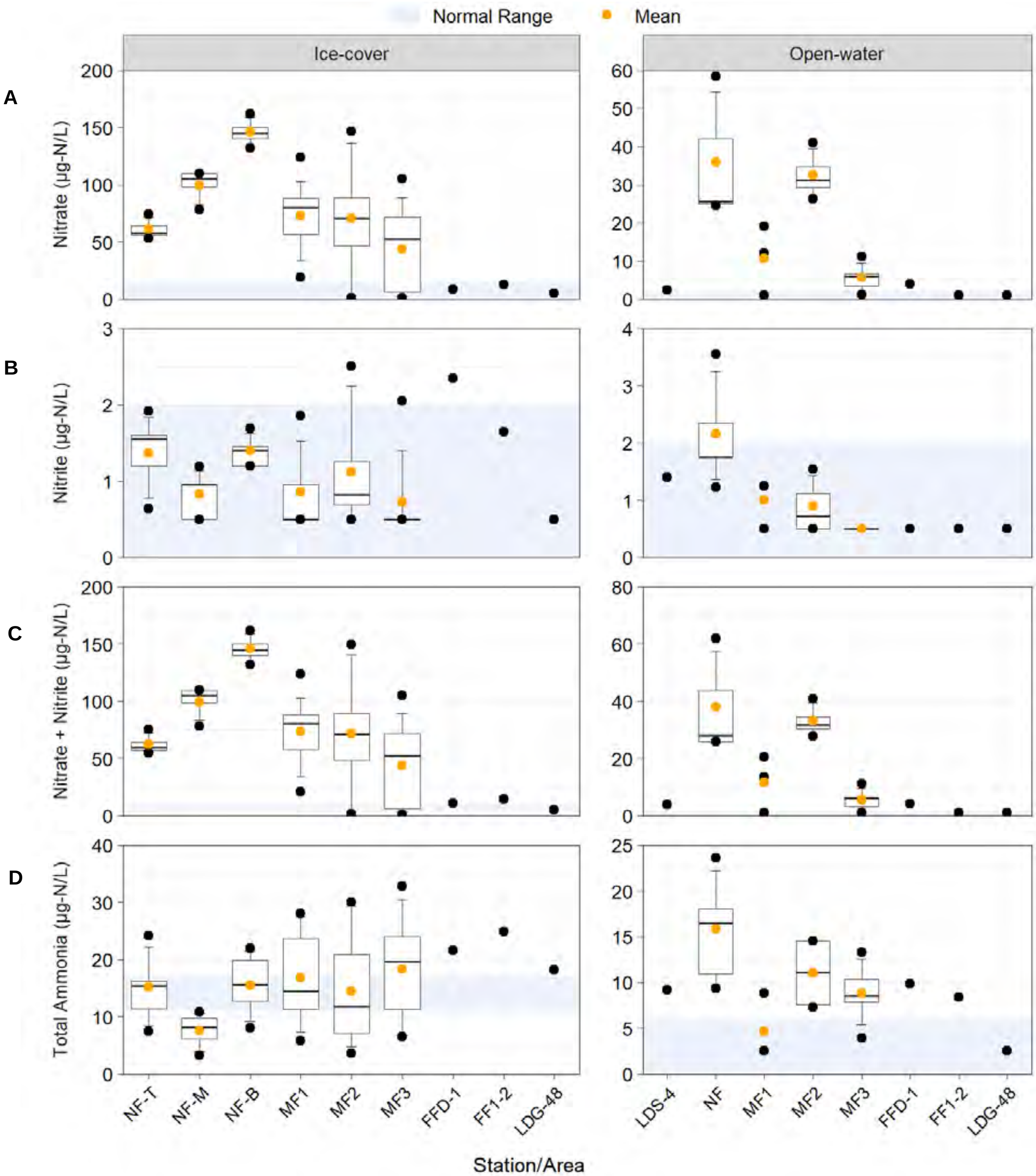
As with the other nitrogen species (except nitrite), total ammonia concentrations were greater during the ice-cover season compared to the open-water season (Figure 3-11D). This pattern is commonly observed, because concentrations decline as algae assimilate dissolved nutrients for growth during the open-water season (Wetzel 2001). During the ice-cover season, mean total ammonia concentrations were within or just above the normal range. Concentrations were more similar among the MF areas and top and bottom depths in the NF area, and lowest in the middle depth of the NF area (Figure 3-11D). Total ammonia concentrations were above the normal range at FFD-1, FF1-2, and LDG-48.

During the open-water season, total ammonia concentrations followed a similar pattern as nitrate (Figure 3-11D). Most total ammonia concentrations were greater than the normal range. The highest mean concentration was measured in the NF area, and the lowest concentrations in the MF1 area. At LDS-4, the open-water concentration was similar to the mean concentrations in the MF2 and MF3 areas, and at FFD-1 and FF1-2. Total ammonia concentrations at LDG-48 during the ice-cover season were below those in the FF areas, and were comparable to those at MF1.

Concentrations of SRSi during the ice-cover season increased with depth in the NF area (Figure 3-12). Concentrations measured at the bottom depth in the NF area were noticeably higher than in all other areas, while the concentrations at the NF area top depth were similar to those in all other areas. Mean SRSi concentrations decreased with distance from diffuser. Concentrations at FFD-1, FF1-2, and LDG-48 were similar and below the mean concentration in the MF3 area.

Concentrations of SRSi during the open-water season were lower than in the ice-cover season in all areas. The highest concentration was measured at LDS-4. Concentrations in the NF area compared to the MF areas, and the FFD-1, FF1-2 and LDG-48 stations. The measured SRSi concentration at LDG-48 during the open-water season was comparable to the FFD-1 and FF1-2 stations.

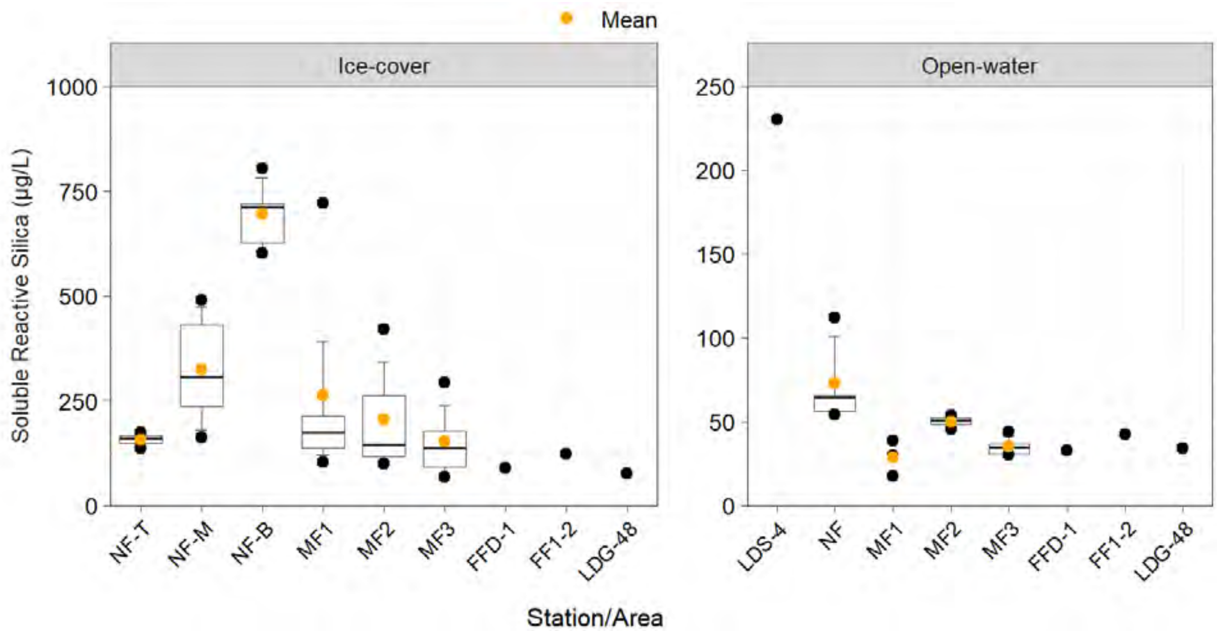
Figure 3-11 Concentrations of Nitrate (A), Nitrite (B), Nitrate + Nitrite (C) and Total Ammonia (D) in Lac de Gras during the Ice-Cover and Open-Water Season, 2021



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown. Non-detect values are plotted at half detection limit.

µg-N/L = micrograms nitrogen per litre; NF = near-field; T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Figure 3-12 Concentrations of Soluble Reactive Silica in Lac de Gras during the Ice-Cover and Open-Water Season, 2021



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

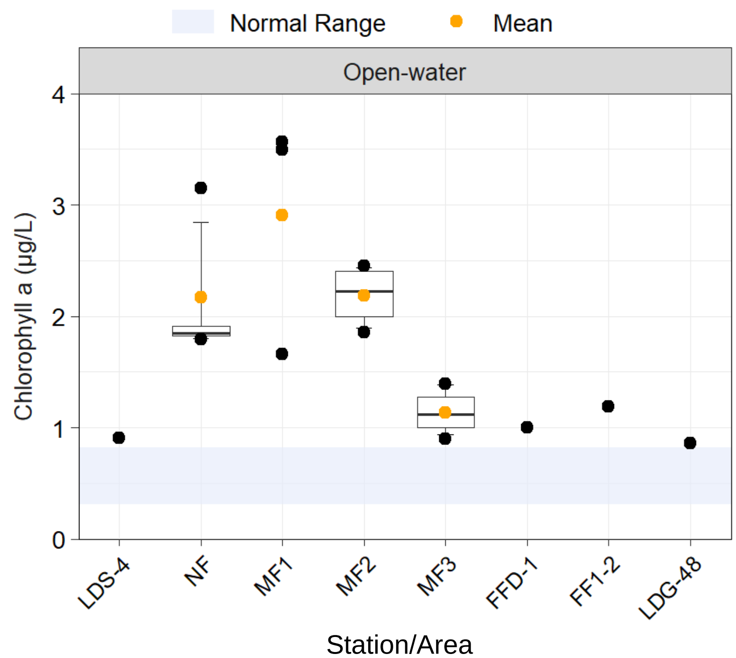
µg/L = micrograms per litre; NF = near-field; T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

3.2.3 Chlorophyll *a*, and Phytoplankton and Zooplankton Biomass

Chlorophyll *a* concentration was used as an indicator of phytoplankton standing crop (i.e., biomass) in Lac de Gras during the open-water season. Ice and snow reduce the amount of light entering the lake to a fraction of surface solar radiation; consequently, algal growth under ice-cover is limited by light and temperature, resulting in low chlorophyll *a* concentrations. Therefore, chlorophyll *a* concentration is not measured at AEMP stations during the ice-cover season.

Mean chlorophyll *a* concentrations in Lac de Gras exceeded the normal range across all areas and at the Lac de Sauvage outlet (LDS-4; Figure 3-13). Concentrations of chlorophyll *a* show a decreasing trend with distance from the diffuser, with the exception of a slight increase in concentration between NF and MF1 areas. The concentrations measured at FFD-1, FF1-2, and LDG-48 were similar and just above the normal range. The lowest chlorophyll *a* concentrations were measured at LDS-4 and LDG-48. The maximum chlorophyll *a* concentration measured in 2021 in the MF1 area was 3.64 µg/L. The 2021 chlorophyll *a* concentrations in Lac de Gras were consistently about double the concentrations measured in 2020, despite a similar TP load from the Mine in both years (2020: 289 kg, 2021: 297 kg) and lower phytoplankton biomass in 2021 compared to 2020.

Figure 3-13 Chlorophyll *a* Concentrations in Lac de Gras during the Open-Water Season, 2021



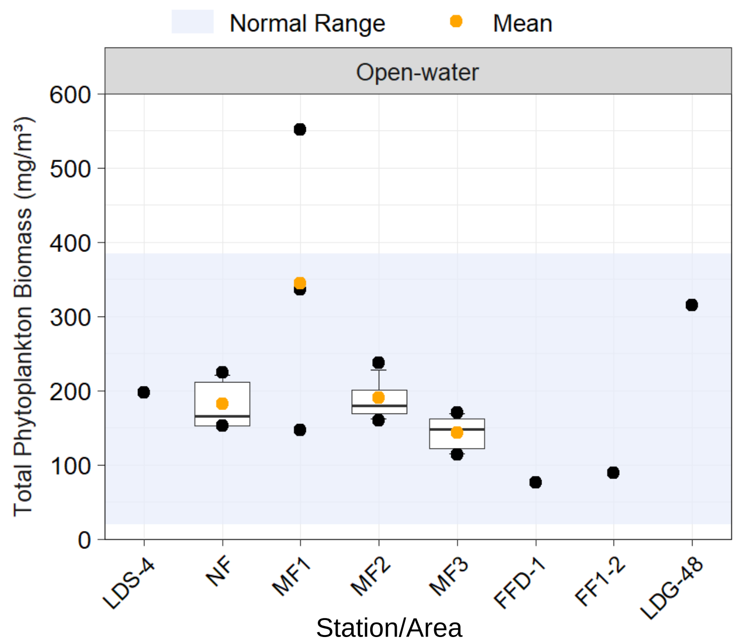
Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

µg/L = micrograms per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet.

Total phytoplankton biomass exceeded the normal range at station MF1-1; all other stations were within the normal range (Figure 3-14). Total phytoplankton biomass generally decreased with distance from the diffuser. Total phytoplankton biomass at LDG-48 was similar to the mean biomass in the MF1 area. It is not clear why chlorophyll *a* concentrations would be elevated without at least some corresponding increase in phytoplankton biomass, suggesting a potential data quality issue associated with the chlorophyll *a* dataset.

Mean zooplankton biomass (as AFDM) was above the normal range in all sampling areas (Figure 3-15). Zooplankton biomass was greater in the NF, MF1, and MF2 areas than in the MF3 area and stations FFD-1 and FF1-2.

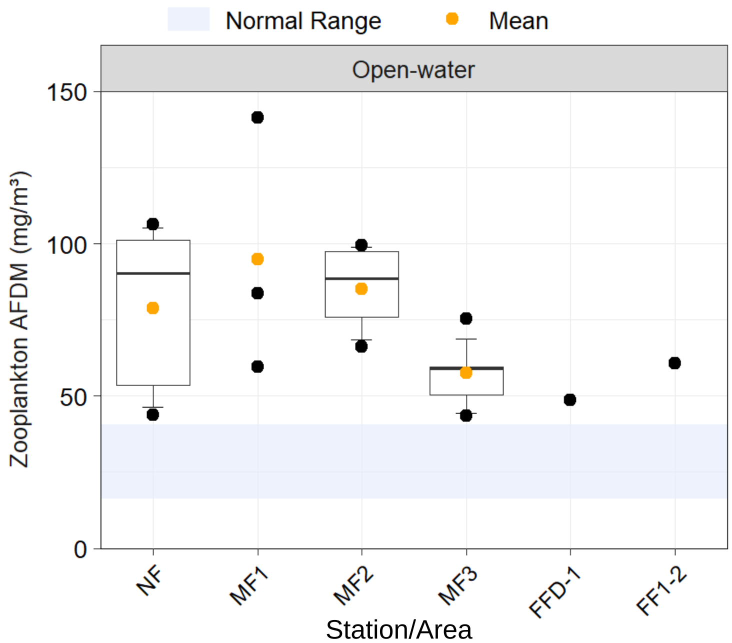
Figure 3-14 Total Phytoplankton Biomass in Lac de Gras during the Open-Water Season, 2021



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Figure 3-15 Total Zooplankton Biomass (as AFDM) in Lac de Gras during the Open-Water Season, 2021



Notes: Zooplankton is not measured at LDS-4 and LDG-48. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

AFDM = ash-free dry mass; mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; FF = far-field; LDS-4 = Lac du Sauvage outlet (the Narrows); LDG-48 = Lac de Gras outlet.

3.2.4 Percent Change from Baseline and Previous Year

Per Directive 2D from the 25 March 2019 WLWB Decision regarding the *AEMP 2017 Annual Report* (Golder 2018), percent change values from the baseline median and the previous year (i.e., 2020) median value were calculated for each eutrophication indicator, by area (i.e., NF, MF1, MF2, MF3, and LDG-48) and season (i.e., ice-cover and open-water). The results are presented in Attachment C, Tables C-1 to C-10, and indicate that median values of eutrophication indicators have generally increased in the NF area relative to baseline (Table C-1 and Table C-6), consistent with EA predictions and interpretation of AEMP data during annual reporting. With respect to changes from the previous year, chlorophyll *a* concentrations were greater in 2021 relative to 2020 in all sampling areas and at LDG-48, whereas no changes or lower total phytoplankton biomass was observed in 2021 in the NF and MF areas. Further discussion of these results is provided in Attachment C.

3.2.5 Gradient Analysis

3.2.5.1 Secchi Depth

Secchi depth along the MF1 transect appeared to increase with increasing distance from the effluent discharge (Figure 3-16), which is consistent with reduced Secchi depth due to greater phytoplankton biomass in the water column closer to the diffusers, as also shown by phytoplankton biomass (i.e., biovolume) results and chlorophyll *a* concentrations along the MF1 transect for each. However, along the MF2 and MF3 transects, Secchi depth decreased with increasing distance from the effluent discharge, suggesting the results may represent background variability, rather than a Mine effect. The slope of the regression line was significantly different from zero for the MF1 and MF3 transects, in opposite directions, but not for the MF2 transect (Table 3-1).

Table 3-1 Gradient Analysis Results for Secchi Depth during the Open-water Season, 2021

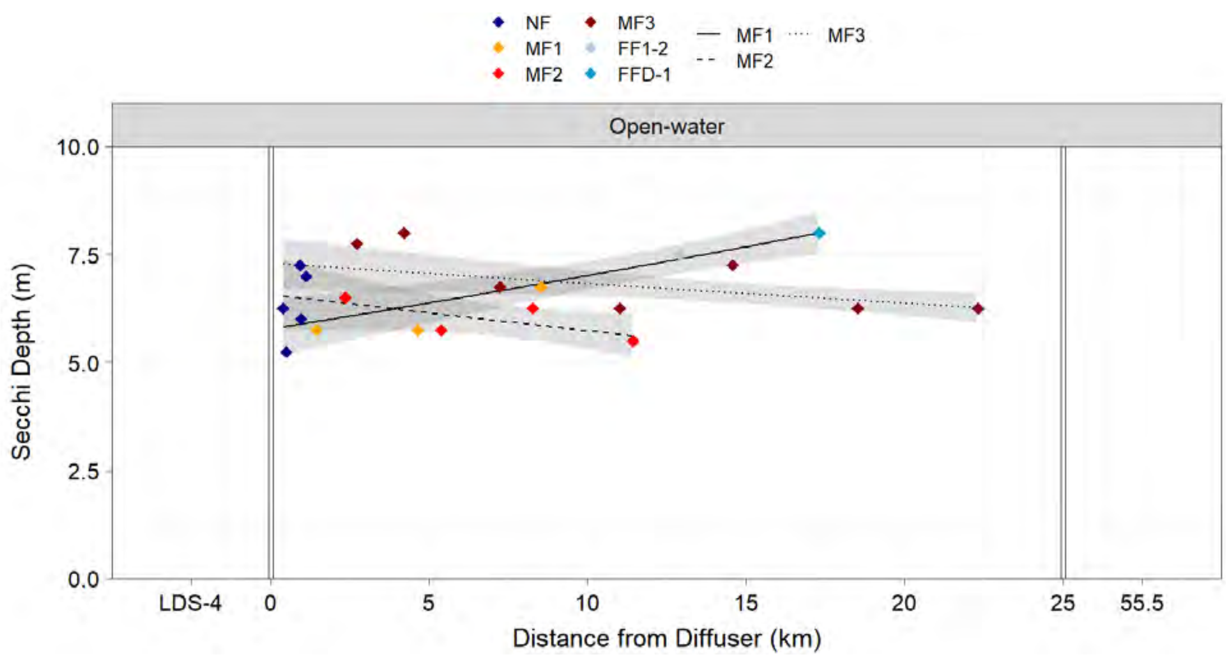
Variable	Model	Transformation[a]	Gradient	Slope[a]	*P*-value	R^2
Secchi Depth	Model 1	0.5	MF1	↑	**<0.001**	0.65
			MF2	↓	0.093	
			MF3	↓	**<0.014**	

Note: **Bold** indicates *P*-value significant at <0.05.

a) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent diffusers, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent diffusers.

- = not applicable; MF = mid-field; *P* = probability; R^2 = coefficient of determination.

Figure 3-16 Secchi Depth in Lac de Gras According to Distance from the Effluent Discharge, 2021



Note: Secchi depth is not measured at LDS-4 and LDG-48, which are too shallow for this measurement. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).
NF = near-field; MF = mid-field; FF = far-field; LDS-4 = Lac du Sauvage outlet (the Narrows); LDG-48 = Lac de Gras outlet.

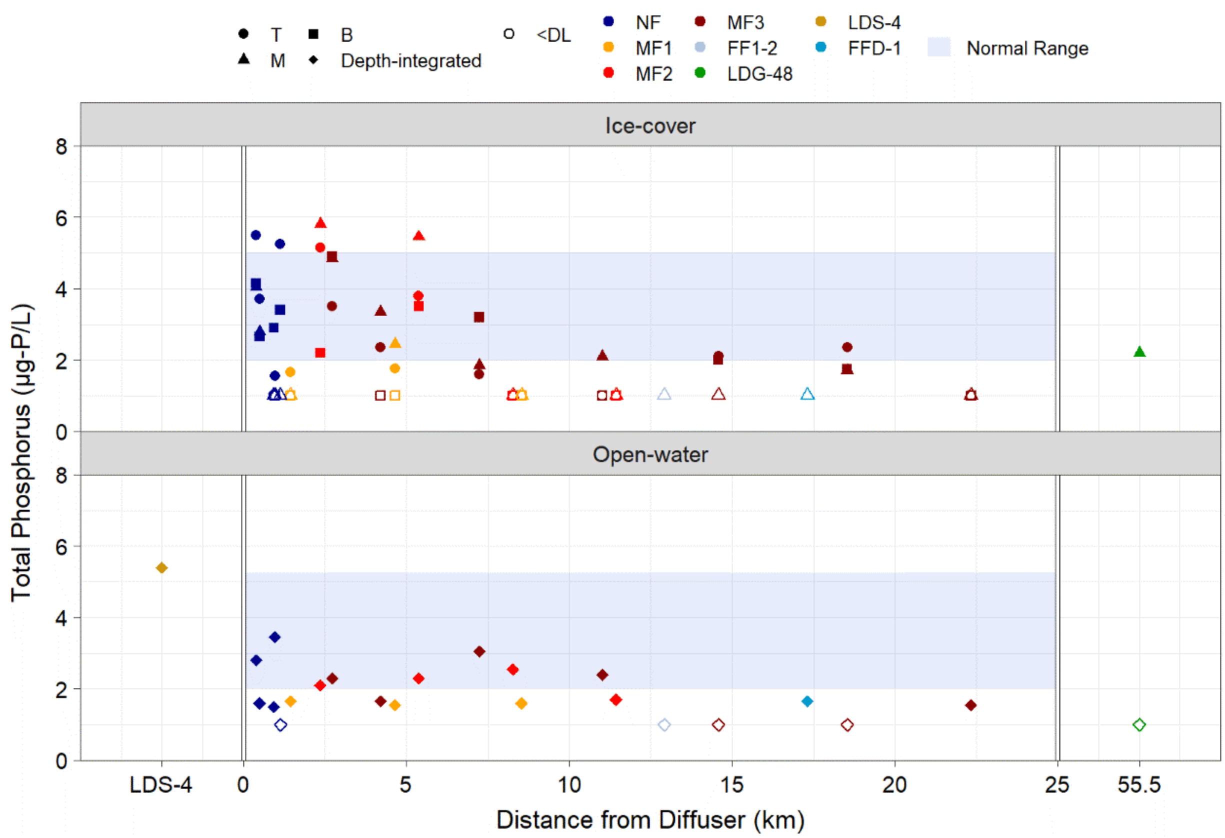
3.2.5.2 Nutrients

Gradient analysis was not done for phosphorus species (TP, TDP, and SRP) because of the low detection frequency.

During the ice-cover season, TP concentrations were within or below the normal range at most stations with the exceptions of the top depths at two NF stations, top and middle depth at MF2-1, and middle depth at MF2-3 (Figure 3-17). Concentrations were variable, but greater concentrations were observed at stations within 5 km of the diffuser and lower concentrations were measured at more distant stations. Concentration at LDG-48 was similar to those measured at MF3-7.

During the open-water season, all TP concentrations were within or below the normal range, and there was no apparent trend with distance from the diffuser (Figure 3-17). The concentration of TP at LDS-4 during the open-water season was higher than the NF area, while TP concentration at LDG-48 was below DL.

Figure 3-17 Concentrations of Total Phosphorus in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021

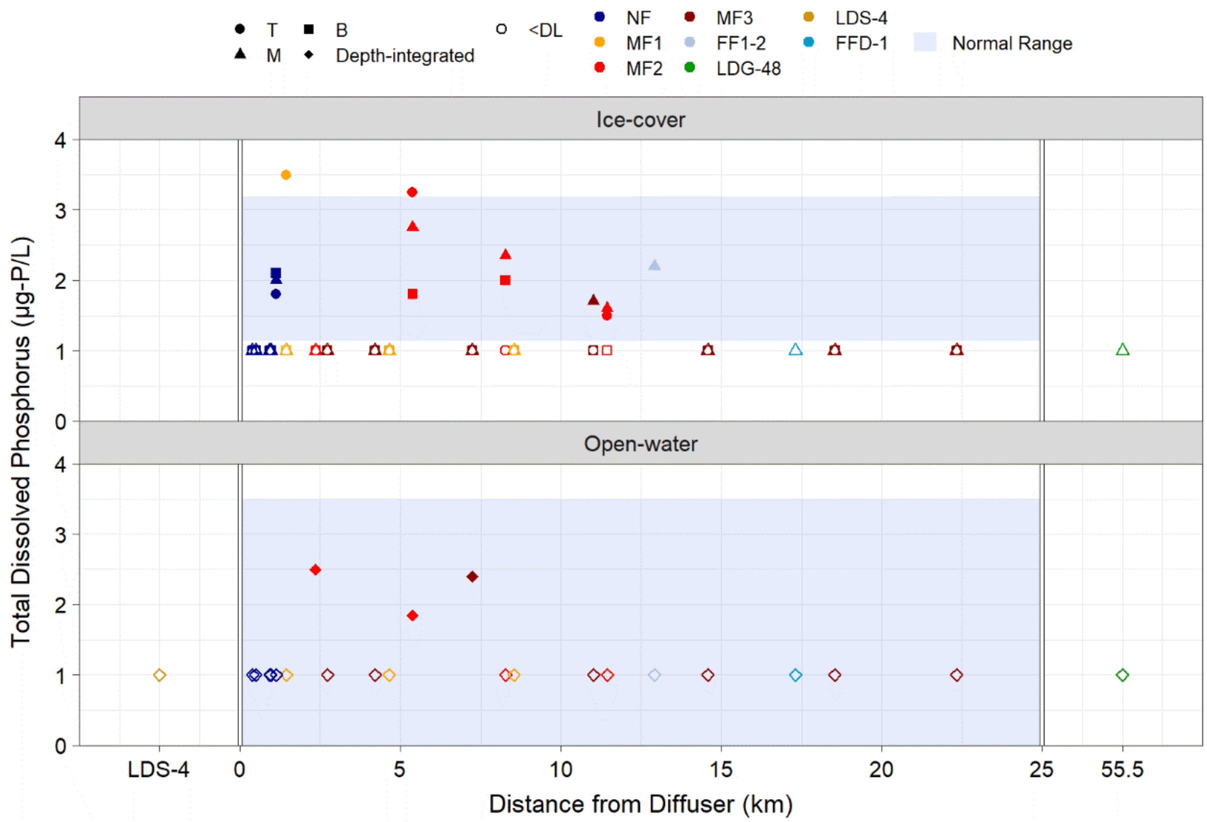


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season.

µg-P/L = micrograms phosphorus per litre; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Concentrations of TDP during the ice-cover season were within or just below the normal range at nearly all stations, except for those at MF1-1 and MF2-3 top depths (Figure 3-18). Concentrations appeared to decrease from MF2-3 to FF2-5. During the open-water season, TDP concentrations were within the normal range, and most were below DL.

Figure 3-18 Concentrations of Total Dissolved Phosphorus in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021

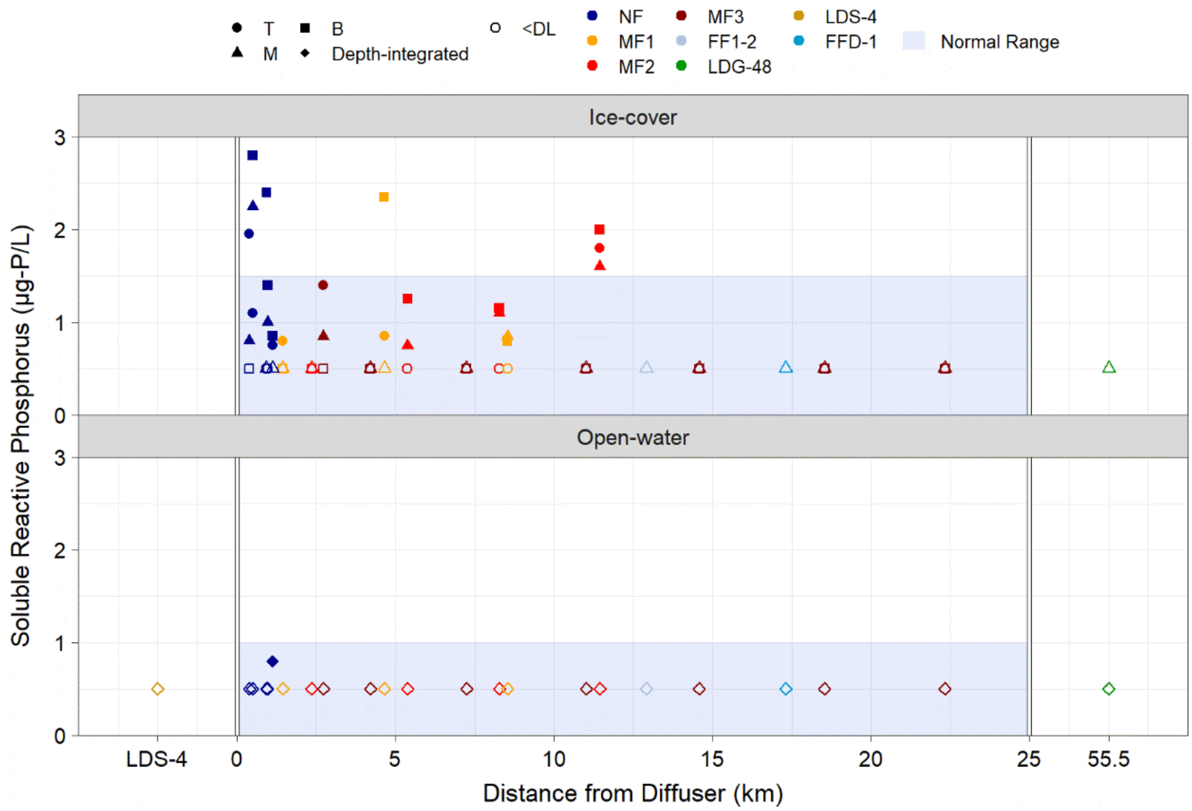


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season.

µg-P/L = micrograms phosphorus per litre; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDS-4 = Lac du Sauvage outlet (the Narrows); LDG-48 = Lac de Gras outlet.

Concentrations of SRP during the ice-cover season were generally within the normal range at most stations, except at three NF stations, bottom depth at MF1-3, and at FF2-5 (Figure 3-19). Elevated concentrations in the NF area were likely due to the effluent, whereas elevated concentrations at FF2-5 likely reflect the influence of the Lac du Sauvage inflow. The concentration at LDG-48 was below the DL. During the open-water season, SRP concentrations were mostly not detectable (Figure 3-19).

Figure 3-19 Concentrations of Soluble Reactive Phosphorus in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



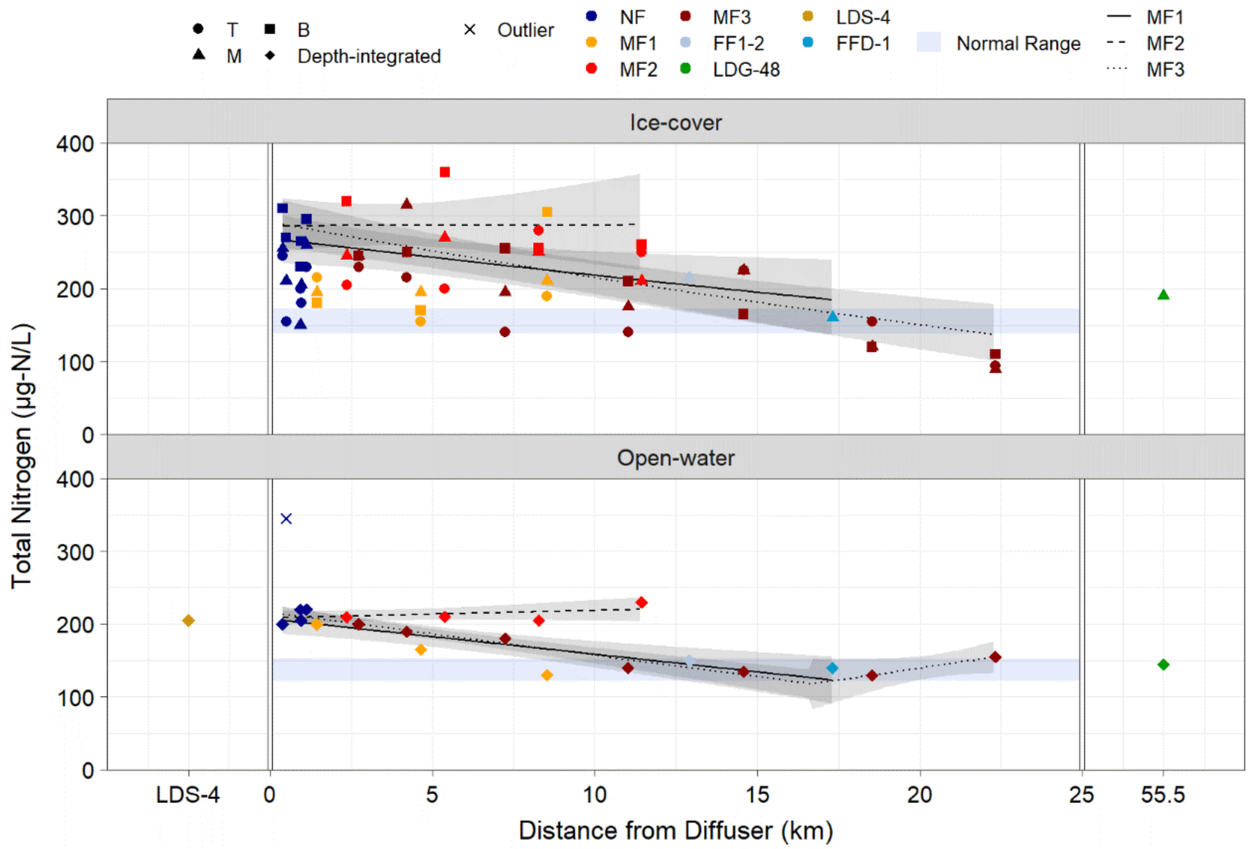
Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season.

µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDS-4 = Lac du Sauvage outlet (the Narrows); LDG-48 = Lac de Gras outlet.

Concentrations of TN were generally above the normal range to a distance of up to 15 km from the diffuser during the ice-cover season and up to 11 km during the open-water season (Figure 3-20). Significant decreasing trends in TN concentrations were observed along the MF1 transect during both seasons, and along the MF3 transect during the ice-cover season (Table 3-2). Concentrations along the MF3 transect in the open-water season significantly decreased, with a reversal in direction beyond the breakpoint of the broken stick regression (Table 3-2, Figure 3-20). During both seasons, TN concentrations appeared to increase with distance along the MF2 transect, but the slopes were not significantly different from zero. The open-water season concentration measured at LDS-4 suggests that TN concentrations along this transect are influenced by the inflow from Lac du Sauvage.

Similar results were observed for TDN during the ice-cover season, except that no significant trend was observed for MF1 transect during ice-cover conditions (Figure 3-21 and Table 3-2). Gradient analysis was not done for TDN for the open-water season because of the low detection frequency. Based on visual evaluation of TDN during the open-water season, a slight declining trend in TDN concentration was apparent with increasing distance from the diffusers.

Figure 3-20 Concentrations of Total Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Table 3-2 Gradient Analysis Results for Nutrients, 2021

Variable	Season	Model	Transformation	Gradient	Slope[(a)]	Breakpoint (km)[(b)]	*P*-value	r^2 or R^2 [(c)]
Total Nitrogen	Ice-cover	Model 1	0.5	MF1	↓	-	**0.024**	0.54
		Model 1		MF2	↑	-	0.977	
		Model 1		MF3	↓	-	**<0.001**	
	Open-water[(d)]	Model 2	Log	MF1	↓	-	**0.001**	0.69
		Model 2		MF2	↑	-	0.268	
		Model 3		MF3 (1st slope)	↓	16.7	**0.01**	0.92
		Model 3		MF3 (2nd slope)	↑		-	
Total Dissolved Nitrogen	Ice-cover	Model 1	Log	MF1	↓	-	0.053	0.79
		Model 1		MF2	↑	-	0.862	
		Model 1		MF3	↓	-	**<0.001**	
Total Kjeldahl Nitrogen	Ice-cover	Model 2	Log	MF1	↑	-	0.338	0.41
		Model 2		MF2	↑	-	**0.004**	
		Model 3		MF3 (1st slope)	↑	15.2	**0.008**	0.88
		Model 3		MF3 (2nd slope)	↓		-	
	Open-water[(e)]	Model 1	Log	MF1	↓	-	**0.005**	0.46
		Model 1		MF2	↑	-	0.960	
		Model 1		MF3	↓	-	**0.002**	
Dissolved Kjeldahl Nitrogen	Ice-cover	Model 1	-	MF1	↑	-	0.323	0.27
		Model 1		MF2	↑	-	**0.007**	
		Model 1		MF3	↓	-	0.234	
Nitrate	Ice-cover[(f)]	Model 2	-	MF1	↓	-	**<0.001**	0.85
		Model 2		MF2	↓	-	**0.003**	
		Model 3		MF3 (1st slope)	↓	4.6	**0.003**	0.96
		Model 3		MF3 (2nd slope)	↓		-	
	Open-water	Model 2	0.5	MF1	↓	-	**0.001**	0.55
		Model 2		MF2	↑	-	0.847	
		Model 3		MF3 (1st slope)	↓	1.6	**0.013**	0.9
		Model 3		MF3 (2nd slope)	↓			
Nitrate + Nitrite	Ice-cover[(g)]	Model 2	-	MF1	↓	-	**<0.001**	0.84
		Model 2		MF2	↓	-	**0.004**	
		Model 3		MF3 (1st slope)	↓	4.7	**0.003**	0.96
		Model 3		MF3 (2nd slope)	↓		-	
Total Ammonia	Ice-cover	Model 3	-	MF1	↑	-	0.570	0.02
		Model 3		MF2	↑	-	0.102	
		Model 3		MF3	↑	-	0.162	
	Open-water	Model 3	0.5	MF1	↓	-	0.194	-0.04
		Model 3		MF2	↓	-	0.862	
		Model 3		MF3	↓	-	0.385	

Table 3-2 Gradient Analysis Results for Nutrients, 2021

Variable	Season	Model	Transformation	Gradient	Slope[a]	Breakpoint (km)[b]	*P*-value	r^2 or R^2 [c]
Soluble Reactive Silica	Ice-cover[h]	Model 2	Log	MF1	↓	-	**<0.001**	0.77
		Model 2		MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	6.0	**0.002**	0.93
		Model 3		MF3 (2nd slope)	↓		-	
	Open-water[i]	Model 2	0.5	MF1	↓	-	0.191	0.3
		Model 2		MF2	↓	-	0.055	
		Model 3		MF3 (1st slope)	↓	4.1	**0.021**	0.92
		Model 3		MF3 (2nd slope)	↓		-	

Note: **Bold** indicates *P*-value significant at <0.05. Gradient analysis was not done for the following variables because of low detection frequency: total phosphorus (ice-cover and open-water), total dissolved phosphorus (ice-cover and open-water), soluble reactive phosphorus (ice-cover and open-water), nitrate (open-water), nitrite (ice-cover and open-water), nitrate + nitrite (open-water), ammonia (open-water).

a) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent diffusers, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent diffusers.

b) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

c) For the MF3 broken stick model, r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, because there is more than one predictor, i.e., distance and gradient.

d) Outlier removed: 345 µg-N/L.

e) Outlier removed: 276 µg-N/L.

f) Outlier removed: 145 µg-N/L.

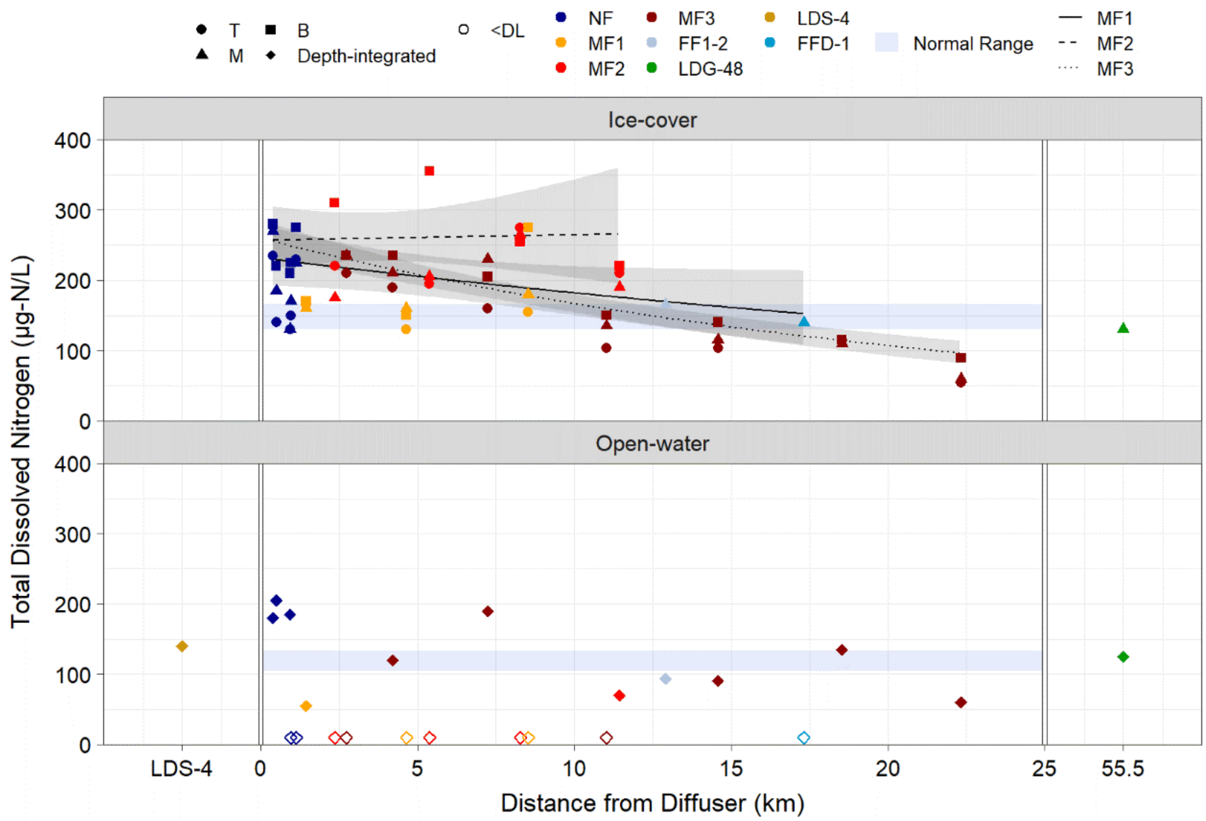
g) Outlier removed: 145 µg-N/L.

h) Outlier removed: 1,050 µg/L.

i) Outlier removed: 124 µg/L.

- = not applicable; MF = mid-field; *P* = probability; r^2 or R^2 = coefficient of determination.

Figure 3-21 Concentrations of Total Dissolved Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



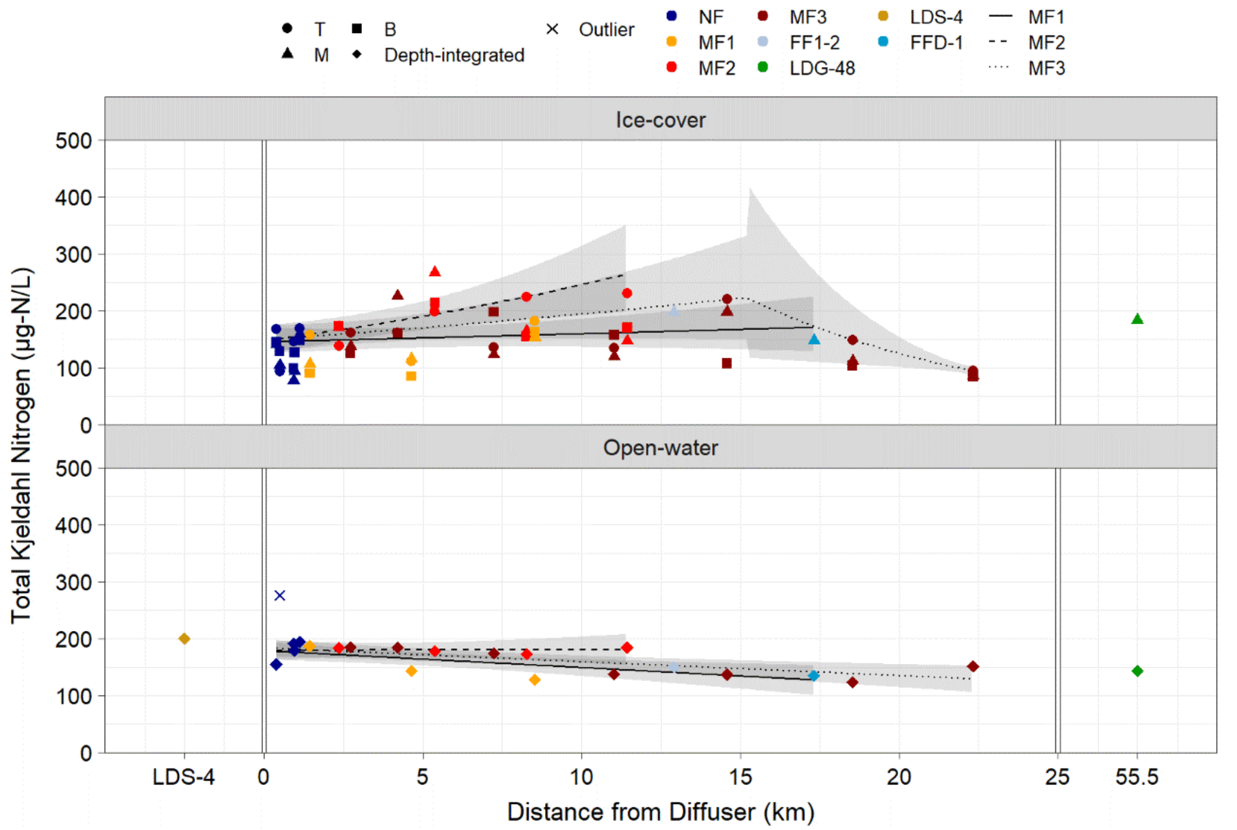
Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDS-4 = Lac du Sauvage outlet (the Narrows).

Gradients in TKN concentrations were similar to those in TN during the open-water season, with significant decreasing trends along the MF1 and MF3 transects with distance from the diffuser (Table 3-2, Figure 3-22). In contrast, significant increasing trends in concentrations of TKN were observed along the MF2 and MF3 transects during the ice-cover season, with a reversal in direction beyond the breakpoint of the broken stick regression along the MF3 transect (Table 3-2, Figure 3-22). This was opposite to the gradients observed in TN and TDN.

Significant increasing trends in concentrations of DKN were observed along the MF2 transect during the ice-cover season (Table 3-2, Figure 3-23). Gradient analysis was not done for DKN for the open-water season because of the low detection frequency. Visual evaluation of DKN during the open-water season shows variation in the detectable results with no apparent gradient.

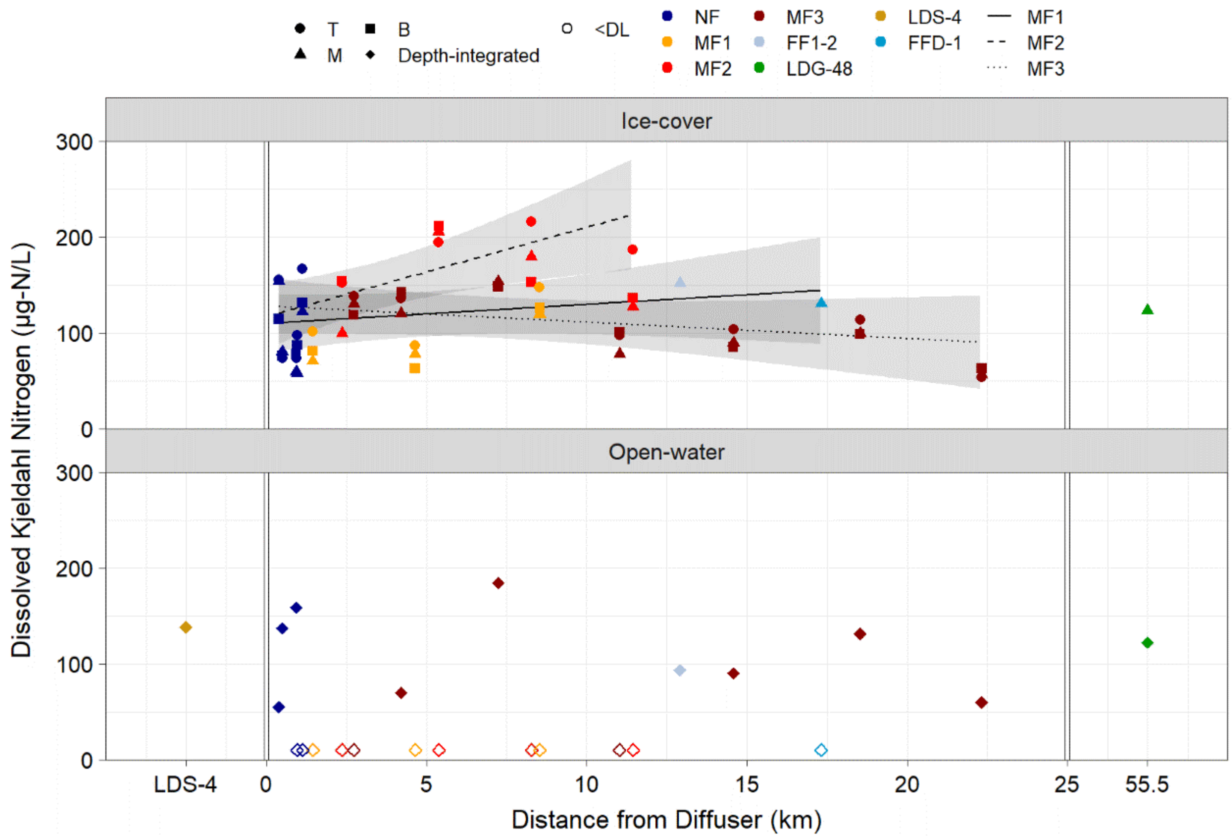
Figure 3-22 Concentrations of Total Kjeldahl Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Figure 3-23 Concentrations of Dissolved Kjeldahl Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



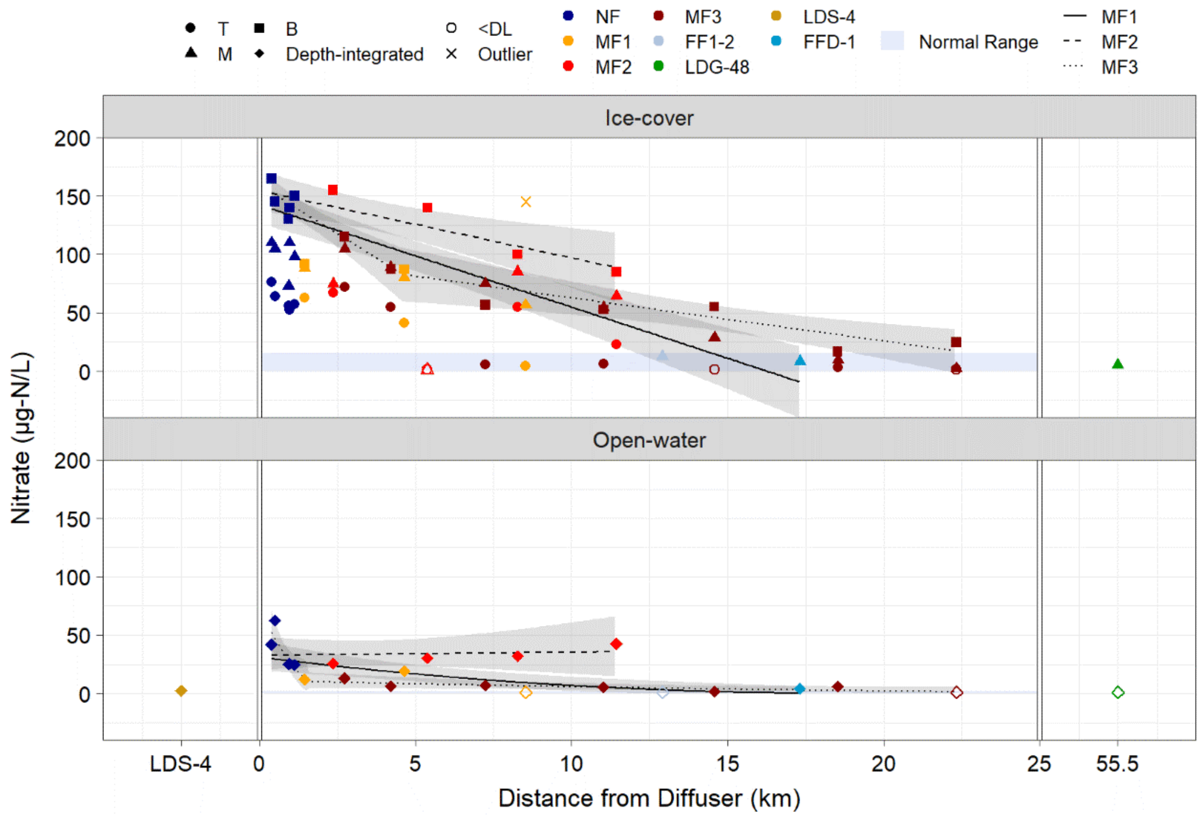
Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). The open-water data were not statistically analyzed because of the high frequency of non-detects in the dataset.

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Concentrations of nitrate were generally above the normal range during the ice-cover season with some exceptions until approximately 22 km from the diffuser (Figure 3-24). Significant decreasing trends in nitrate concentrations during the ice-cover season were observed along all MF transects (Table 3-2). The concentration of nitrate at LDG-48 was within normal range and similar in magnitude to the MF3-6 station.

During the open-water season, nitrate concentrations were generally above normal range until approximately 19 km from the diffuser (Figure 3-24). Significant decreasing trends in nitrate concentrations were observed along the MF1 and MF3 transects (Table 3-2). Nitrate was not detected at LDG-48.

Figure 3-24 Concentrations of Nitrate in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021

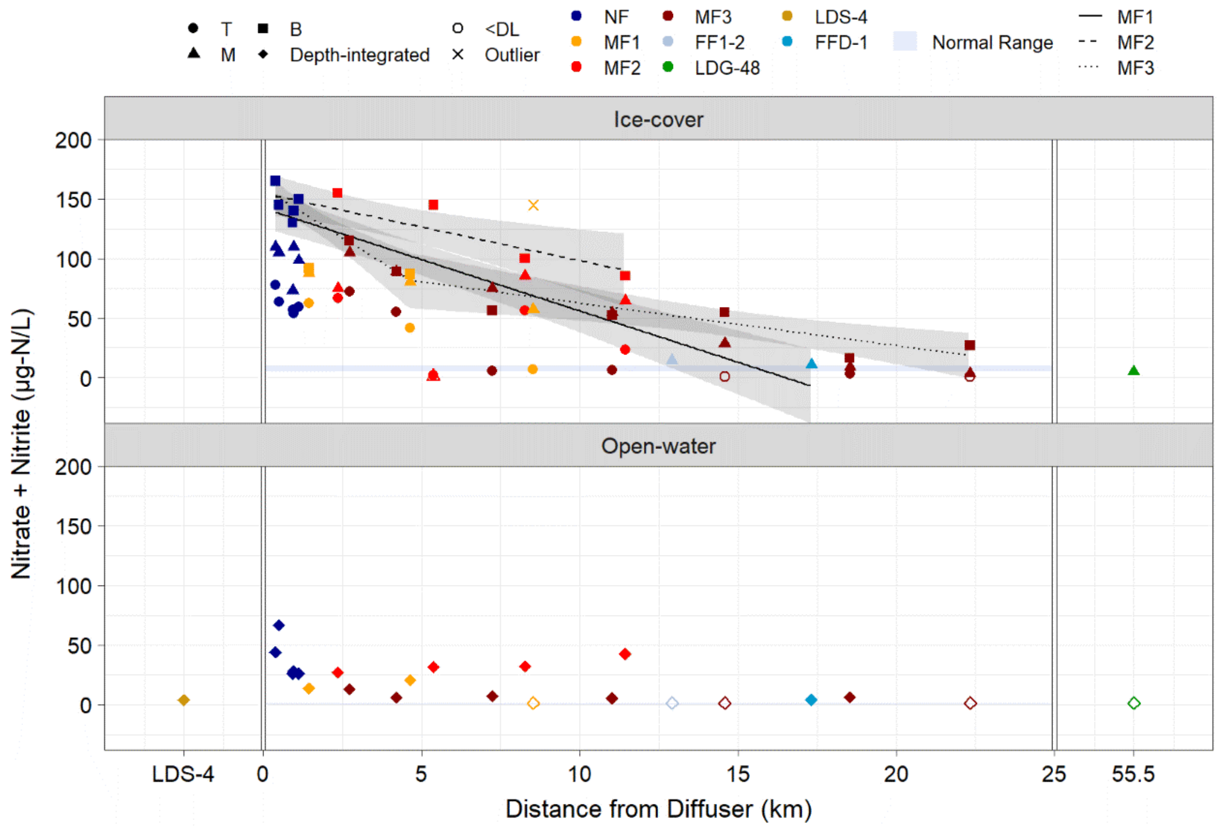


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

The results for nitrate + nitrite mirror those for nitrate. Both had the same stations with concentrations that exceeded normal range and significant decreasing trends with distance from the diffusers along all transects during the ice-cover season (Table 3-2, Figure 3-25). During the open-water season, nitrate + nitrite concentrations were not detected frequently enough to allow for linear regression analysis. Based on visual evaluation, a shallow decreasing concentration gradient was apparent along each MF transect.

Figure 3-25 Concentrations of Nitrate + Nitrite in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021

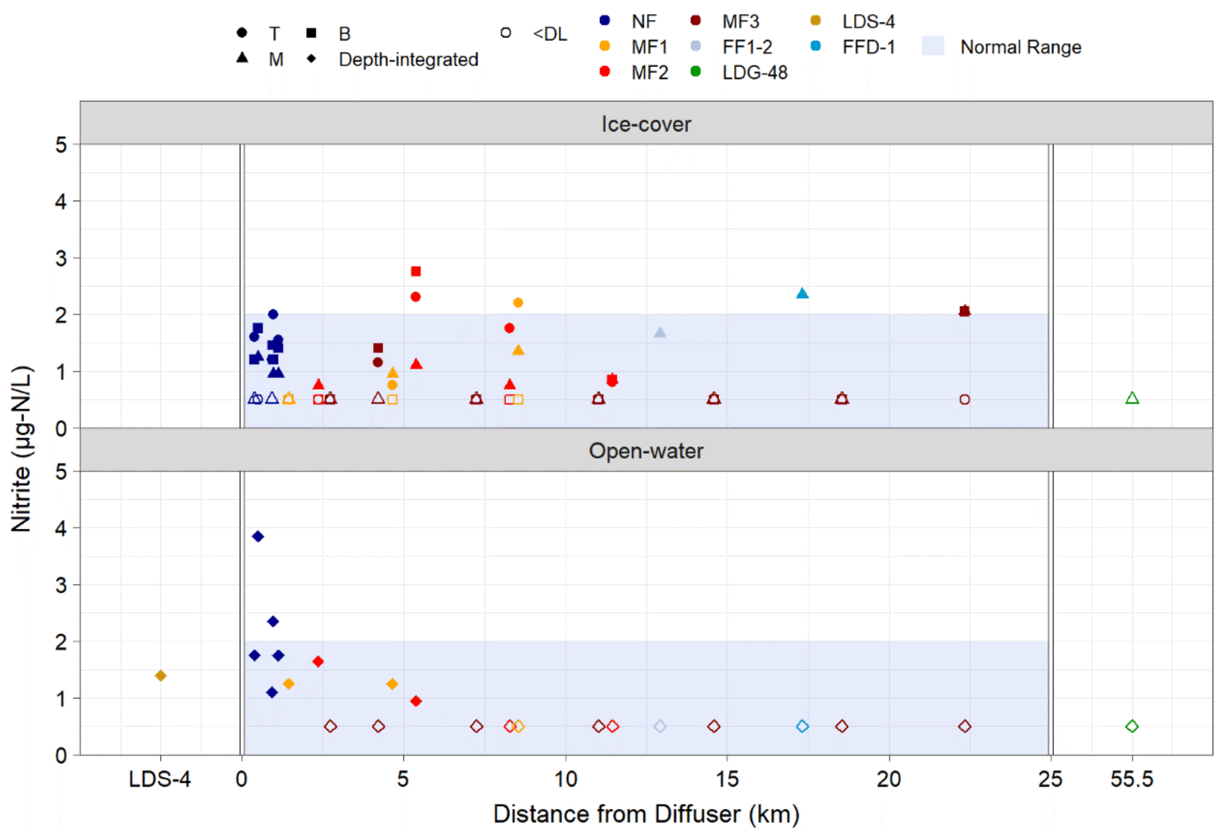


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). The open-water data were not statistically analyzed because of the high frequency of non-detects in the dataset.

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Nitrite concentrations were generally within the normal range during both ice-cover and open-water seasons (Figure 3-26). During the ice-cover season, nitrite concentrations were above the normal range at MF2-3, FFD-1, and MF3-7 stations. During the open-water season, nitrite concentrations were above normal range at two NF stations. However, nitrite concentrations were not detected frequently enough to allow gradient analysis in either season. Based on visual evaluation, nitrite concentration decreased with distance from the diffusers to a distance of about 7 km during the open-water season, but no trend was apparent during ice-cover.

Figure 3-26 Concentrations of Nitrite in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021

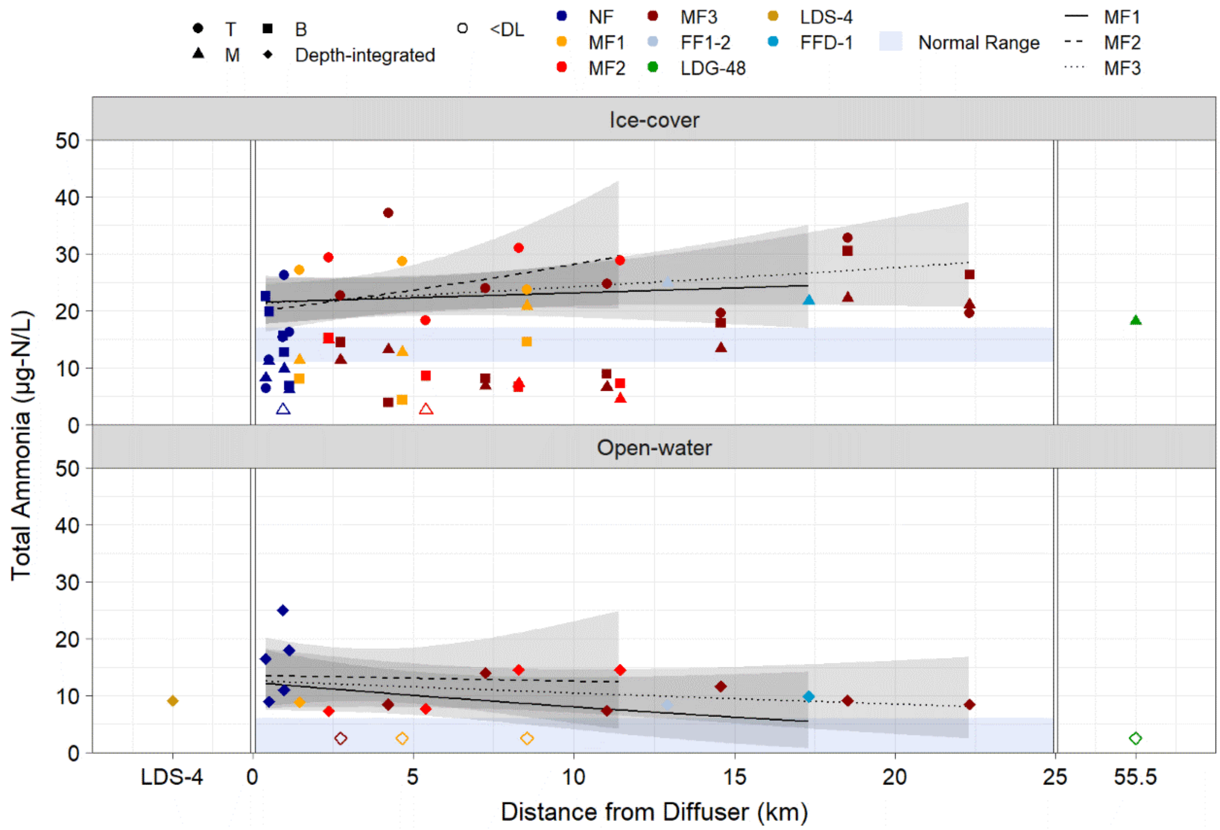


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season.

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Total ammonia concentrations were generally greater than the normal range during both the ice-cover and open-water seasons at most stations (Figure 3-27). No significant trends were detected along transects during the ice-cover or open-water seasons (Table 3-2).

Figure 3-27 Concentrations of Total Ammonia in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021

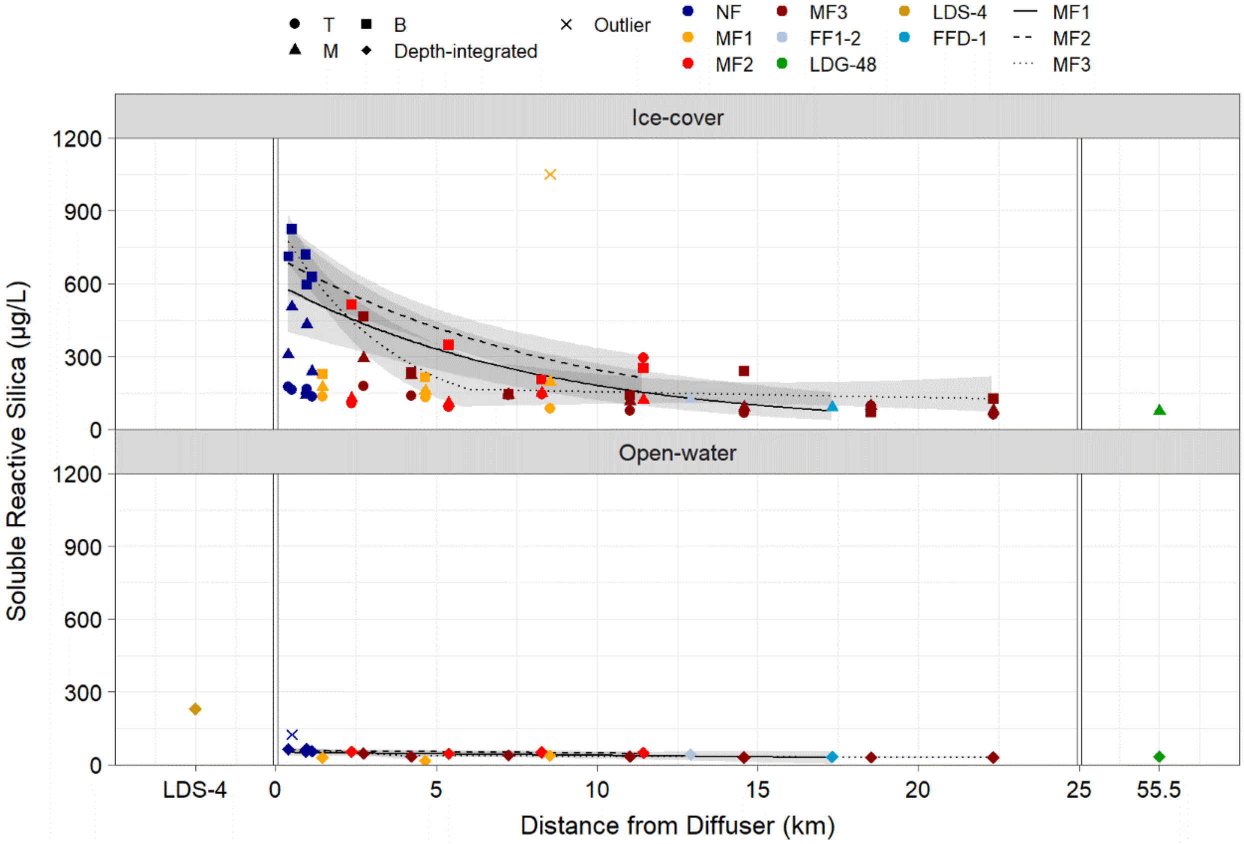


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

The concentrations of SRSi were higher during ice-cover compared to the open-water season (Figure 3-28). Significant decreasing trends in concentrations of SRSi were observed along all MF transects during the ice-cover season and along the MF3 transect during the open-water season (Table 3-2, Figure 3-28).

Figure 3-28 Concentrations of Soluble Reactive Silica in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). The open-water data were not statistically analyzed because of the high frequency of non-detects in the dataset.

µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

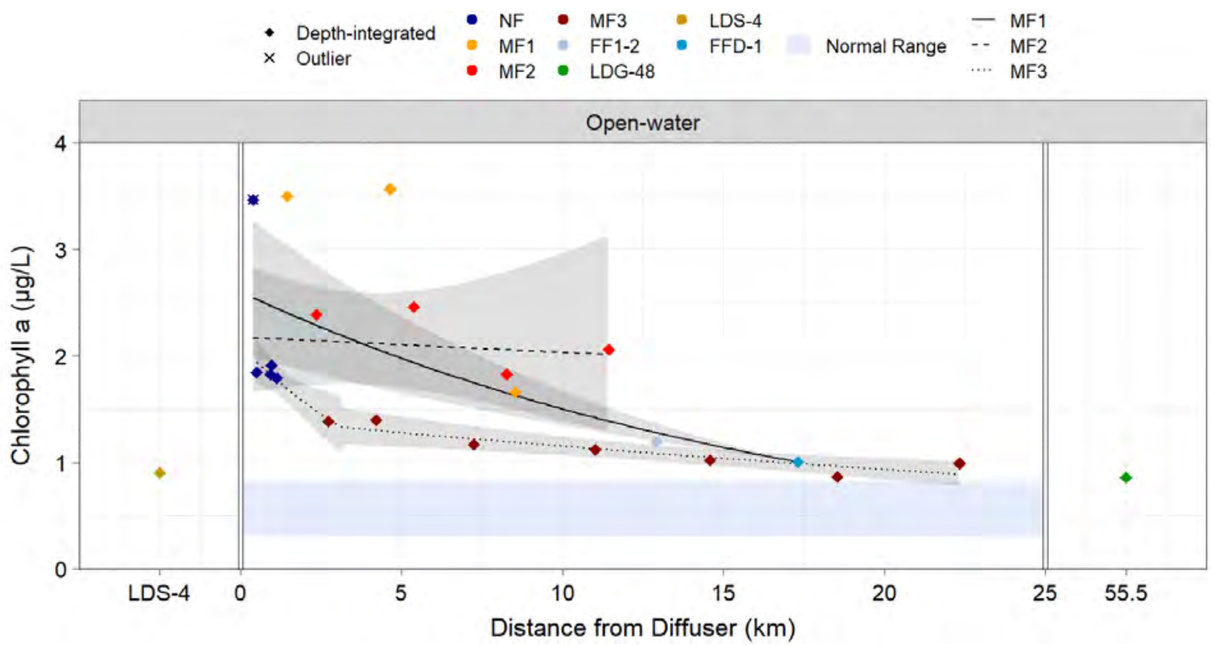
3.2.5.3 Chlorophyll *a*, and Phytoplankton and Zooplankton Biomass

Chlorophyll *a* concentrations were above the normal range at all stations (Figure 3-29). There were significant decreasing trends in chlorophyll *a* concentration with distance from the diffuser along the MF1 and MF3 transects (Table 3-3, Figure 3-29).

Total phytoplankton biomass was above the normal range at one station along the MF1 transect; biomass at all other stations was within the normal range (Figure 3-30). Phytoplankton biomass had a significant decreasing trend along the MF1 transect (Table 3-3, Figure 3-30).

Zooplankton biomass (as AFDM) was above the normal range at almost all stations (Figure 3-31). Significant decreasing trends in zooplankton biomass with distance from the diffuser were observed along the MF1 and MF3 transects (Table 3-3).

Figure 3-29 Concentrations of Chlorophyll *a* in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Table 3-3 Gradient Analysis Results for Biological Variables during the Open-Water Season, 2021

Variable	Model	Transformation	Gradient	Slope[(a)]	Breakpoint (km)[(b)]	*P*-value	r^2 or R^2[(c)]
Chlorophyll *a*[(d)] (µg/L)	Model 2	Log	MF1	↓	-	**<0.001**	0.87
	Model 2		MF2	↓	-	0.783	
	Model 3		MF3 (1st slope)	↓	3.1	**0.022**	0.94
	Model 3		MF3 (2nd slope)	↓		-	
Phytoplankton Biomass (mg/m³)	Model 1	Log	MF1	↓	-	**0.021**	0.14
	Model 1		MF2	↑	-	0.812	
	Model 1		MF3	↓	-	0.529	
Zooplankton Biomass as AFDM (mg/m³)	Model 1	Log	MF1	↓	-	**0.002**	0.66
	Model 1		MF2	↑	-	0.974	
	Model 1		MF3	↓	-	**<0.001**	

a) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent diffusers, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent diffusers.

b) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

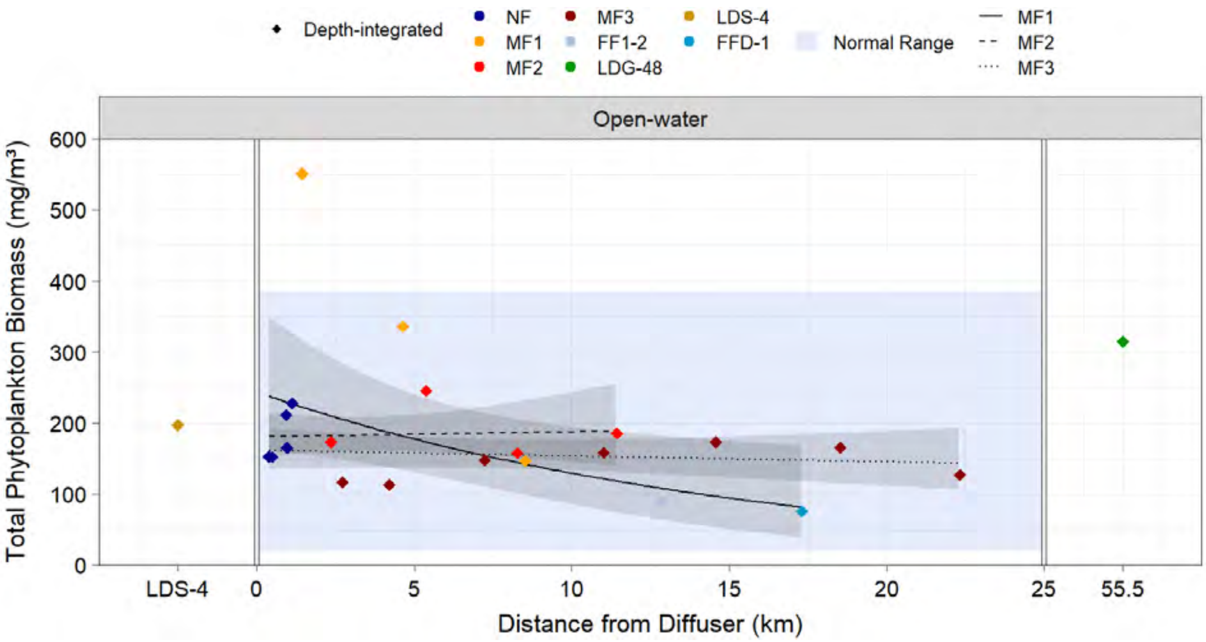
c) For the MF3 broken stick model, r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, because there is more than one predictor, i.e., distance and gradient.

d) Outlier removed: 3.47 µg/L.

Note: **Bold** indicates *P*-value significant at <0.05. The *P*-value relevant to the second slope is not reported by the statistical software because it cannot be estimated (Muggeo 2008).

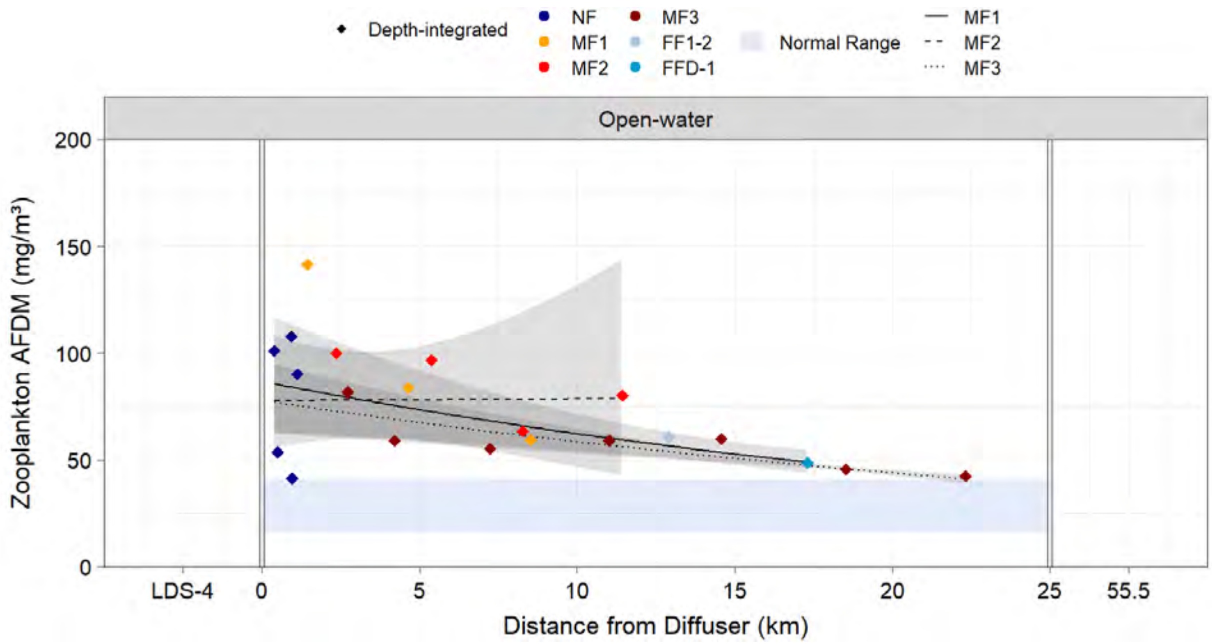
µg/L = micrograms per litre; AFDM = ash-free dry mass; MF = mid-field; - = not applicable; < = less than; r^2 or R^2 = coefficient of determination.

Figure 3-30 Total Phytoplankton Biomass in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).
mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS = Lac du Sauvage outlet (the Narrows).

Figure 3-31 Total Zooplankton Biomass in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2021



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).
mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage outlet (the Narrows).

3.2.6 Extent of Effects

As required by Directive 2B from the 25 March 2019 WLWB Decision regarding the *AEMP 2017 Annual Report* (Golder 2018), the spatial extent of effects of TP and TN was estimated for both the ice-cover and open-water seasons, and all three depths (i.e., top, middle, and bottom) for the ice-cover season. Maximum extent of effects for each variable is shown in figures in this section, and seasonal extents of effects are shown in Attachment D.

The spatial extent of effects on TP concentrations has generally been low throughout the AEMP monitoring years, and the lake area affected has remained at or near 0% since 2018 (Figure 3-32, Table 3-4). In 2021, TP concentrations were below the normal range at all stations in the open-water season and at the bottom depth in the ice-cover season. Concentrations of TP were above the normal range at the top depths at NF1, NF4, and MF2-1 and the middle depths at MF2-1 and MF2-3 during the ice-cover season (Figure E-1). Therefore, the area of the lake affected was 0% during the open-water season and 3.4% during the ice-cover season (Table 3-4).

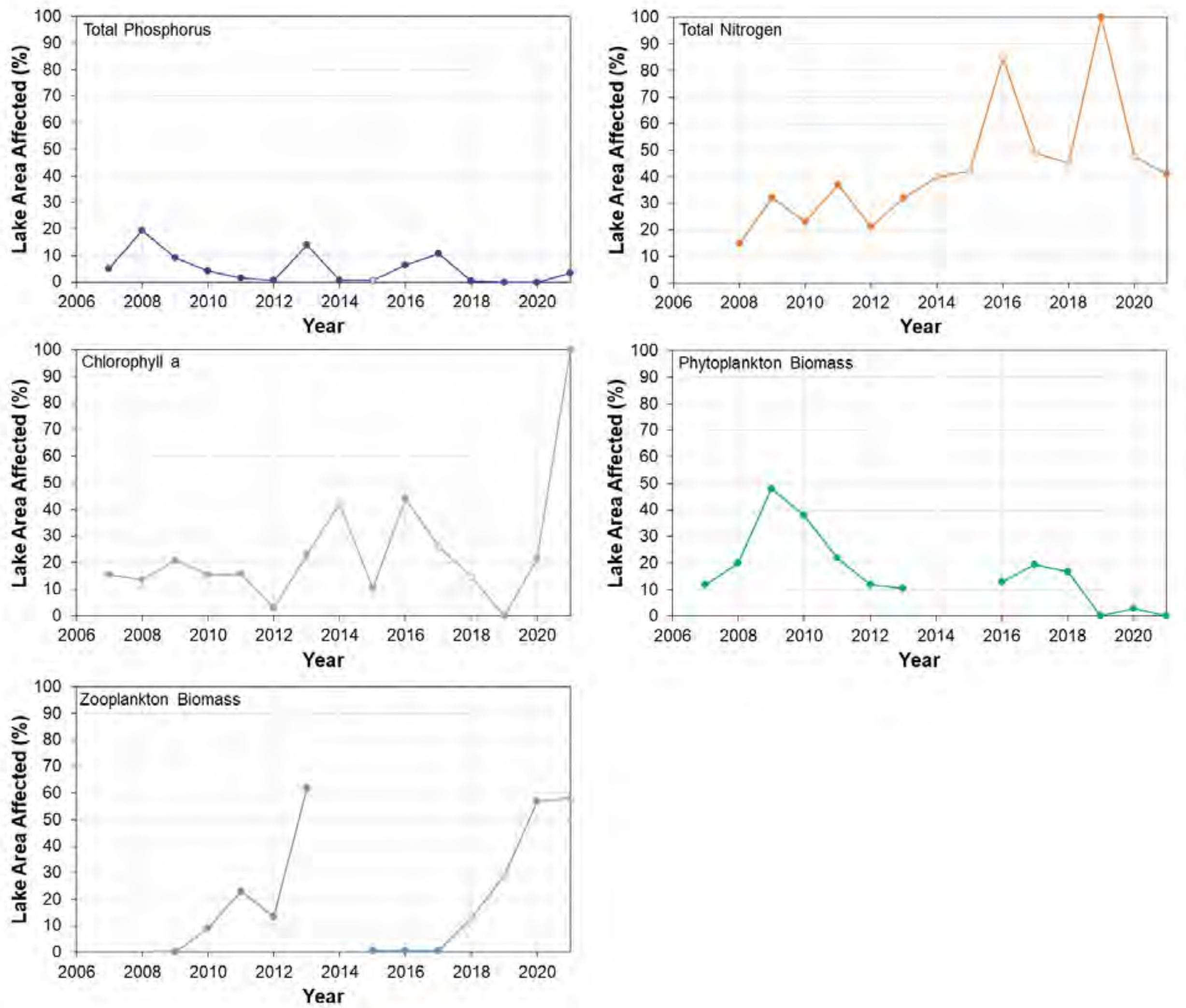
The area of lake affected by elevated TN concentrations was lower in 2021 than in 2020 (Figure 3-32). In 2021, concentrations of TN were above the normal range at some stations along the MF1 and MF3 transects and at all stations along the MF2-FF2 transect, with the area affected lower during the open-water season and varying with depth during the ice-cover season (Figure E-2). The area of the lake affected for TN was 20% during the open-water season and 41% during the ice-cover season based on middle depth concentrations (Table 3-4 and Figure 3-34).

Chlorophyll *a* concentrations were higher in 2021 than in recent years, with concentrations at all stations above the normal range. Concentrations were similar to those measured in 2014 and 2016, with the exception that chlorophyll *a* concentration at LDG-48 was slightly above the normal range in 2021. Chlorophyll *a* concentration at LDG-48 was 0.86 µg/L, which is just above the upper limit of the normal range of 0.82 µg/L. Although FFA and FFB areas were not sampled this year, stations FF1-2 and FFD-1 provided useful information as to the extent of the elevated concentrations along the MF1 and MF3 transects. Thus, based on measured concentrations, it was assumed that the entire lake was affected (100%; Table 3-4 and Figure 3-35). The elevated concentration at LDG-48 results in a higher spatial extent of effects than has been observed in the past (Figure 3-32). As data are not available for a large extent of Lac de Gras between stations MF3-7 and LDG-48, the estimated extent of effects is subject to greater uncertainty that those for other variables which had boundaries of effects within the sampled areas.

Total phytoplankton biomass was below the normal range in the NF area and at all stations except for MF1-1. Thus the area of the lake affected was 0%, which is the same as that observed in 2019 (Figure 3-32 and Figure 3-36; Table 3-4). This smaller extent of effects for total phytoplankton biomass is generally consistent with the results for TP but inconsistent with the results for chlorophyll *a.* It is not clear why chlorophyll *a* concentration (an indicator of phytoplankton biomass) would be elevated without some corresponding increase in measured phytoplankton biomass.

Effects on zooplankton biomass (as AFDM) were observed in the NF area and extended along all three transects (Figure 3-37). The boundary of effects on zooplankton biomass to the northwest (i.e., MF1 transect) extended to FF1-2 and FFD-1 stations. The boundary of effects to the northeast of the Mine (i.e., MF2 transect) extended throughout the entire transect, reaching the Lac du Sauvage outlet (LDS-4). The boundary to the south of the Mine (i.e., MF3 transect) extended to MF3-7. As zooplankton biomass was above the normal range at the MF3-7 station, and sampling did not occur in the FFA and FFB areas during the 2021 sampling program, the extent of effects could have been greater than the estimated area. Thus, the area demonstrating effects on zooplankton biomass (as AFDM) was estimated as greater than or equal to 332 km^2, or 58% of the lake area (Table 3-4).

Figure 3-32 Eutrophication Indicators Affected Area in Lac de Gras, 2007 to 2021



Note: Open symbols represent years where the percent lake area affected could not be estimated with certainty due to limited sampling in the far-field area. Breaks in connecting lines represent years with no data. Values presented are from Table 3-4. As required by Requirement #3e from the 31 January 2022 WLWB Decision regarding the *AEMP 2020 Annual Report* (Golder 2021), the following description provides additional detail on how the extent of effects were calculated for phytoplankton biomass in this figure. The values for 2021 were calculated in this report using the 2021 data and the methods outlined in Section 2.4.4.3. Lake area affected for years prior to 2021 were not re-calculated as part of the data analysis for this current report. The values for years previous to 2021 were taken from the AEMP Annual Report associated for that year. For example, area affected of 13% for phytoplankton biomass in 2016 was calculated and presented in the 2016 AEMP Annual Report using the upper limit of the normal range approved at the time of that report (i.e., 351.6 mg/m^3). The currently approved normal range for phytoplankton biomass (i.e., 384.7 mg/m^3) was approved in time to be used in the *AEMP 2019 Annual Report* (Golder 2020c), and has been used in every AEMP Annual Report since then, including this current 2021 AEMP Annual Report. If the new normal range is applied to older data (i.e., pre-2019), then the area affected may slightly decrease from what was originally reported. This is because the area affected calculation estimates the area with concentrations above the normal range based on the magnitude of those concentrations relative to the upper limit of the normal range. As the new normal range is slightly higher than the old one, the difference in magnitude above the normal range will be smaller.

Table 3-4 Spatial Extent of Effects on Concentrations of Total Phosphorus, Total Nitrogen and Chlorophyll *a*, and Phytoplankton and Zooplankton Biomass, 2007 to 2021

Year	Total Phosphorus		Total Nitrogen		Chlorophyll *a*		Phytoplankton Biomass		Zooplankton Biomass (AFDM)	
	Area (km^2)[a]	Lake Area (%)[a,b]	Area (km^2) [a]	Lake Area (%)[a,b]	Area (km^2)	Lake Area (%)[b]	Area (km^2)	Lake Area (%)[b]	Area (km^2)	Lake Area (%)[b]
2007	29	5.1	-	-	89	15.5	67	11.7	-	-
2008	112	19.6	85	14.8	77	13.5	116	20	-	-
2009	54	9.3	180	32	121	21	274	48	0	0
2010	24	4.2	132	23	89	15.5	217	38	52	9.1
2011	9.2	1.6	213	37	89	15.6	125	22	129	23
2012	3.6	0.6	118	21	17.0	3.0	67	11.8	77	13.4
2013	81	14.1	183	32	129	23	59	10.4	355	62
2014	3.5	0.6	≥230[c]	≥40[c]	≥243[c]	≥42[c]	-[d]	-[d]	-	-
2015	<3.5[e]	<0.6[e]	≥243[c]	≥42[c]	59	10.3	-[d]	-[d]	<3.5[e]	<0.6[e]
2016	37	6.5	≥485[c]	≥85[c]	250	44	75	13.0	2.9	0.5
2017	0 (OW)	0 (OW)	≥257 (OW)[c]	≥49 (OW)[c]	≥150[c]	≥26[c]	111	19.4	<3.5[e]	<0.6[e]
	62 (IC)	10.8 (IC)	≥240 (IC)[c]	≥42 (IC)[c]						
2018	0 (OW)	0 (OW)	229 (OW)	40 (OW)	≥84[c]	≥14.7[c]	96	16.8	≥74[c]	≥12.8[c]
	2.6 (IC)	0.5 (IC)	≥257[c]	≥45[c]						
2019	0[f]	0[f]	573 (OW)	100 (OW)	0.5	0.1	0	0	≥168[c]	≥29[c]
			484 (IC)	85 (IC)						
2020	0[f]	0[f]	191 (OW)[g]	33 (OW)[g]	123	22	16.2	2.8	326	57
			≥276 (IC)[c]	≥48 (IC)[c]						
2021	0 (OW)	0 (OW)	113 (OW)	20 (OW)	573	100	0	0	≥332[c]	≥58[c]
	19.3 (IC)	3.4% (IC)	235 (IC)	41 (IC)						

a) For years 2007 to 2016, lake area reported for total phosphorus and total nitrogen is the greater of the area affected during the ice-cover and open-water seasons. For years 2017 to 2021, lake area affected by nutrient concentrations greater than normal range was calculated for both the open-water and ice-cover seasons, and for all three depths (top, middle, bottom) for the ice-cover season. The results for the ice-cover season are for the depth with the greatest area affected.

b) The lake area affected represents the percentage (%) of lake area experiencing levels greater than the normal range, and was calculated relative to the total surface area of Lac de Gras (573 km^2).

c) Due to an uncertain effect boundary at the end of the MF1 and/or MF3 transect, the extent of effects could have been greater than the area presented.

d) Only the NF area was sampled in 2014 and 2015; therefore, extent of effects was not calculated.

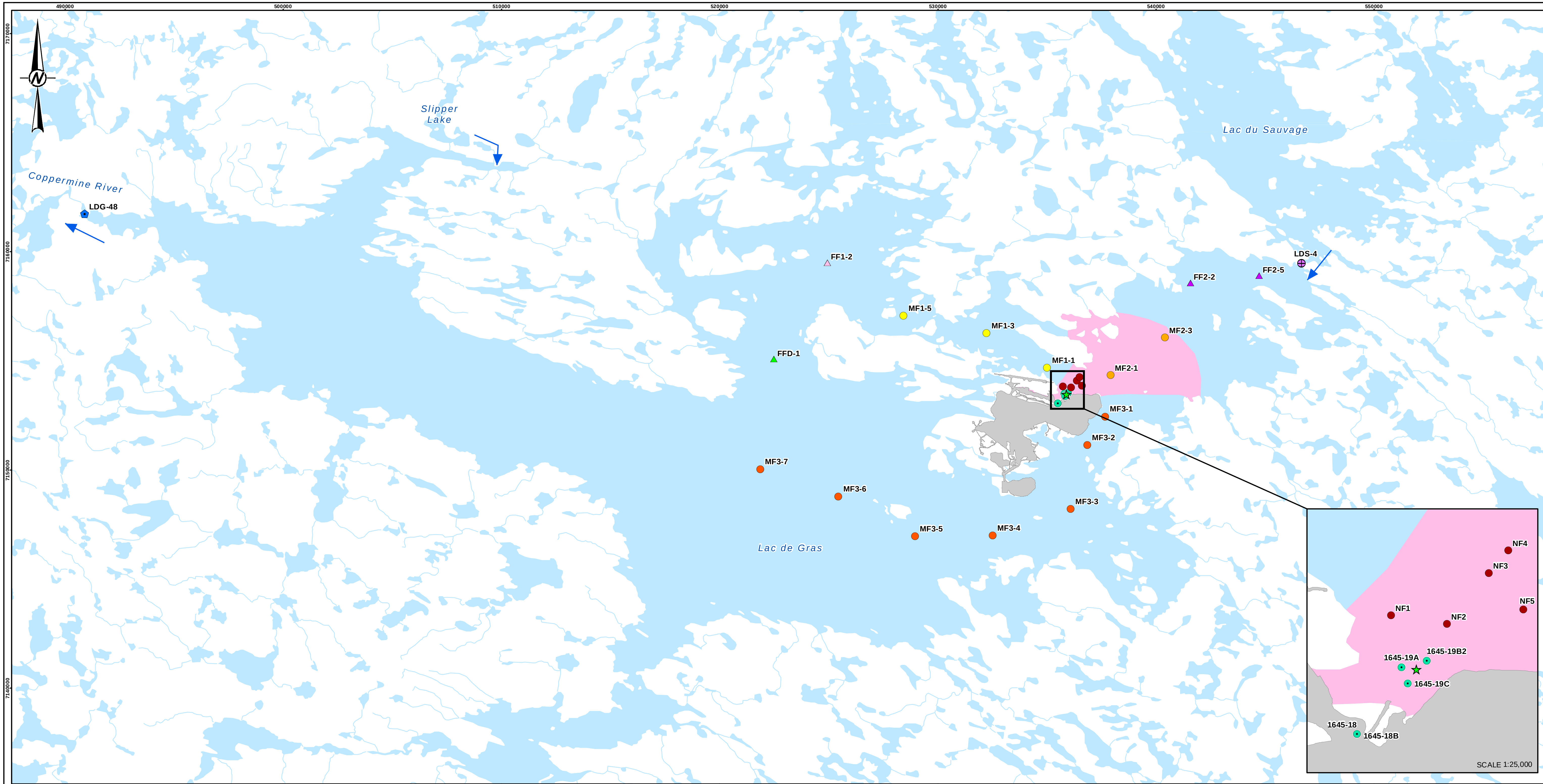
e) The mean of the NF area stations was within the normal range. Since only one or two NF stations exceeded the normal range, the affected area was assumed to be less than the total area of the NF area (i.e., 0.6% of lake area).

f) There was no difference in area affected among seasons or depths.

g) In the 2020 AEMP Annual report, the extent of effect for TN during the open-water season was incorrect. The extent of effect along the MF3 transect was incorrectly shown to be between stations MF3-6 and MF3-7; however, the TN concentration at MF3-6 during the open-water season was 135 µg/L, which is below the upper limit of the normal range of 153 µg/L. Thus the revised total area affected during the open-water season for 2020 is presented.

< = less than; ≥ = greater than or equal to; - = no data are available; NF = near-field; MF = mid-field; FF = far-field; AFDM = ash-free dry mass.

Note: To enhance readability, numbers greater than 20 km^2 or 20% in this table were rounded to whole numbers.



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD

- FLOW DIRECTION
- WATERCOURSE
- AFFECTED AREA[1]
- DIAVIK FOOTPRINT
- WATERBODY

0 5 10

1:175,000 KILOMETRES

NOTE(S)

1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON LARGEST EXTENT OF EFFECT ACROSS SAMPLED SEASONS AND DEPTHS.

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

RioTinto

CONSULTANT

WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

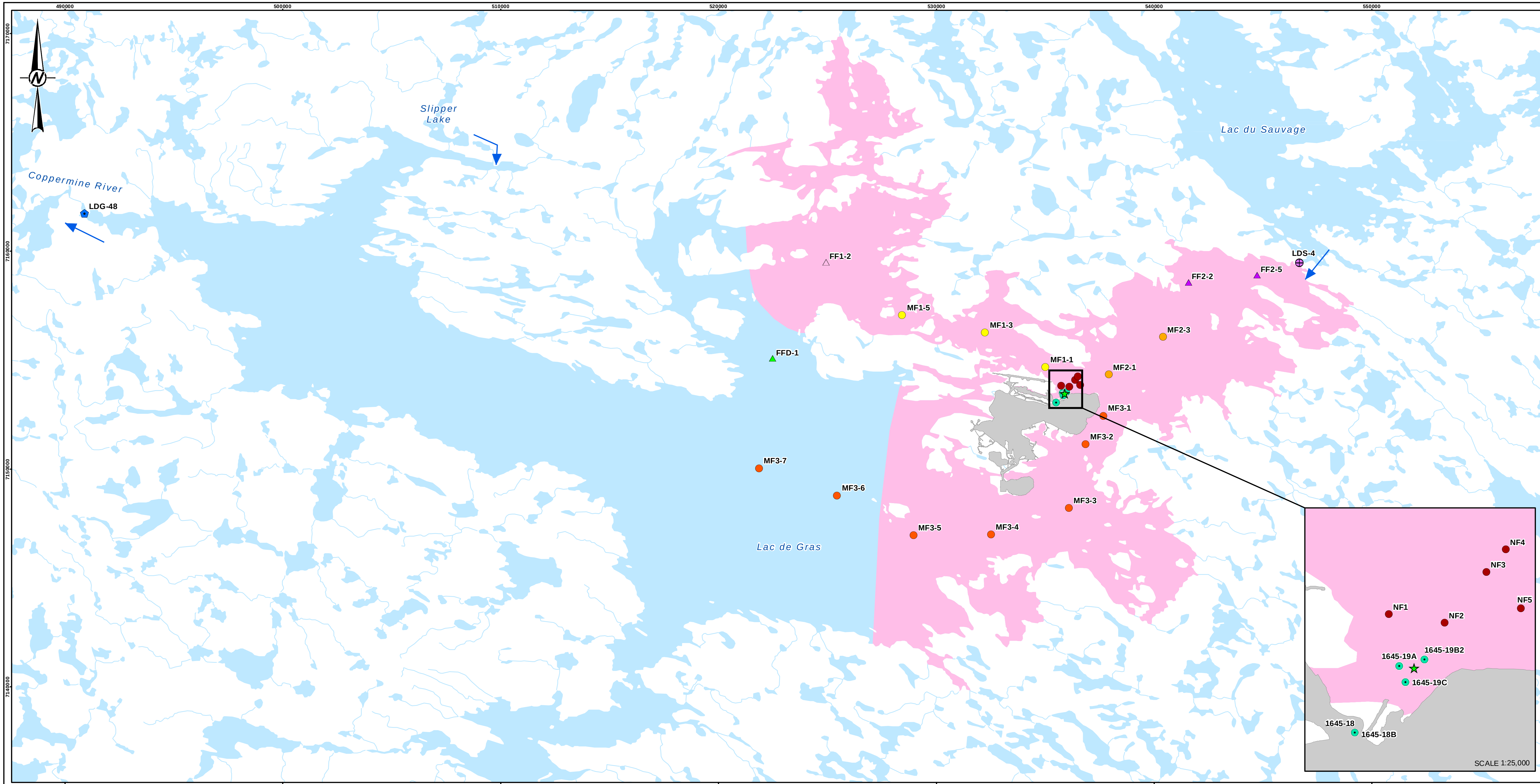
PROJECT

DIAVIK DIAMOND MINES (2012) INC.

TITLE

TOTAL PHOSPHORUS AFFECTED AREA IN LAC DE GRAS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	3-33



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD

- FLOW DIRECTION
- WATERCOURSE
- AFFECTED AREA[1]
- DIAVIK FOOTPRINT
- WATERBODY

0 5 10

1:175,000 KILOMETRES

NOTE(S)

1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON LARGEST EXTENT OF EFFECT ACROSS SAMPLED SEASONS AND DEPTHS.

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT: RioTinto

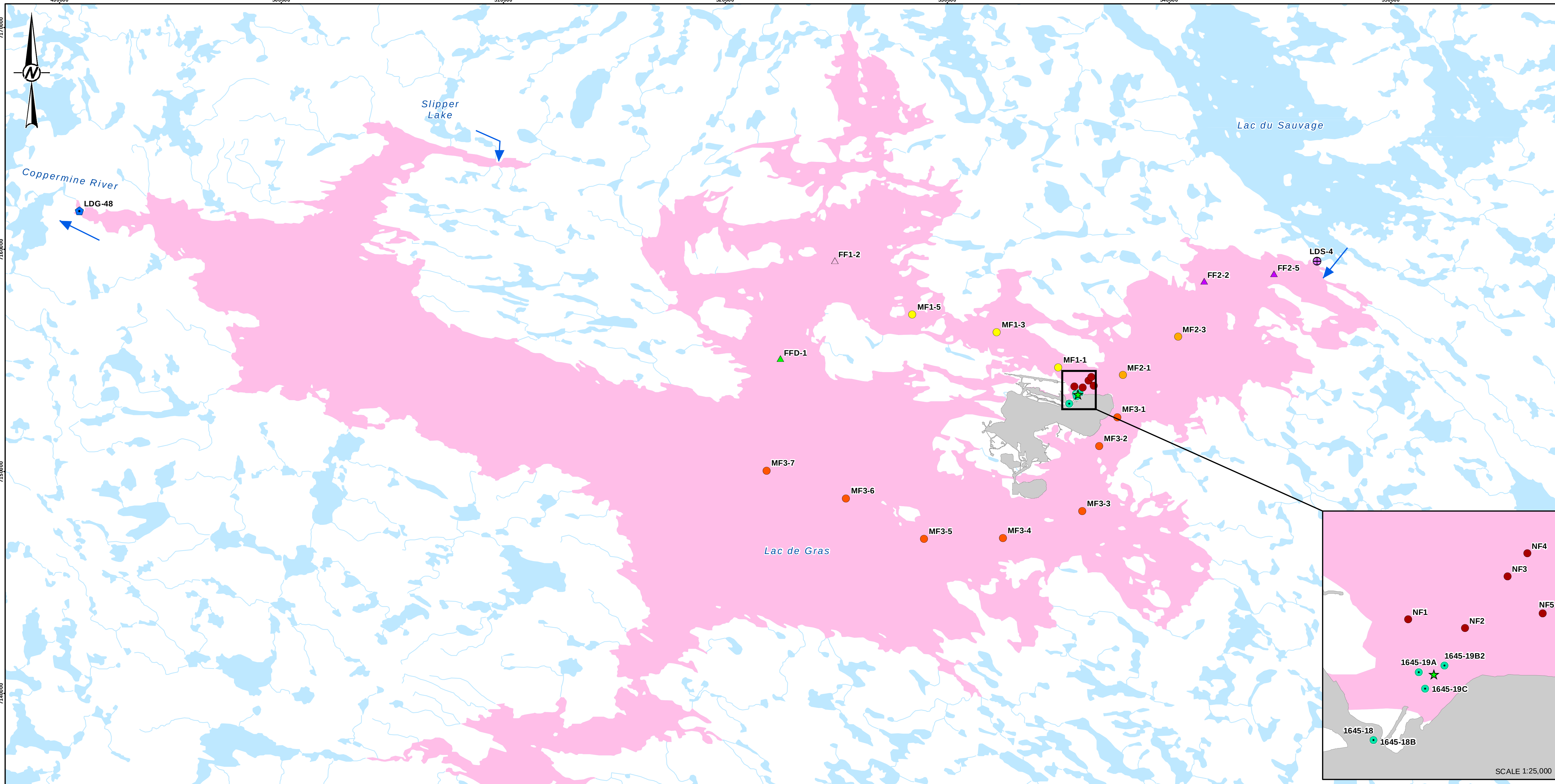
PROJECT: DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT: WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

TITLE
TOTAL NITROGEN AFFECTED AREA IN LAC DE GRAS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	3-34



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD

- FLOW DIRECTION
- WATERCOURSE
- AFFECTED AREA[1]
- DIAVIK FOOTPRINT
- WATERBODY

0 5 10
1:175,000 KILOMETRES

NOTE(S)

1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON OPEN-WATER DATA.

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

TITLE
CHLOROPHYLL A AFFECTED AREA IN LAC DE GRAS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	3-35

PATH: I:\CLIENTS\DIAVIK\21452119\Mapping\Fish\AEMP_2021\Fig3-35_21452119_AEMP_2021AffectedAreas_ChlorophyllA_Rev0.mxd PRINTED ON: 2022-03-28 AT: 2:20:45 PM

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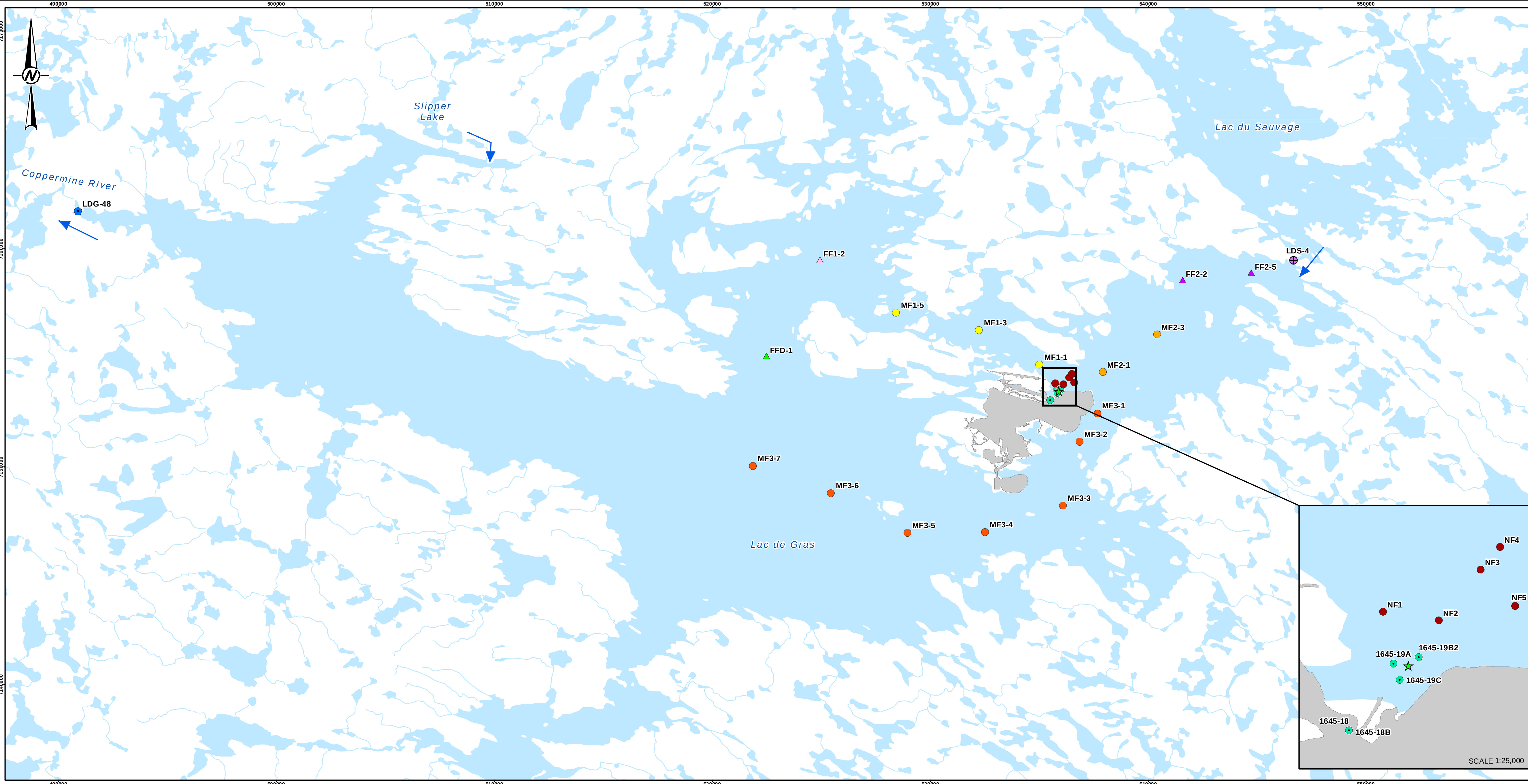
25mm



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD

- FLOW DIRECTION
- WATERCOURSE
- AFFECTED AREA[1]
- DIAVIK FOOTPRINT
- WATERBODY

0 5 10

1:175,000 KILOMETRES

NOTE(S)

1. NO AFFECTED AREA. ALL STATIONS HAD PHYTOPLANKTON BIOMASS RESULTS THAT WERE LESS THAN THE UPPER BOUND OF THE NORMAL RANGE.

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

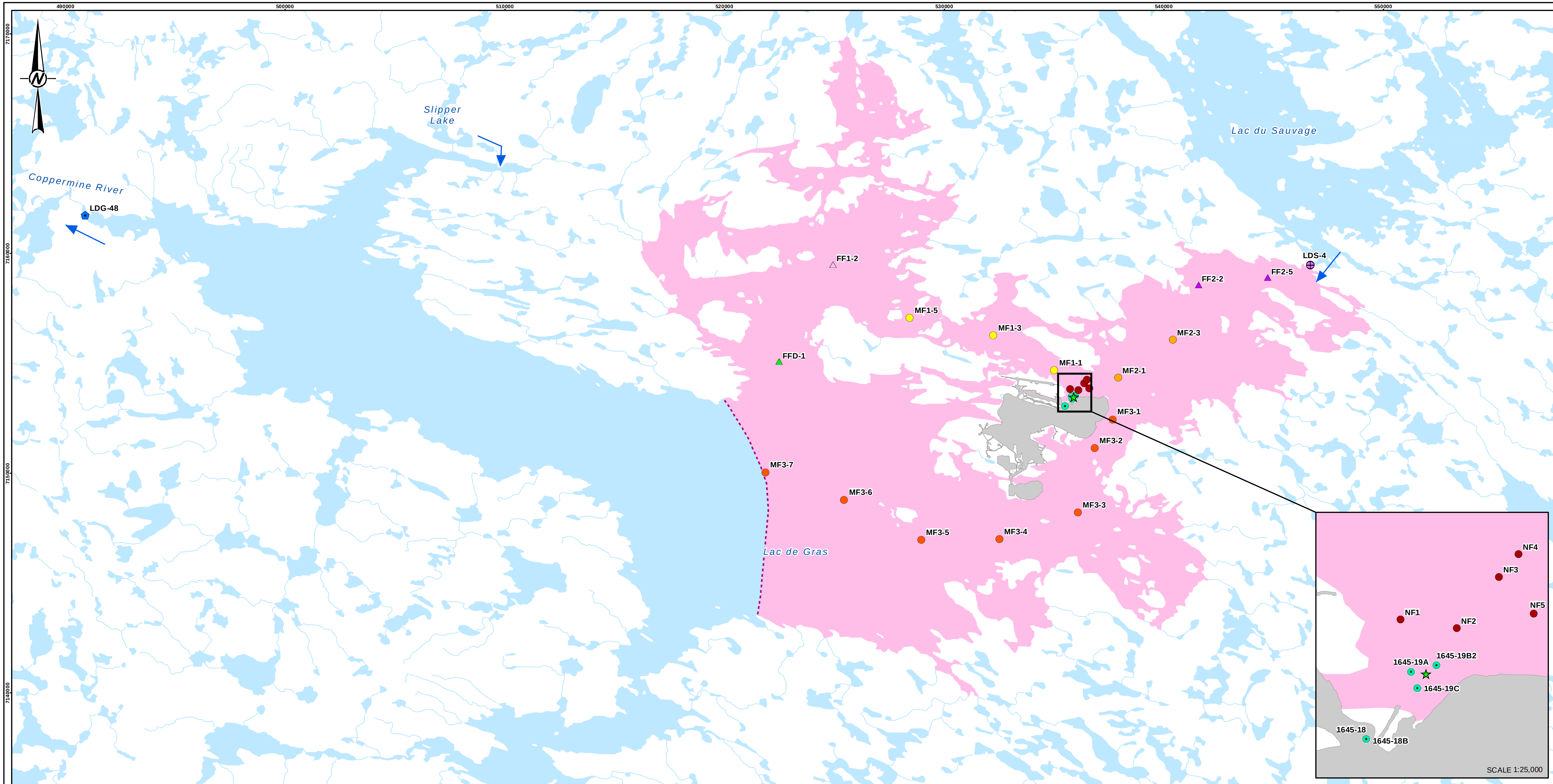
CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

TITLE
TOTAL PHYTOPLANKTON BIOMASS AFFECTED AREA IN LAC DE GRAS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	3-36

25mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD

- FLOW DIRECTION
- UNCERTAIN EFFECT BOUNDARY
- WATERCOURSE
- AFFECTED AREA[1]
- DIAVIK FOOTPRINT
- WATERBODY

0 5 10
1:175,000 KILOMETRES

NOTE(S)
1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON OPEN-WATER DATA.

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

CONSULTANT
wsp GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

TITLE
TOTAL ZOOPLANKTON BIOMASS (AS AFDM) AFFECTED AREA IN LAC DE GRAS, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	3-37

3.2.7 Role of Nitrogen in Spatial Extent of Chlorophyll *a*

Pearson correlation coefficients in 2021 indicated no relationship between TN and chlorophyll *a* (r = 0.336, P = 0.117, n = 23), TP and chlorophyll *a* (r = 0.015, P = 0.946, n = 23), SRP and chlorophyll *a* (r = 0.010, P = 0.963, n = 23), or between SRSi and chlorophyll *a* (r = 0.136, P = 0.535, n = 23). However, Pearson correlation coefficients indicate a moderately strong and significant correlation between TDS and chlorophyll *a* (r = 0.711, P = 0.0001, n =23). These results are consistent with nitrogen not being the limiting nutrient in Lac de Gras, and also imply a potential Mine-related enrichment effect related to an increase in micronutrients associated with TDS.

These results are also consistent with the implications of year-to-year variation in effects on nutrient concentrations and productivity indicators illustrated in Figure 3-32. Although a notable increase in the affected area by TN has occurred between 2007 and 2021, similar trends are not apparent in affected areas for indicators of primary productivity. In 2021, the large spatial extent of chlorophyll *a* is not consistent with the much lower spatial extent of TN. Combined with the results of the correlations described above, monitoring results indicate no notable influence of nitrogen loading from the Mine effluent on the spatial extent of effects on primary producers in Lac de Gras.

3.2.8 Effects of Dust Deposition

Phosphorus load to Lac de Gras from dustfall was estimated using snow water chemistry data collected as part of the 2021 Dust Deposition Report (Appendix I), with consideration of background and anthropogenic TP deposition rates (Attachment E). The methods for calculating TP loads in dust are provided in Attachment E and are the same as those used in the *AEMP 2020 Annual Report* (Golder 2021) and the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b).

It should be noted that the dust sampling program was not designed to be as precise as the AEMP effluent assessment for measuring TP loading to Lac de Gras. As stated in Section 3.1, the total TP load from Mine effluent based on TP concentrations in effluent discharge was 297 kg (or 0.3 tonnes [t]) in 2021. This load estimate is associated with a high degree of confidence because it is based on direct measurements of TP concentrations in effluent and effluent volume. The estimate of the TP load from dust is considered to have low precision, with an order of magnitude variance. Therefore, low confidence should be placed in the estimate of TP load from dust and it should not be directly compared to the TP load from effluent.

In 2021, the rate of dust deposition was highest within the Mine footprint, declined exponentially with distance, and was indistinguishable from background at approximately 4.9 km from the Mine centroid, which is comparable to the dust ZOI (i.e., 4.8 km) estimated in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b). Dustfall within the Mine footprint was assumed to be captured within the Mine water management system and thus incorporated within the estimate of TP load in effluent. Therefore, only dustfall to surfaces outside the Mine footprint was included in the estimate of the atmospheric TP load to Lac de Gras. The estimated TP load includes both particulate-bound and potentially bioavailable phosphorus.

The anthropogenic TP loads to Lac de Gras and the watershed (excluding the Mine and lake) in 2021 were 0.63 and 0.46 t, respectively, for a total (including Mine effluent) of 1.4 t in 2021. The anthropogenic TP loads to Lac de Gras (direct) were consistent with those estimated for 2020 (0.69 t/yr; Golder 2021) and for the 2017 to 2019 period in the last re-evaluation report (0.65 t/yr; Golder 2020b). The indirect anthropogenic

TP load was higher in 2021 (0.46 t/yr compared to 0.35 t/yr in 2020, and 0.33 t/yr in the 2017 to 2019 period). However, the estimated contribution of background TP loads to the Lac de Gras watershed was much lower in 2021 (5.2 t/yr) than previously (23 t/yr in 2020, and 21 t/yr in the 2017 to 2019 period). Thus, the contribution of anthropogenic sources to the total TP loads to Lac de Gras was 21% due to dust and 4.5% due to effluent for a total of 27%, which was higher than estimated in previous years. Thus although the TP loadings due to the Mine were similar in 2021 to previous years, the percent contribution appears much higher due to the low background TP deposition rate in 2021.

Although the magnitude of the estimated TP load from dust suggests that dust is a greater contributor to phosphorus-related effects in Lac de Gras than effluent, several lines of evidence indicate that this is not the case:

- The estimates of TP loads from dust are subject to uncertainty, in part because the loading estimates related to dust did not take into account retention of deposited phosphorus on land. It was assumed that all atmospheric deposition of TP (i.e., background and anthropogenic) that fell within the Lac de Gras watershed either fell directly on Lac de Gras or were delivered to Lac de Gras with no terrestrial attenuation. The lack of terrestrial attenuation is a conservative assumption and is expected to result in an overestimation of the TP load from dustfall to Lac de Gras.
- A large proportion of phosphorus from dust deposition that reached the lake may not be bioavailable because it would be mostly in particulate form. As discussed in the Dust SES, the potential for mobilization of phosphorus from Mine-related dustfall is low. It is likely that the mineralogical source of phosphorus in dustfall is the phosphate mineral apatite, which has low solubility under the pH and redox conditions in lake water and would not dissolve. Dust-associated phosphorus would settle to the sediment instead of dissolving and becoming available for algae to uptake. Therefore, dust-associated phosphorus is unlikely to contribute dissolved phosphorus in amounts that would result in a measurable contribution to nutrient enrichment observed in the lake.
- Water quality results indicate that effluent was the primary driver of nutrient enrichment in Lac de Gras. Concentrations of TP in Lac de Gras during the open-water season, measured as part of the 2021 AEMP, were below the normal range at all stations in the ZOI from dust deposition (i.e., NF1 to NF5, MF1-1, MF3-1, MF3-2, MF3-3) (Figure 3-38). Chlorophyll *a* concentrations were greater than the upper bound of the normal range of 0.82 µg/L at all stations throughout the lake (Figure 3-38). Concentrations followed an overall decreasing trend in concentrations with distance from the diffuser along the MF1 and MF3 transects. This trend is consistent with an effluent-related, rather than a dust-related effect. No significant trend was observed in chlorophyll *a* concentrations along the MF2 transect (Section 3.2.5.3), which is consistent with previous years. This is likely due to the input of water entering Lac de Gras from Lac du Sauvage; station LDS-4 had the highest TP concentration in the open-water season, which was above those measured in the NF stations and above normal range (Figure 3-17). Chlorophyll *a* concentration was also above the normal range at station LDS-4, although not higher than those measured at the NF stations or FF2-5 (Figure 3-29).
- Wind directions at the site in 2021 were generally omnidirectional with northwest, southeast and east being the dominant directions (Appendix I). Therefore, the expectation is that airborne material will be deposited in all directions around the mine with a west, northwest and southeast emphasis. Similar to previous years, the results of the 2021 Dust Deposition Report (Appendix I) show that proximity to Mine activity is a stronger indicator of dust deposition than wind direction. Figure 3-39 shows the relative concentrations of total phosphorus and chlorophyll *a* in relation to the Mine footprint. On these plots,

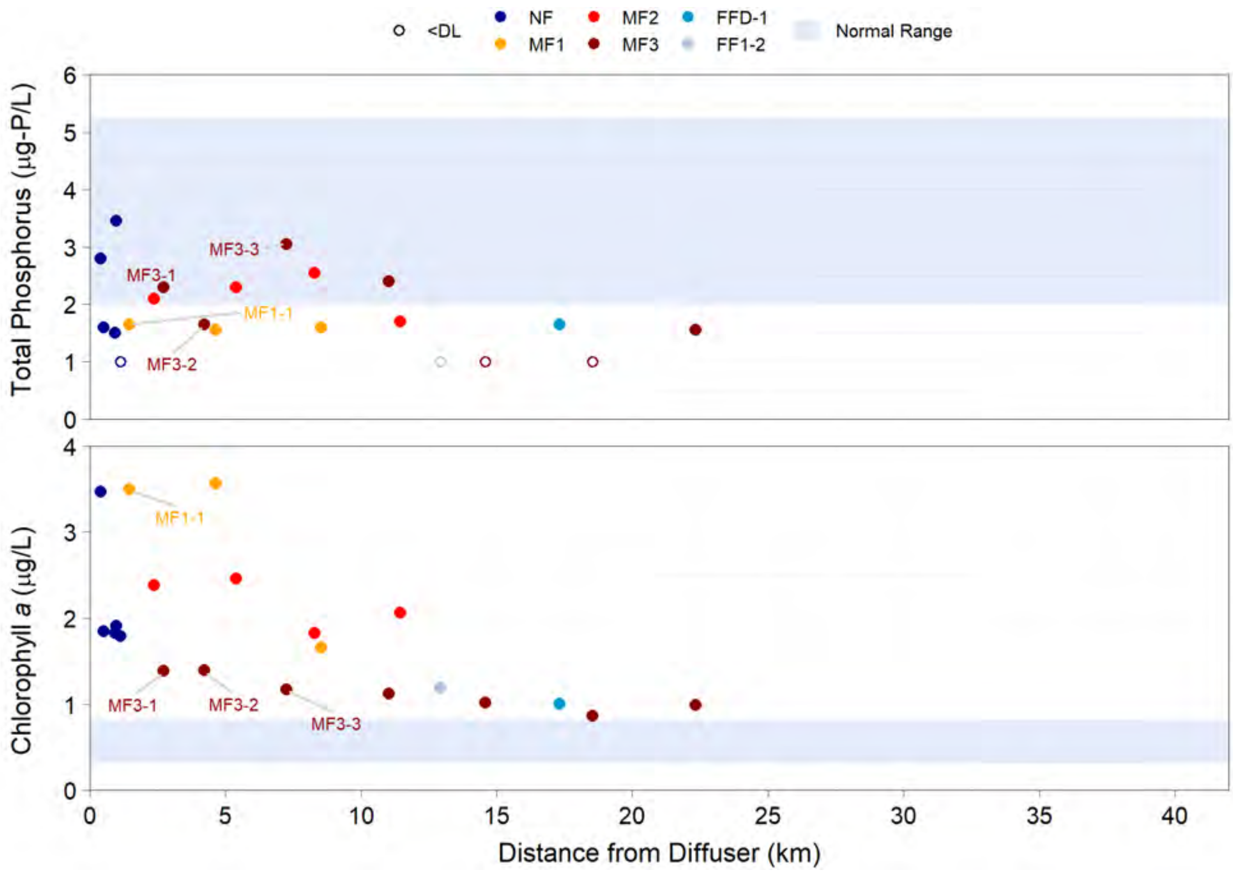
elevated concentrations of chlorophyll *a* were observed closest to the diffuser in the NF area, and were not observed to the east and southeast, as would be expected if dust was as prominent a contributor as effluent. The highest TP concentration occurred at the outlet of Lac du Sauvage, which is not expected to be influenced by dust from Diavik Mine. The inflow from Lac du Sauvage is likely to represent a major influence on TP concentration and primary productivity in the eastern portion of Lac de Gras.

- The lack of obvious dust-related effects on TP and chlorophyll *a* in the 2021 AEMP are supported by the Dust SES that was conducted in 2019. TP and chlorophyll *a* sampling was completed at four additional stations in 2019 as part of the Dust SES to evaluate the influence of dust deposition on water quality in Lac de Gras. These stations were located within the dust ZOI but were much closer to dust-generating Mine activities than AEMP stations and, therefore, had the potential to be more influenced by dust deposition than the AEMP stations. Mean TP concentrations at these stations were similar to those measured in other areas of Lac de Gras, and were also below the upper bound of the normal range. Chlorophyll *a* concentrations at these stations were also lower than those measured at nearby AEMP stations (i.e., MF3-1 to MF3-4), and were at or below the lower bound of the normal range. Instead of TP and chlorophyll *a* concentrations being higher at these SES stations due to higher dust deposition, concentrations were consistent with the overall declining trends away from the effluent diffusers. The Dust SES also concluded that although the Mine effluent and dustfall samples have distinct geochemical signatures, the signature of lake water is similar to that of effluent, and the influence of dust could not be differentiated from that of effluent.

- The *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) estimated phosphorus input from dust under the annual worst-case loading condition (i.e., spring break-up) at AEMP sampling stations within and outside the dust ZOI. Calculations indicated that adding all TP and SRP deposited to snow during the ice-cover season to the lake at spring break-up would likely result in negligible to small increases in TP and SRP in lake water, within and outside the dust ZOI. In addition, only a portion of the added phosphorus would remain in the water column and be bioavailable. It is known from analysis of AEMP biological data that the input of phosphorus from continuous effluent discharge typically results in only a small area with detectable increases in phosphorus concentration, because the added phosphorus is quickly utilized by phytoplankton in this oligotrophic lake. Similarly, the bioavailable portion of the phosphorus load from dust during spring break-up is expected to be quickly taken up by algae and would not be available beyond a short period after break-up. Open-water season phosphorus loading from dust deposition is diffuse and episodic and would be even less likely to result in a measurable increase in phosphorus concentrations in lake water or a biological effect.

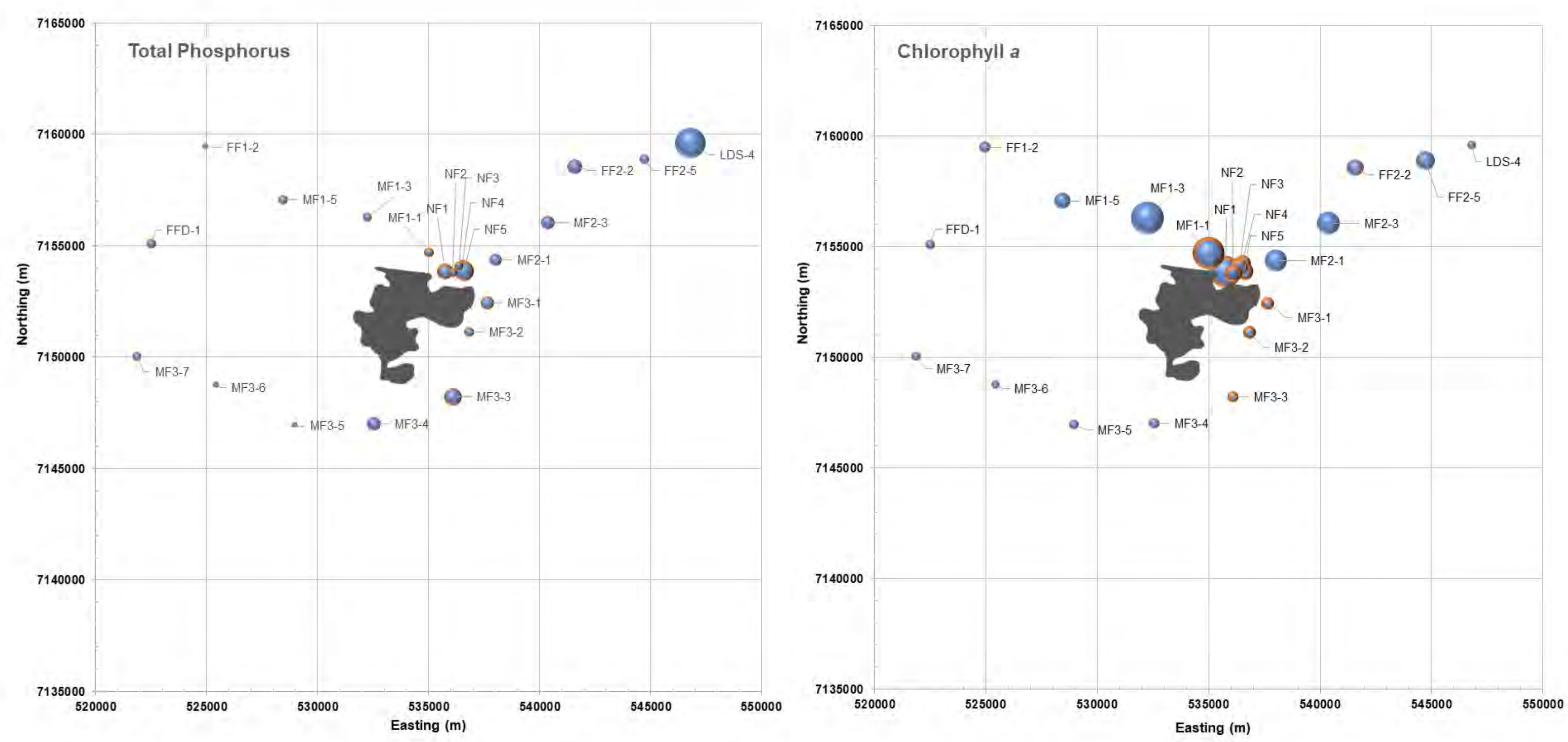
In summary, despite the estimated potentially large contribution of TP from dust relative to other sources, the 2021 AEMP provided no evidence that dust deposition had an additional measurable effect on concentrations of TP or chlorophyll *a* in Lac de Gras, beyond the effect apparent from the Mine effluent discharge. Additionally, since the potential effect of dust deposition and the known effluent effect are spatially confounded, an approach based on AEMP field data to separate the two effects is highly unlikely to be successful. The usefulness of continuing to calculate TP load from dust is questionable; the resulting estimate appears to consistently overestimate the contribution of TP in dust to nutrient enrichment in the lake. The AEMP sampling design provides sufficient and appropriate data to evaluate the effects in Lac de Gras from all Mine-related sources, including dustfall.

Figure 3-38 Concentrations of Total Phosphorus and Chlorophyll *a* in Lac de Gras in Relation to Distance from the Diffuser during the Open-water Season, 2021



Note: MF stations in the zone of influence from dust deposition are labelled (i.e., MF1-1, MF3-1, MF3-2, MF3-3); all NF stations are within the zone of influence.
µg-P/L = micrograms phosphorus per litre; µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field.

Figure 3-39 Concentrations of Total Phosphorus and Chlorophyll *a* in Lac de Gras during the Open-water Season in Relation to the Mine Footprint, 2021



Note: Bubble size indicates relative total phosphorus concentrations among all AEMP stations. Mine footprint and location on plots are approximate. AEMP stations in the zone of influence from dust deposition are outlined in orange (i.e., all NF stations, MF1-1, MF3-1, MF3-2, MF3-3).
NF = near-field; MF = mid-field; FF = far-field.

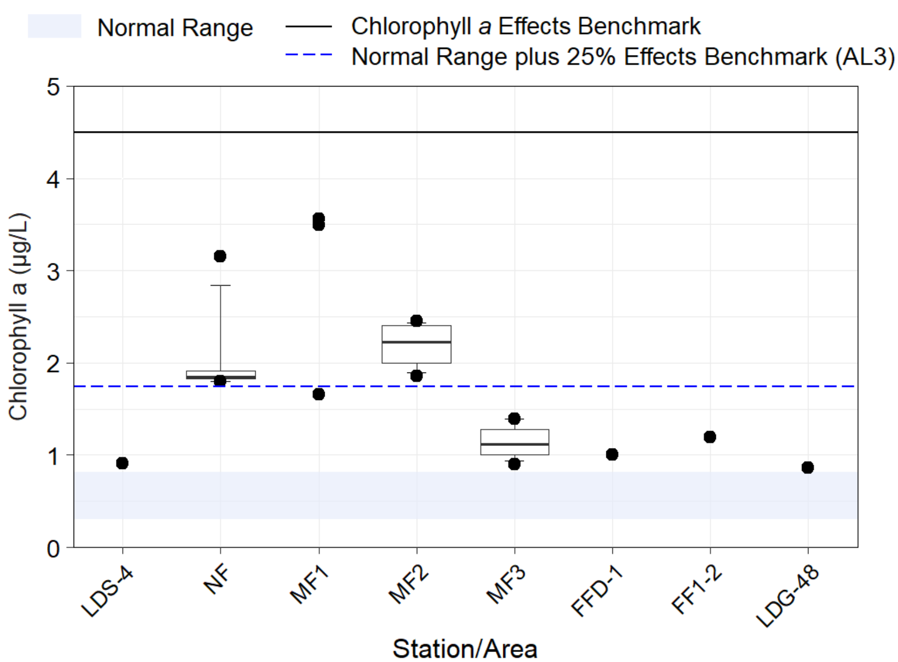
3.3 Action Level Evaluation

The 2021 eutrophication indicators results indicate that Action Level 2 has been triggered for chlorophyll *a*, and Action Level 1 has been triggered for TP.

In 2021, 100% of the lake area had chlorophyll *a* concentrations above the normal range (Figure 3-35; Table 3-5). Concentrations of chlorophyll *a* were greater than the 25% of the Effects Benchmark value of 1.74 µg/L in the NF area (all stations), MF1 area (two stations: MF1-1 and MF1-3 only), and the MF2-FF2 area (all stations) (Figure 3-40 and Figure 3-41). The area affected at this level represented less than 20% of the lake (13%; Table 3-5). Therefore, Action Level 3 was not triggered for chlorophyll *a*.

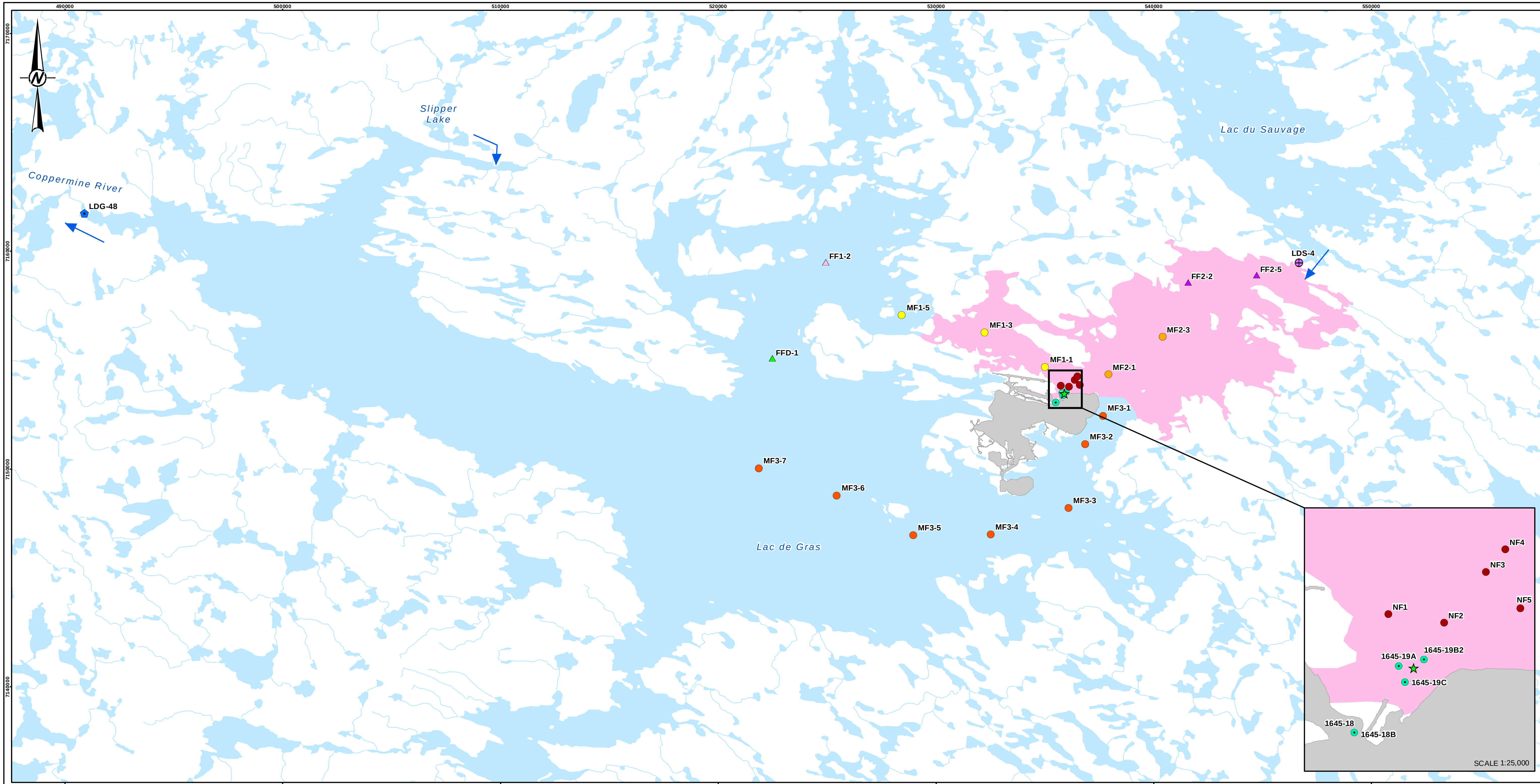
This is the first year that Action Levels have been evaluated for TP. During the open-water season, TP concentrations in all NF and MF stations were below the normal range (Figure 3-9). During the ice-cover season, TP concentrations were above the normal range at two NF stations (top depth; NF1 and NF4) and two MF2 stations (top depth at MF2-1 and middle depth at MF2-1 and MF2-3). The 95th percentile of MF values was above the normal range of 5.3 µg/L in the ice-cover season; however, less than 20% of the lake was affected (Figure 3-33 and Table 3-5). Therefore, Action Level 2 was not triggered for TP.

Figure 3-40 Concentrations of Chlorophyll *a* by Area in Lac de Gras, 2021



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

µg/L = micrograms per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet.



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD
- FLOW DIRECTION
- WATERCOURSE
- AFFECTED AREA[1]
- DIAVIK FOOTPRINT
- WATERBODY

0 5 10
1:175,000 KILOMETRES

NOTE(S)

1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON OPEN-WATER DATA.

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

CONSULTANT
WSP GOLDER

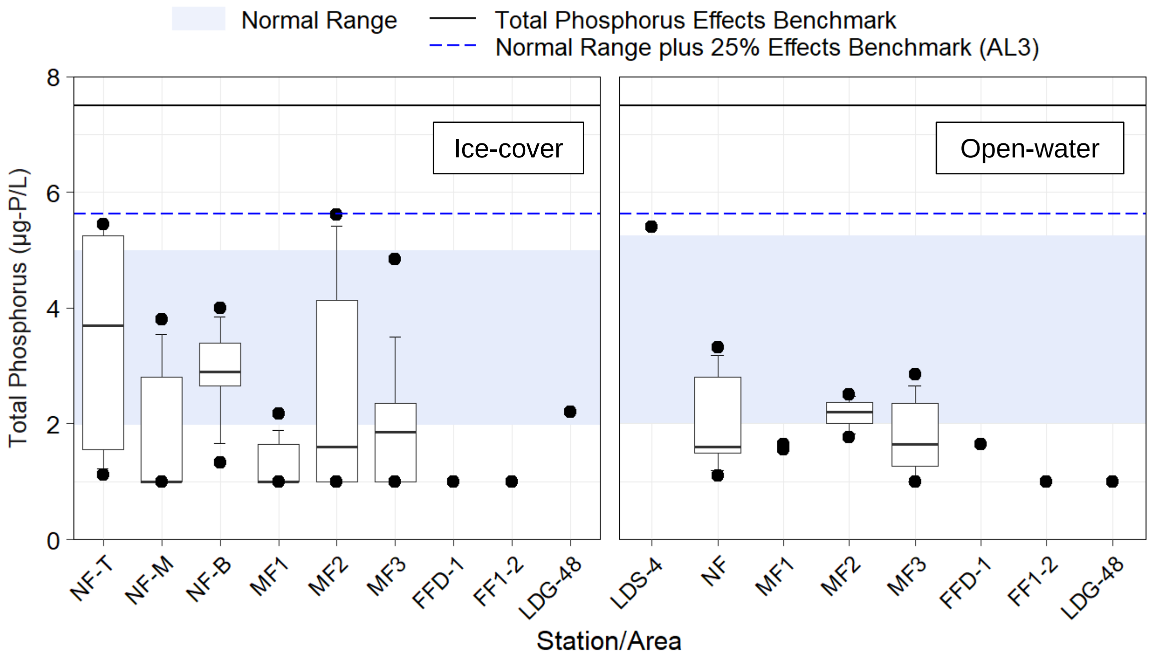
YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

TITLE
AREA OF LAC DE GRAS WHERE CHLOROPHYLL A CONCENTRATIONS ARE ABOVE THE ACTION LEVEL 3

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	3-41

Figure 3-42 Concentrations of Total Phosphorus by Area in Lac de Gras, 2021



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

µg/L = micrograms per litre; NF = near-field; T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Table 3-5 Action Level Classification for Chlorophyll *a*, 2021

Action Level	Action Level Classification				2021 Assessment		Action Level Triggered?
	Magnitude of Effect	Extent of Effect	Description	Value (µg/L)	Value (µg/L)	Extent of Effects	
1	Top of normal range[a]	MF station	95th percentile of MF values greater than normal range[a]	0.82	3.5	MF area	Y
2	Top of normal range[a]	20% of lake area or more	NF and MF values greater than normal range[a]	0.82	>0.82	100% of lake	Y
3	Normal range plus 25% of Effects Benchmark[b]	20% of lake area or more	NF and MF values greater than normal range plus 25% of Effects Benchmark[b]	1.74	>1.74	13% of lake	N
4	Normal range plus 50% of Effects Threshold[c]	20% of lake area or more	NF and MF values greater than normal range plus 50% of Effects Threshold[c]	[d]	-[d]	-[d]	N
5	Effects Threshold	20% of lake area or more	NF and MF values greater than Effects Threshold	-[d]	-[d]	-[d]	N
6	Effects Threshold + 20%	20% of lake area or more	NF and MF values greater than Effects Threshold +20%	-[d]	-[d]	-[d]	N
7	Effects Threshold + 20%	All MF stations	95th percentile of MF values greater than Effects Threshold +20%	-[d]	-[d]	-[d]	N
8	Effects Threshold + 20%	FFB	95th percentile of FFB values greater than Effects Threshold +20%	-[d]	-[d]	-[d]	N
9[e]	Effects Threshold + 20%	FFA	95th percentile of FFA values greater than Effects Threshold +20%	-[d]	-[d]	-[d]	N

a) The normal range for chlorophyll *a* was obtained from the *AEMP Reference Conditions Report, Version 1.4* (Golder 2019a).
b) Indicates 25% of the difference between the Effects Benchmark (i.e., 4.5 µg/L) and the top of the normal range.
c) Indicates 50% of the difference between the Effects Threshold and the top of the normal range.
d) Undefined, because the Effects Threshold has not been established.
e) Although the Significance Threshold is not an Action Level, it is shown as the highest Action Level to demonstrate escalation of effects towards the Significance Threshold.
n/a = not applicable; N = no; - = undefined, because the Effects Threshold has not been established; NF = near-field; MF = mid-field; FF = far-field.

Table 3-6 Action Level Classification for Total Phosphorus, 2021

Action Level	Action Level Classification				2021 Assessment		Action Level Triggered?
	Magnitude of Effect	Extent of Effect	Description	Value (µg/L)	Value (µg/L)	Extent of Effects	
1	Top of normal range[(a)]	MF station	95th percentile of MF values greater than normal range[(a)]	5.0	5.1	MF area	Y
2	Top of normal range[(a)]	20% of lake area or more	NF and MF values greater than normal range[(a)]	5.0	>5.0	3.4% of lake	N
3	Normal range plus 25% of Effects Benchmark[(b)]	20% of lake area or more	NF and MF values greater than normal range plus 25% of Effects Benchmark[(b)]	5.6	<5.6	0% of lake	N
4	Normal range plus 50% of Effects Threshold[(c)]	20% of lake area or more	NF and MF values greater than normal range plus 50% of Effects Threshold[(c)]	-[(d)]	-[(d)]	-[(d)]	N
5	Effects Threshold	20% of lake area or more	NF and MF values greater than Effects Threshold	-[(d)]	-[(d)]	-[(d)]	N
6	Effects Threshold + 20%	20% of lake area or more	NF and MF values greater than Effects Threshold +20%	-[(d)]	-[(d)]	-[(d)]	N
7	Effects Threshold + 20%	All MF stations	95th percentile of MF values greater than Effects Threshold +20%	-[(d)]	-[(d)]	-[(d)]	N
8	Effects Threshold + 20%	FFB	95th percentile of FFB values greater than Effects Threshold +20%	-[(d)]	-[(d)]	-[(d)]	N
9[(e)]	Effects Threshold + 20%	FFA	95th percentile of FFA values greater than Effects Threshold +20%	-[(d)]	-[(d)]	-[(d)]	N

a) The normal range for TP was obtained from the *AEMP Reference Conditions Report, Version 1.4* (Golder 2019a).
b) Indicates 25% of the difference between the Effects Benchmark (i.e., 7.5 µg/L) and the top of the normal range.
c) Indicates 50% of the difference between the Effects Threshold and the top of the normal range.
d) Undefined, because the Effects Threshold has not been established.
e) Although the Significance Threshold is not an Action Level, it is shown as the highest Action Level to demonstrate escalation of effects towards the Significance Threshold.
n/a = not applicable; N = no; - = undefined, because the Effects Threshold has not been established; NF = near-field; MF = mid-field; FF = far-field.

4 SUMMARY AND DISCUSSION

During 2021, phosphorus loads to Lac de Gras and phosphorus concentrations in effluent tended to be variable throughout the year, with the highest monthly loads in April, May, June, and September. The annual TP load in 2021 was 297 kg, which was comparable to the 2020 annual load of 289 kg and was less than both the monthly and average annual loading criteria of 300 kg/mo and 1,000 kg/yr, respectively, defined in the Water Licence. Concentrations of TP, TDP and SRP in effluent were generally greater during the ice-cover season, which resulted in greater monthly loads. Patterns in phosphorus concentrations at the mixing zone boundary generally reflected patterns observed in the Mine effluent.

Concentrations and loads of TN, nitrate, nitrite, and total ammonia in effluent tracked closely together, and followed a similar trend to effluent volume. Most of the TN was present as nitrate in the effluent. Monthly loads and concentrations of TN and nitrate in effluent were lowest from February to April and highest in June. On average, loads were greater during the open-water season than in the ice-cover season. Concentrations at the mixing zone boundary generally followed the trends in the effluent. Nitrate and total ammonia concentrations decreased between May and July at the mixing zone boundary; however, TN concentrations increased between May and July, before decreasing again between September and October.

Secchi depth measurements showed good light penetration in all areas of Lac de Gras, indicating that a large proportion of the total volume of Lac de Gras was within the euphotic zone and supports phytoplankton growth. Secchi depth along the MF1 transect appeared to increase with increasing distance from the effluent discharge, which is consistent with reduced Secchi depth close to the diffuser due to greater phytoplankton biomass. However, along the MF2 and MF3 transects, Secchi depth decreased with increasing distance from the effluent discharge, suggesting the results may represent background variability, rather than a Mine effect.

Phosphorus and nitrogen enter Lac de Gras from Mine effluent throughout the year; however, seasonal cycles are apparent in nutrient concentrations in effluent (Section 3.1). Phosphorus concentrations at the mixing zone boundary and in the lake were somewhat higher in the ice-cover season than in the open-water season. Phosphorus concentrations continued to be low in 2021, as observed in 2020, likely due to the lower phosphorus load from effluent. Phosphorus concentrations in the lake were within or below the normal range during the open-water season, but above the normal range at some depths and NF and MF1 stations during the ice-cover season. Therefore, the lake area affected was 0% in the open-water season and 3.4% in the ice-cover season. Similarly, nitrogen species had concentrations that were greater during the ice-cover season compared to the open-water season. Concentrations of TN were greater in the NF area, generally above the normal range, and decreased with distance from the diffuser. Lake area affected for TN was smaller than in 2020, at 20% during the open-water season and 41% during the ice-cover season. Seasonal differences in SRSi were observed, with greater concentrations during the ice-cover season compared to the open-water season. Concentrations were greater in the NF area, and decreased with distance from diffuser. The lower concentrations of dissolved inorganic nutrients (i.e., nitrate, total ammonia, SRSi) in Lac de Gras during the open-water season likely reflect quick assimilation of nutrients by bacteria and algae (Wetzel 2001).

Despite low nutrient concentrations compared to a number of previous years, a Mine-related nutrient enrichment effect on the primary producers in Lac de Gras was evident in 2021, as indicated by the gradient analysis results and spatial trends apparent along transects sampled in Lac de Gras. Chlorophyll *a* and zooplankton biomass were highest in the NF area and decreased with distance from the diffuser. Chlorophyll *a* concentrations were above the normal range across the lake including the lake outlet (LDG-48) whereas zooplankton was above normal range in the NF and along all three MF transects. Chlorophyll *a* concentrations were higher in 2021 than in recent years, with concentrations at all stations above the normal range. Concentrations were similar to those measured in 2014 and 2016 except at LDG-48, where concentration was higher. Chlorophyll *a* concentration at LDG-48 was slightly above the normal range, which results in a larger spatial extent of effects (i.e., 100%, although subject to uncertainty due to interim monitoring year spatial coverage) than has been observed in the past. However, total phytoplankton biomass was below the normal range in the NF area and at all stations except for MF1-1; thus the area of the lake affected was 0%, which is similar to the last two years (i.e., 0% in 2019, 2.8% in 2020). This smaller extent of effects for total phytoplankton biomass is generally consistent with the results for TP but inconsistent with the results for chlorophyll *a.* It is not clear why chlorophyll *a* concentrations would be elevated without at least some corresponding increase in phytoplankton biomass, suggesting a potential data quality issue associated with the chlorophyll *a* dataset. Lake area affected for zooplankton biomass was likely greater in 2021 than in 2020, at greater than or equal to 58%, although subject to uncertainty in the effect boundary at the end of the MF3 transect, as the FFA and FFB areas were not sampled in 2021, which was an interim monitoring year.

The combined results of nutrient–productivity indicator relationships, year-to-year variation in affected areas for nutrients and productivity indicators, and nutrient ratios calculated previously (Golder 2020b) suggest at most a limited influence of nitrogen loading from the Mine effluent on the spatial extent of effects on primary producers in Lac de Gras.

The 2021 AEMP provided no evidence that dust deposition had an additional measurable effect on concentrations of TP or chlorophyll *a* in Lac de Gras, beyond the effect apparent from the Mine effluent discharge.

5 RESPONSE FRAMEWORK

Current conditions indicate that Action Level 2 has been triggered based on chlorophyll *a* and Action Level 1 based on TP (Section 3.3). Action Level 2 was triggered for chlorophyll *a* because the chlorophyll *a* concentrations in the NF area (all stations), MF1 area (two stations – MF1-1 and MF1-3 only), and the MF2-FF2 area (all stations) were greater than the upper limit of the normal range (0.82 µg/L) in an area representing more than 20% of the lake (Table 3-5). Action Level 3 was not triggered in 2021 because concentrations of chlorophyll *a* remained below the normal range upper bound plus 25% of the Effects Benchmark of 1.74 µg/L at all stations except NF area stations, MF1-1 and MF1-2, which represents less than 20% of the lake. Action Level 1 for TP was triggered because ice-cover concentrations in two MF stations (MF2-1 and MF2-3) at middle depth were greater than the upper limit of the normal range (5.0 µg/L in ice-cover conditions). However, the extent of effect was less than 20% of the lake. An Effects Benchmark has already been established for chlorophyll *a* (i.e., 4.5 µg/L), per the requirements of triggering an Action Level 2 previously, and for TP as presented in *AEMP Design Plan Version 5.2* (Golder 2020a). Therefore, no further action is required.

6 CONCLUSIONS

This report presents the assessment of data collected by DDMI for the eutrophication indicators component of the 2021 AEMP. Results of the 2021 eutrophication assessment indicate the following:

- The Mine is having a nutrient enrichment effect in Lac de Gras, as evidenced by greater nutrient and chlorophyll *a* concentrations, and zooplankton biomass in the NF area and MF areas, compared to the rest of the lake. This result is consistent with observations reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) and the AEMP 2020 Annual Report (Golder 2021).
- TP, TDP, and SRP concentrations were within or below the normal range at most stations in Lac de Gras during both the ice-cover and open-water seasons. However, some TP and SRP concentrations at some depths in the NF and MF2 stations, and some TDP concentrations in the MF1 and MF2 stations, were above normal range during the ice-cover season. The lower phosphorus concentrations in lake water relative to previous years were at least partly due to the lower TP loads from Mine effluent in 2021.
- Nitrogen concentrations were above the normal range up to 15 km from the diffuser in Lac de Gras, with significant decreasing concentrations with distance from the diffusers.
- Along most transects, a significant decreasing trend in SRSi concentration was observed, indicating a Mine effect.
- Chlorophyll *a* concentrations and zooplankton biomass decreased with distance from the diffuser and were above the normal range across the whole lake for chlorophyll *a*, and in the NF and MF areas for zooplankton biomass. The FFA and FFB areas were not sampled in 2021, thus there is some uncertainty of the spatial extent of effects past the boundary of the end of the MF3 transect. Total phytoplankton biomass decreased with distance from the diffuser; however, most results were within the normal range.
- This smaller extent of effects for total phytoplankton biomass is generally consistent with the results for TP but inconsistent with the results for chlorophyll *a.* It is not clear why chlorophyll *a* concentrations would be elevated without at least some corresponding increase in phytoplankton biomass, suggesting a potential data quality issue associated with the chlorophyll *a* dataset. Field procedures were reviewed and the analytical laboratory was contacted to verify the 2021 chlorophyll *a* results; this review identified no data quality issues.
- The spatial extent of effects on eutrophication indicators in 2021 varied from 0% to 100% of the lake area depending on indicator:
  - The extent of effect was 0 to 3.4% for TP and 20% to 41% of the lake area for TN, depending on season.
  - The extent of effect was 100% for chlorophyll *a* concentration (although subject to uncertainty), 0% for phytoplankton biomass and greater than or equal to 58% of the lake area for zooplankton biomass. The FFA and FFB areas were not sampled in 2021, thus there is some uncertainty of the spatial extent of effects past the boundary of the end of the MF3 transect.

  - This is generally consistent with observations reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) and the *AEMP 2020 Annual Report* (Golder 2021); extent of effects for TP has been low and variable and less than 20%, for chlorophyll *a*, it has been variable and generally less than 45%, for TN extent of effects has been greater than 40% since 2014, and for plankton extent of effects has been variable. The higher spatial extent of effects for chlorophyll *a* in 2021 is due to higher measured concentration at LDG-48 compared to other years.

- Chlorophyll *a* in Lac de Gras was not correlated with TN, TP, SRP, or SRSi, but was moderately strongly correlated with TDS. These results are consistent with nitrogen not being the limiting nutrient in Lac de Gras, and also imply a potential Mine-related enrichment effect related to an increase in micronutrients associated with TDS.

- All evidence indicates that effluent is the main source of Mine effects on Lac de Gras, with a negligible contribution from dust deposition. This conclusion is consistent with the results of the 2019 Dust SES, which did not detect a dust-related chemical signature in lake water, and suggested limited bioavailability of phosphorus in dust.

- The magnitude and extent of effects on chlorophyll *a* triggered Action Level 2, which was consistent with observations reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b); either Action Level 1 or 2 were triggered in the 2007 to 2018 and 2020 AEMPs, and no Action Level was triggered in 2019.

- This is the first year that Action Levels were evaluated for TP. The magnitude and extent of effects on TP triggered Action Level 1 based on elevated concentrations in the MF areas, in an area of less than 20% of Lac de Gras.

- The 2021 results are consistent with the EA prediction of greater concentrations of nutrients, particularly phosphorus from the minewater discharge, resulting in an increase in primary productivity in Lac de Gras.

Overall, the conclusions from the 2021 AEMP are consistent with those reported in previous AEMPs, in that the Mine is having a nutrient enrichment effect in Lac de Gras, inputs of phosphorus appear to be the main driver to increases in primary productivity, and the main source of Mine-related effects on eutrophication indicators is the effluent. Action Level 2 was triggered for chlorophyll *a* and an Action Level 1 for TP. Given that an Effects Benchmark for chlorophyll *a* and TP have already been established as discussed in the *AEMP Design Plan Version 5.2* (Golder 2020a), no further action is required based on the 2021 monitoring results.

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8 CLOSURE

We trust the information in this report meets your requirements at this time. If you have any questions relating to the information contained in this report, please do not hesitate to contact the undersigned.

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ATTACHMENT A

AEMP SAMPLING SCHEDULE

Table A-1 2021 AEMP Sampling Schedule

Stations	Ice-cover											Open-water										
	April						May					August		September								
	19	20	21	23	24	25	2	3	7	8	9	15	27	1	2	3	6	10	11	13	14	15
NF1											N(b)			Np								
NF2						N							Np									
NF3						N											Np					
NF4										N							Np(c)					
NF5						N							Np									
MF1-1					N											Np						
MF1-3					N(c)										Np(c)							
MF1-5		N	N(c)												Np							
MF2-1									N							Np						
MF2-3										N						Np						
FF2-2		N(c)																		Np(c)		
FF2-5	N																			Np(c)		
MF3-1										N							Np					
MF3-2									N								Np					
MF3-3									N											Np		
MF3-4							N	N(b)												Np		
MF3-5							N											Np				
MF3-6							N											Np				
MF3-7				N																	Np	N
FF1-2(a)		N(c)																	Np			
FFD-1(a)		N																			Np	
LDG-48(a)											N	N(d)										
LDS-4(a)												N(d)										

Notes:
a) Discrete samples were collected at mid-depth.
b) Quality control samples were collected for total ammonia BV Labs only, for the Black Cap vial samples.
c) Quality control samples were collected for total ammonia BV Labs and total ammonia ALS only.
d) Only chlorophyll *a* was sampled, not plankton.
If a quality control sample was collected at the same time as the Nutrient sample, then the "N" was colour-coded: Equipment Blank (EB), Field Blank (FB), Travel Blank (TB), and Field Duplicate (FD).
N = nutrient sample collected; p = chlorophyll *a* and plankton sample collected; NF = near-field; MF = mid-field; FF = far-field; LDG = lac de Gras; LDS = Lac du Sauvage.

ATTACHMENT B

QUALITY ASSURANCE AND QUALITY CONTROL

QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting, and are described in the *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017). Quality assurance encompasses management and technical practices designed to generate consistent, high quality data. Quality control is an aspect of quality assurance and includes the techniques used to assess data quality and the corrective actions to be taken when the data quality objectives are not met. This Attachment describes QA/QC practices applied during the 2021 eutrophication indicators component of the Aquatic Effects Monitoring Program (AEMP), evaluates quality control (QC) data, and describes the implications of QC results to the interpretation of study results.

Quality Assurance

Field Staff Training and Operations

Diavik Diamond Mines (2012) Inc. (DDMI) field staff are trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality sampling. Field work was completed according to specified instructions and standard operating procedures (SOP). The procedures are described in:

- ENVI-923-0119 “AEMP SOP Combined Open-Water and Ice-Cover”
- ENVI-902-0119 “SOP Quality Assurance Quality Control”
- ENVI-900-0119 “SOP Chain of Custody”

These SOPs include guidelines for field record-keeping and sample tracking, guidance for use of sampling equipment, relevant technical procedures, and sample labelling, shipping and tracking protocols.

Laboratory

Quality assurance at the DDMI Environmental Laboratory encompasses all quality-related activities related to aquatic testing and analysis, and relevant technical support (ENVI-902-0119 “SOP Quality Assurance Quality Control”).

DDMI’s quality assurance places an emphasis on four aspects:

- infrastructure (instruments, testing capabilities, calibrations, SOPs)
- control measures (e.g., internal and external blanks and duplicates)
- personnel (competence, ethics, and integrity)
- data management

Nutrient samples, excluding soluble reactive silica (SRSi), were sent for analysis to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics), Edmonton or Calgary, Alberta, Canada, a laboratory accredited by the Canadian Association of Laboratory Accreditation (CALA). All open-water samples were analyzed by BV Labs in Edmonton; the ice-cover samples were divided between the two locations. Separate samples for total ammonia analysis were also sent to ALS Laboratories (ALS) in Vancouver, British Columbia, Canada; ALS is also a CALA accredited laboratory. SRSi samples were only sent to ALS. Nutrient analysis followed standard analytical methods. Under the accreditation program, performance assessments are completed annually for laboratory procedures, analytical methods, and internal quality control.

Chlorophyll *a* samples were sent to the Biogeochemical Analytical Service Laboratory at the University of Alberta, Edmonton, Alberta, Canada, and analyzed by fluorometric analysis. Zooplankton biomass (as ash free dry mass [AFDM]) samples were submitted to BV Labs and analyzed by gravimetric analysis.

Field and Office Operations

A quality assurance system was established as an organized system of data control, analysis and filing. Relevant elements of this system are as follows:

- pre-field meetings to discuss specific work instructions with field crews
- field crew check-in with task managers every 24 to 48 hours to report work completed during that period
- designating two crew members responsible for:
  - collecting all required samples
  - downloading and storing electronic data
  - completing chain-of-custody and analytical request forms; labelling and documentation
  - processing, where required, and delivering samples to analytical laboratory in a timely manner
- cross-checking chain-of-custody forms and analysis request forms by the task manager to verify that the correct analysis packages had been requested
- review of field sheets by the task manager for completeness and accuracy
- reviewing laboratory data immediately after receipt from the analytical laboratory
- creating backup files before data analysis
- completing appropriate logic checks and verifying accuracy of calculations

Quality Control

Methods

Quality control is a specific aspect of quality assurance that includes the techniques used to assess data quality. The field QC program consisted of the collection of field blanks, equipment blanks, travel blanks, and duplicate samples. The blanks are used to assess potential sample contamination in the field, and the duplicates are used to assess within-station variation and sampling precision. Field, travel, and equipment blank samples were collected during both the open-water and ice-cover seasons. All stations and parameters were sampled in duplicate. In addition, duplicate samples for total ammonia analysis were submitted to both BV Labs and ALS. Consistent with the selection of total ammonia data for use in the Effluent and Water Chemistry Report (Appendix II), total ammonia data from ALS was used for the ice-cover season and total ammonia data from BV Labs was used for the open-water season in the eutrophication indicators data analysis.

Field, Travel, and Equipment Blanks

Blanks contained de-ionized water obtained from the laboratory. Field blanks consisted of samples prepared in the field. Equipment blanks were exposed to all aspects of sample collection and analysis, including the procedures used in the field, and contact with all sampling devices and other equipment. Travel blanks were transported with the crew during daily sampling procedures and remained unopened during field sampling. Blanks were submitted blind to the laboratory for the same analyses as the field samples. Equipment and travel blanks provide information regarding potential sample contamination from equipment or sample transport.

The field, travel, and equipment blanks were also used to detect potential contamination during collection, shipping, and analysis. Although concentrations should be below DLs in these blanks, detected concentrations were considered notable if they were greater than five times the corresponding DL. This threshold is based on the Practical Quantitation Limit defined by the United States Environmental Protection Agency (US EPA 1994, 2007; BC MOE 2009), which takes into account the potential for data accuracy errors when variable concentrations approach or are below DLs.

Notable results observed in the field blanks were evaluated relative to analyte concentrations observed in the field samples to evaluate whether sample contamination was limited to the QC sample or was apparent in other samples as well. Where, based on this comparison, sample contamination was not an isolated occurrence, the field data were flagged and interpreted with this limitation in mind.

Duplicate Samples

Duplicate samples consisted of two samples collected from the same location at the same time, using the same sampling and sample handling procedures. They were labelled and preserved individually and submitted separately to the analytical laboratory for identical analyses. Duplicate samples were used to check within-station variation and the precision of field sampling and analytical methods. Differences between concentrations measured in duplicate water samples were calculated as the relative percent difference (RPD) for each variable. Before calculating the RPD, concentrations below the DL were replaced with 0.5 times the DL value. Substitution with half the DL is a common approach used to deal with censored data (US EPA 2000) and is consistent with the approved methods applied in the calculation of the normal range in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019). The RPD was calculated using the following formula:

$$RPD = (|\text{difference in concentration between duplicate samples}| / \text{mean concentration}) \times 100$$

The RPD value for a given variable was considered notable if both conditions were true:

- it was greater than 40%
- concentrations in one or both samples were greater than or equal to five times the DL

These criteria were approved as part of the QAPP (Golder 2017).

The number of variables which exceeded the assessment criteria was compared to the total number of variables analyzed to evaluate analytical precision. The analytical precision was rated as follows:

- high, if less than 10% of the total number of variables were notably different from one another
- moderate, if 10% to 30% of the total number of variables were notably different from one another
- low, if more than 30% of the total number of variables were notably different from one another

Total Versus Dissolved Forms

The concentrations of total nitrogen (TN), total Kjeldahl nitrogen (TKN), and total phosphorus (TP) consist of both particulate and dissolved forms of the analyte. Thus, total dissolved nitrogen (TDN), dissolved Kjeldahl nitrogen (DKN), and total dissolved phosphorus (TDP) should be equal to or less than the total concentrations. Typically, the RPD between the two forms should not exceed 20%. If the RPD was found to be greater than 20% and one or both of the samples were greater than or equal to five times the DL, these data were flagged, and the validity of the data was investigated.

Results

Detection Limits

In general, achieved DLs were the same as target DLs, with the exception of a few samples (Table B-1).

For TDP, most samples (i.e., 208 samples, including QC samples) were analyzed at the target DL of 2 µg/L, but one equipment blank and one field duplicate were analyzed at 4 µg/L. In both cases, the corresponding duplicate (all samples are collected in duplicate, even blank and field duplicates) used the target DL of 2 µg/L, and none of the samples had detected concentrations of TDP.

For TDN, most samples (i.e., 199 samples, including QC samples) were analyzed at the target DL of 20 µg/L, but five samples were analyzed at a DL of 100 µg/L and one sample at 200 µg/L. For DKN, most samples (i.e., 203 samples, including QC samples) were analyzed at the target DL of 20 µg/L, but two samples were analyzed at a DL of 100 µg/L. Since TN is the more useful variable for evaluating effects related to nutrient enrichment, and there were data for multiple nutrient species to support the interpretation of results, these deviations from target DLs were considered unlikely to affect the overall conclusions of the assessment.

For soluble reactive silica (SRSi), most samples (including QC samples) were analyzed at the target DL of 10 µg/L. A total of 17 samples were analyzed at a DL of 50 µg/L. This year (2021) is the third year that SRSi has been added to the analytical suite, and significant declining trends in SRSi concentrations with distance from diffuser were identified (see Section 3.2.5.2 of the main report). It is unlikely that the raised DL impaired interpretation of the results, or that the overall conclusions of the assessment would be different with lower DLs.

Table B-1 Target and Achieved Detection Limits, 2021

Variable	Unit	Target DL	Achieved DL for Most Samples	Other DL	Sample	Sample Type	Season
Total Phosphorus	µg-P/L	2	2	n/a			
Total Dissolved Phosphorus	µg-P/L	2	2	4	MF3-4B-1-5	EB	IC
				4	MF3-6B-5	FD	IC
Soluble Reactive Phosphorus	µg-P/L	1	1	n/a			
Total Nitrogen	µg-N/L	20	20	n/a			
Total Dissolved Nitrogen	µg-N/L	20	20	100	MF1-1-5	N	OW
					MF3-2-4	N	OW
					MF3-2-5	N	OW
					MF3-7-4	N	OW
					FF2-5-4	N	OW
				200	NF1-5	N	OW
Total Kjeldahl Nitrogen	µg-N/L	20	20	n/a			
Dissolved Kjeldahl Nitrogen	µg-N/L	20	20	100	MF3-2-5	N	OW
					MF3-7-4	N	OW
Nitrate	µg-N/L	2	2	n/a			
Nitrite	µg-N/L	1	1	n/a			
Nitrate + Nitrite	µg-N/L	2	2.2 in IC 2 in OW	n/a			
Total Ammonia (ALS)	µg-N/L	5	5	n/a			
Total Ammonia (BV Labs)	µg-N/L	5	5	n/a			
Soluble Reactive Silica	µg/L	10	10	50	MF1-5B-4	N	IC
					MF1-5B-5	N	IC
					MF2-1B-4	N	IC
					NF1B-4	N	IC
					NF1B-5	N	IC
					NF4B-4	N	IC
					NF4B-5	N	IC
					NF3M-5	N	IC
					NF3B-4	N	IC
					NF3B-5	N	IC
					NF5B-4	N	IC
					NF5B-5	N	IC
					NF2M-4	N	IC
					NF2M-5	N	IC
					NF2B-4	N	IC
					NF2B-5	N	IC
					MF3-7M	N	OW

Note: DL = detection limit; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; N = normal (field) sample; IC = ice-cover; OW = open-water; n/a = not applicable.

Field, Travel, and Equipment Blanks

Eleven travel blanks, 13 equipment blanks, and 14 field blanks were collected during the 2021 AEMP eutrophication indicators component field program; 24 blank samples were collected during the ice-cover season (Table B-2) and 14 blank samples were collected during the open-water season (Table B-2). Of these 38 blanks, 18 blanks were analyzed for all nutrient variables (i.e., 12 blanks during ice-cover season and 6 during open-water season), and 20 blanks were only analyzed for total ammonia (i.e., duplicate samples at BV Labs and ALS; 12 blanks during ice-cover season and 8 during open-water season).

Notable results (i.e., detected concentrations more than five times the detection limit [DL]) were observed for total ammonia in several samples (i.e., eight ice-cover samples, one open-water sample), for TN and TKN in one ice-cover sample, for TDN and DKN in one ice-cover sample, and for soluble reactive silica (SRSi) in two ice-cover samples (which were duplicates from the same station). These results are discussed below.

Total Ammonia

During the ice-cover season, total ammonia concentrations that were more than five times the DL were observed in three samples analyzed by ALS (equipment blank MF1-5T-1-5, field blank MF2-1B-2-4 and equipment blank MF3-4B-1-4) and six samples analyzed by BV Labs (equipment blanks MF1-5T-1-4, MF1-5T-1-5, MF3-4B-1-4-BLACK CAP, MF3-4B-1-5-BLACK CAP, and field blanks NF1B-2-4-BLACK CAP, NF1B-2-5-BLACK CAP; Table B-2).

There were fewer notable results for total ammonia in blank samples during the open-water season. All blank samples analyzed by BV Labs had total ammonia concentrations that were either below detection or less than five times the DL (Table B-3). Only one equipment blank, MF1-3-1-5, analyzed by ALS had a concentration more than five times the DL (i.e., 27.9 µg/L). The duplicate of this blank had a concentration below the DL (i.e., <5 µg/L), and was similar to other blanks (Table B-3).

As discussed in the Effluent and Water Chemistry Report (Appendix II), BV Labs identified a contamination issue for total ammonia in the ice-cover dataset. BV Labs identified their black capped vials as a likely source of ammonia contamination part-way through the ice-cover season. BV labs switched to the same vials with septa caps following this discovery. Stations were mostly split between black capped, or septa capped vials, with both container types only used at two stations (i.e., MF3-5 and MF3-6). At the stations where both vials were used, the septa cap vials clearly had lower concentrations. BV Labs recommended use of BV Labs data from stations sampled with septa cap vials and the ALS data from the other stations. This suggestion was not accepted as it is preferred to use a complete dataset for each season from a single laboratory. Therefore, total ammonia data generated by ALS was used for the ice-cover season in the 2021 AEMP data analysis.

For the open-water season, BV Labs used septa cap vials exclusively for all samples. An interlaboratory comparison study conducted by BV Labs suggested that the total ammonia data generated by BV Labs had fewer data quality issues than the ALS dataset and should, therefore, be used for the analysis of the open-water dataset. This recommendation was accepted, and the total ammonia data generated by BV Labs was used for the open-water season in the 2021 AEMP data analysis.

Total and Dissolved Nitrogen, Total and Dissolved Kjeldahl Nitrogen

During the ice-cover season, concentrations above five times the DL were observed in one sample for TN and TKN (field blank MF2-1B-2-4) and one sample for TDN and DKN (travel blank MF3-3T-3-4). For each of these blanks, the duplicates had lower concentrations that were similar to other blanks (Table B-2). Concentrations of other nitrogen species were within DQOs. It is unlikely that these results indicate an issue with contamination. Rather, it is possible that there was an error in sample bottle labelling, either in the field or by the laboratory, because these samples were collected on the same day and at the same station as the two samples for which abnormally low values were recorded for TN and TKN in MF2-1-B-4, and for TDN and DKN in MF3-3T-4. As discussed below under the sub-heading "Nutrient Duplicate Samples", the abnormally low values were removed from the dataset. The values in the corresponding duplicates were more representative of those stations than the low values. Thus the reported nitrogen concentrations in these two blanks are unlikely to indicate systemic contamination, or affect the reliability of the dataset.

During the open-water season, all blank samples analyzed by BV Labs for TN, TDN, TKN, and DKN had concentrations that were either below detection or less than five times the DL (Table B-3).

Soluble Reactive Silica

During the ice-cover season, two blank samples had SRSi concentrations above five times the DL, which were also duplicates of one another (travel blanks MF3-3T-3-4 and MF3-3T-3-5). The measured concentrations in these blanks were 141 µg/L and 148 µg/L, which are within the range of concentrations observed in field samples. Despite these elevated concentrations, it is unlikely that these results indicate systemic contamination that would affect the reliability of the SRSi dataset, because elevated concentrations were not observed in other blanks sampled during the ice-cover season. Three other sets of blanks were collected and analyzed for SRSi, including two field blanks and one equipment blank (Table B-3). While there were measured concentrations of SRSi in these blanks, concentrations were low and within five times the DL (i.e., 13 to 19 µg/L analyzed at a DL of 10 µg/L).

Ice-cover SRSi concentrations varied widely in 2021, ranging from 61 to 1,070 µg/L and with a median value of 150 µg/L. This is a similar range to that observed in 2020 (range of 49 to 1,040 µg/L) with a slightly smaller median of 124 µg/L in 2020. If the observed concentrations in the travel blanks were indicative of systemic contamination, then much higher results would be expected in the field samples, which was not observed. Thus, the elevated SRSi concentrations in one of the four blanks are not likely to indicate systemic contamination or affect the reliability of the dataset.

During the open-water season, all blank samples analyzed by ALS for SRSi had concentrations that were either below detection or less than five times the DL (Table B-3).

Table B-2 Concentrations of Nutrients in Travel, Equipment and Field Blanks during the Ice-cover Season, 2021

Variable	Unit	DL	Ice-Cover																							
			FF1-2M-2-4	FF1-2M-2-5	FF2-5T-1-4	FF2-5T-1-5	MF1-3B-3-4	MF1-3B-3-5	MF1-5T-1-4	MF1-5T-1-5	MF2-1B-2	MF2-1B-2-4	MF2-1B-2-5	MF3-3T-3	MF3-3T-3-4	MF3-3T-3-5	MF3-4B-1	MF3-4B-1-4	MF3-4B-1-4-BLACK CAP	MF3-4B-1-5	MF3-4B-1-5-BLACK CAP	NF1B-2	NF1B-2-4	NF1B-2-4-BLACK CAP	NF1B-2-5	NF1B-2-5-BLACK CAP
			20-Apr-21	20-Apr-21	19-Apr-21	19-Apr-21	24-Apr-21	24-Apr-21	21-Apr-21	21-Apr-21	7-May-21	7-May-21	7-May-21	7-May-21	7-May-21	7-May-21	3-May-21	3-May-21	3-May-21	3-May-21	3-May-21	9-May-21	9-May-21	9-May-21	9-May-21	9-May-21
			Field Blank	Field Blank	Equipment Blank	Equipment Blank	Travel Blank	Travel Blank	Equipment Blank	Equipment Blank	Field Blank	Field Blank	Field Blank	Travel Blank	Travel Blank	Travel Blank	Equipment Blank	Equipment Blank	Equipment Blank	Equipment Blank	Equipment Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank
Total Phosphorus	µg-P/L	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	<2	-	<2	<2	n/a	<2	n/a	<2	n/a	n/a	<2	n/a	2.1	n/a
Total Dissolved Phosphorus	µg-P/L	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	<2	<2	<2	<2	<2	<2	n/a	<4	n/a	<2	2.3	n/a	<2	n/a
Soluble Reactive Phosphorous	µg- P/L	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<1	<1	<1	<1	<1	<1	<1	<1	n/a	<1	n/a	<1	<1	n/a	<1	n/a
Total Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	53	**340**	37	n/a	<20	<20	n/a	<20	n/a	<20	n/a	n/a	<20	n/a	28	n/a
Total Dissolved Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	32	<20	35	n/a	**120**	30	n/a	<20	n/a	<20	n/a	n/a	<20	n/a	24	n/a
Total Ammonia - ALS	µg-N/L	5	<5	<5	<5	<5	<5	<5	<5	**28.3**	n/a	**57.6**	12.3	n/a	<5	<5	n/a	**56.8**	n/a	17.7	n/a	n/a	<5	n/a	<5	n/a
Total Ammonia - BV Labs	µg-N/L	5	<5	<5	<5	<5	<5	<5	**44**	**160**	<5	<5	<5	n/a	<5	<5	n/a	<5	**660**	<5	**510**	n/a	<5	**49**	<5	**57**
Nitrate	µg-N/L	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	<2	<2	8	2.1	3.4	<2	n/a	<2	n/a	<2	3.7	n/a	<2	n/a
Nitrite	µg-N/L	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<1	<1	<1	<1	<1	<1	<1	<1	n/a	<1	n/a	<1	<1	n/a	<1	n/a
Nitrate + nitrite	µg-N/L	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	<2.2	<2.2	<2.2	<2.2	8	<2.2	3.4	<2.2	n/a	<2.2	n/a	<2.2	3.7	n/a	<2.2	n/a
Total Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	53	**336**	37	n/a	<20	<20	n/a	<20	n/a	<20	n/a	n/a	<20	n/a	28	n/a
Dissolved Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	32	<20	35	n/a	**110**	30	n/a	<20	n/a	<20	n/a	n/a	<20	n/a	24	n/a
Soluble Reactive Silica	µg/L	10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	13	15	n/a	**141**	**148**	n/a	14	n/a	15	n/a	n/a	19	n/a	18	n/a

Notes: **Bolded** numbers indicate QC flags for concentrations that were greater than five times the corresponding DL.

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; DL = detection limit; < = less than; NF = near-field; MF = mid-field; FF = far-field; n/a = not applicable.

Table B-3 Concentrations of Nutrients in Travel, Equipment and Field Blanks during the Open-water Season, 2021

Variable	Unit	DL	Open-Water													
			FF2-2-2-4	FF2-2-2-5	FF2-5-3-4	FF2-5-3-5	MF1-3-1-4	MF1-3-1-5	MF3-4-3-4	MF3-4-3-5	MF3-7-1-4	MF3-7-1-5	NF3-2-4	NF3-2-5	NF4-3-4	NF4-3-5
			13-Sep-21	13-Sep-21	13-Sep-21	13-Sep-21	2-Sep-21	2-Sep-21	13-Sep-21	13-Sep-21	15-Sep-21	15-Sep-21	6-Sep-21	6-Sep-21	6-Sep-21	6-Sep-21
			Field Blank	Field Blank	Travel Blank	Travel Blank	Equipment Blank	Equipment Blank	Travel Blank	Travel Blank	Equipment Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Travel Blank
Total Phosphorus	µg-P/L	2	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	<2	<2	<2	5.3	n/a	n/a
Total Dissolved Phosphorus	µg-P/L	2	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	<2	<2	<2	<2	n/a	n/a
Soluble Reactive Phosphorous	µg-P/L	1	n/a	n/a	n/a	n/a	n/a	n/a	<1	<1	<1	<1	<1	<1	n/a	n/a
Total Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	<20	<20	<20	<20	<20	<20	n/a	n/a
Total Dissolved Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	<20	<20	<20	<20	<20	<20	n/a	n/a
Total Ammonia - ALS	µg-N/L	5	<5	<5	<5	<5	<5	**27.9**	14.6	12.4	<5	<5	<5	8.2	<5	<5
Total Ammonia - BV Labs	µg-N/L	5	<5	<5	<5	<5	<5	<5	7.8	<5	<5	<5	<5	<5	5.1	<5
Nitrate	µg-N/L	2	n/a	n/a	n/a	n/a	n/a	n/a	<2	3.2	3.3	<2	<2	<2	n/a	n/a
Nitrite	µg-N/L	1	n/a	n/a	n/a	n/a	n/a	n/a	<1	<1	<1	<1	<1	<1	n/a	n/a
Nitrate + Nitrite	µg-N/L	2	n/a	n/a	n/a	n/a	n/a	n/a	<2	3.2	3.3	<2	<2	<2	n/a	n/a
Total Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	<20	<20	<20	<20	<20	<20	n/a	n/a
Dissolved Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	n/a	n/a	n/a	n/a	<20	<20	<20	<20	<20	<20	n/a	n/a
Soluble Reactive Silica	mg/L	10	n/a	n/a	n/a	n/a	n/a	n/a	<10	<10	<10	<10	15	12	n/a	n/a

Notes: **Bolded** numbers indicate QC flags for concentrations that were greater than five times the corresponding DL.
µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; DL = detection limit; < = less than; NF = near-field; MF = mid-field; FF = far-field; n/a = not applicable.

Nutrient Duplicate Samples

During the ice-cover season, 52 out of a total of 833 results (6.2%) had an RPD of more than 40% between duplicates, while having concentrations greater than five times the DL in at least one of the samples (Table B-4). Flagged results varied among locations and analytes, including TN, TDN, total ammonia, nitrate + nitrite, TKN, and DKN. However, of the flagged results, 38 of the 52 were total ammonia, and 9 of the flagged results were for samples collected using black capped vials. Because less than 10% of the duplicate pairs were notably different from one another, the analytical precision for the ice-cover nutrient samples was rated as high.

Fewer DQO exceedances were observed during the open-water season. Out of a total of 325 results, six results (1.8%) had an RPD of more than 40% between duplicates, while having concentrations greater than five times the DL in at least one of the samples (Table B-5). As with ice-cover season, flagged results varied among locations and analytes (i.e., TP, TDP, TN, total ammonia, and TKN). Because less than 10% of the duplicate pairs were notably different from one another, the analytical precision for the ice-cover nutrient samples was rated as high.

The following results, which failed DQOs, were removed from the dataset based on the rationales provided below:

- The reported TN and TKN values for MF2-1B-4 collected during the ice-cover season were 33 µg-N/L and <20 µg-N/L, which were lower than their duplicates (TN = 320 µg-N/L, TKN = 173 µg-N/L) and failed the DQO with high RPDs (TN = 163%, TKN = 159%). These values were not consistent with those reported for the mid and top depths. Three lines of evidence suggest that the reported values for MF2-1B-4 were not representative of concentrations at this station: 1) concentrations were much higher and similar to one another at other depths, 2) dissolved concentrations (TDN and DKN) were higher for the same samples, and 3) concentrations at other depths were consistent with concentrations measured in nearby stations.
- The reported TDN and DKN values for MF3-3T-4 collected during the ice-cover season were both 32 µg-N/L, which were lower than their duplicates (TDN = 160 µg-N/L, DKN = 149 µg-N/L) and failed the DQO, with RPDs of 133% and 129%, respectively. The reported TDN and DKN values were not considered representative at this station because the corresponding TN value was much higher (TN = 140 µg-N/L, TKN = 140 µg-N/L) and consistent with other TN and TKN concentrations at nearby stations.
- The reported TDP value for FF1-2 collected during the open-water season was 49.8 µg-P/L, which was substantially higher than its duplicate (2 µg-P/L) and failed the DQO with an RPD of 185%. The value of 2 µg-P/L was considered representative of the station because the corresponding TP value and duplicate were both lower (2 µg-P/L), and consistent with other TP and TDP concentrations at nearby stations.

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Phosphorus (µg - P/L)	IC	FF1-2M	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-2B	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-2M	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-2T	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-5B	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-5M	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-5T	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FFD-1M	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	LDG-48	09 May 2021	2	3.4	<2	52	N	N
	IC	MF1-1B	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-1M	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-1T	24 Apr 2021	2	2.3	<2	14	N	N
	IC	MF1-3B	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-3M	24 Apr 2021	2	2.8	2.1	29	N	N
	IC	MF1-3T	24 Apr 2021	2	<2	2.5	22	N	N
	IC	MF1-5B	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-5M	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-5T	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF2-1B	07 May 2021	2	<2	3.4	52	N	N
	IC	MF2-1M	07 May 2021	2	5.9	5.7	3.4	N	N
	IC	MF2-1T	07 May 2021	2	5.4	4.9	9.7	N	N
	IC	MF2-3B	08 May 2021	2	4.4	2.6	51	N	N
	IC	MF2-3M	08 May 2021	2	3.8	7.1	61	N	N
	IC	MF2-3T	08 May 2021	2	5.2	2.4	74	N	N
	IC	MF3-1B	08 May 2021	2	6.0	3.8	45	N	N
	IC	MF3-1M	08 May 2021	2	4.6	5.1	10	N	N
	IC	MF3-1T	08 May 2021	2	<2	6.0	100	N	N
	IC	MF3-2B	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-2M	07 May 2021	2	3.7	3.0	21	N	N
	IC	MF3-2T	07 May 2021	2	<2	3.7	60	N	N
	IC	MF3-3B	07 May 2021	2	4.2	2.2	63	N	N
	IC	MF3-3M	07 May 2021	2	<2	2.7	30	N	N
	IC	MF3-3T	07 May 2021	2	<2	2.2	9.5	N	N
	IC	MF3-4B	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-4M	02 May 2021	2	<2	3.2	46	N	N
	IC	MF3-4T	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-5B	02 May 2021	2	<2	3.0	40	N	N
	IC	MF3-5M	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-5T	02 May 2021	2	<2	3.2	46	N	N
	IC	MF3-6B	02 May 2021	2	<2	2.5	22	N	N
	IC	MF3-6B[(b)]	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-6M	02 May 2021	2	<2	2.4	18	N	N
	IC	MF3-6T	02 May 2021	2	<2	3.7	60	N	N
	IC	MF3-7B	23 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF3-7M	23 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF3-7T	23 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF1B	09 May 2021	2	4.0	4.3	7.2	N	N
	IC	NF1M	09 May 2021	2	5.1	3.0	52	N	N
	IC	NF1T	09 May 2021	2	5.0	6.0	18	N	N
	IC	NF2B	25 Apr 2021	2	<2	4.3	73	N	N
	IC	NF2M	25 Apr 2021	2	3.6	<2	57	N	N
	IC	NF2T	25 Apr 2021	2	2.2	5.2	81	N	N
	IC	NF3B	25 Apr 2021	2	2.1	3.7	55	N	N
	IC	NF3M	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF3T	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF4B	08 May 2021	2	4.1	2.7	41	N	N
	IC	NF4M	08 May 2021	2	<2	<2	0.0	N	N
	IC	NF4M[(c)]	08 May 2021	2	3.1	5.6	58	N	N
	IC	NF4T	08 May 2021	2	6.3	4.2	40	N	N
	IC	NF5B	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF5M	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF5T	25 Apr 2021	2	<2	2.1	4.9	N	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Dissolved Phosphorus (µg - P/L)	IC	FF1-2M	20 Apr 2021	2	3.4	<2	52	N	N
	IC	FF2-2B	19 Apr 2021	2	3.0	<2	40	N	N
	IC	FF2-2M	19 Apr 2021	2	<2	3.7	60	N	N
	IC	FF2-2T	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-5B	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FF2-5M	19 Apr 2021	2	<2	2.2	9.5	N	N
	IC	FF2-5T	19 Apr 2021	2	<2	<2	0.0	N	N
	IC	FFD-1M	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	LDG-48	09 May 2021	2	<2	<2	0.0	N	N
	IC	MF1-1B	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-1M	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-1T	24 Apr 2021	2	6.0	<2	100	N	N
	IC	MF1-3B	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-3M	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-3T	24 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-5B	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-5M	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF1-5T	20 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF2-1B	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF2-1M	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF2-1T	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF2-3B	08 May 2021	2	2.6	<2	26	N	N
	IC	MF2-3M	08 May 2021	2	2.9	2.6	11	N	N
	IC	MF2-3T	08 May 2021	2	3.2	3.3	3.1	N	N
	IC	MF3-1B	08 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-1M	08 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-1T	08 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-2B	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-2M	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-2T	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-3B	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-3M	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-3T	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-4B	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-4M	02 May 2021	2	<2	2.4	18	N	N
	IC	MF3-4T	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-5B	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-5M	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-5T	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-6B	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-6B[(b)]	02 May 2021	2	<2	< 4	67	N	N
	IC	MF3-6B[(b)]	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-6M	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-6T	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-7B	23 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF3-7M	23 Apr 2021	2	<2	<2	0.0	N	N
	IC	MF3-7T	23 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF1B	09 May 2021	2	<2	<2	0.0	N	N
	IC	NF1M	09 May 2021	2	<2	<2	0.0	N	N
	IC	NF1T	09 May 2021	2	<2	<2	0.0	N	N
	IC	NF2B	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF2M	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF2T	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF3B	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF3M	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF3T	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF4B	08 May 2021	2	3.2	<2	46	N	N
	IC	NF4M	08 May 2021	2	<2	3	40	N	N
	IC	NF4M[(b)]	08 May 2021	2	<2	<2	0.0	N	N
	IC	NF4M[(b)]	08 May 2021	2	2.2	<2	9.5	N	N
	IC	NF4T	08 May 2021	2	<2	2.6	26	N	N
	IC	NF5B	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF5M	25 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF5T	25 Apr 2021	2	<2	<2	0.0	N	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Soluble Reactive Phosphorous (µg - P/L)	IC	FF1-2M	20 Apr 2021	1	<1	<1	0.0	N	N
	IC	FF2-2B	19 Apr 2021	1	1.3	<1	26	N	N
	IC	FF2-2M	19 Apr 2021	1	<1	1.7	52	N	N
	IC	FF2-2T	19 Apr 2021	1	<1	<1	0.0	N	N
	IC	FF2-5B	19 Apr 2021	1	1.8	2.2	20	N	N
	IC	FF2-5M	19 Apr 2021	1	1.9	1.3	3	N	N
	IC	FF2-5T	19 Apr 2021	1	1.4	2.2	44	N	N
	IC	FFD-1M	20 Apr 2021	1	<1	<1	0.0	N	N
	IC	LDG-48	09 May 2021	1	<1	<1	0.0	N	N
	IC	MF1-1B	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-1M	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-1T	24 Apr 2021	1	<1	1.1	9.5	N	N
	IC	MF1-3B	24 Apr 2021	1	2.5	2.2	13	N	N
	IC	MF1-3M	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-3T	24 Apr 2021	1	<1	1.2	18	N	N
	IC	MF1-5B	20 Apr 2021	1	<1	1.1	9.5	N	N
	IC	MF1-5M	20 Apr 2021	1	1.2	<1	18	N	N
	IC	MF1-5T	20 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF2-1B	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF2-1M	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF2-1T	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF2-3B	08 May 2021	1	1.4	1.1	24	N	N
	IC	MF2-3M	08 May 2021	1	<1	<1	0.0	N	N
	IC	MF2-3T	08 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-1B	08 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-1M	08 May 2021	1	<1	1.2	18	N	N
	IC	MF3-1T	08 May 2021	1	1.4	1.4	0.0	N	N
	IC	MF3-2B	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-2M	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-2T	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-3B	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-3M	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-3T	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-4B	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-4M	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-4T	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-5B	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-5M	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-5T	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6B[(b)]	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6B	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6B[(b)]	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6M	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6T	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-7B	23 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF3-7M	23 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF3-7T	23 Apr 2021	1	<1	<1	0.0	N	N
	IC	NF1B	09 May 2021	1	<1	<1	0.0	N	N
	IC	NF1M	09 May 2021	1	1.1	<1	9.5	N	N
	IC	NF1T	09 May 2021	1	1.5	2.4	46	N	N
	IC	NF2B	25 Apr 2021	1	2.7	2.9	7.1	N	N
	IC	NF2M	25 Apr 2021	1	2.5	2.0	22	N	N
	IC	NF2T	25 Apr 2021	1	1.7	<1	52	N	N
	IC	NF3B	25 Apr 2021	1	2.1	2.7	25	N	N
	IC	NF3M	25 Apr 2021	1	<1	<1	0.0	N	N
	IC	NF3T	25 Apr 2021	1	<1	<1	0.0	N	N
	IC	NF4B	08 May 2021	1	1.2	<1	18	N	N
	IC	NF4M[(c)]	08 May 2021	1	1.2	<1	18	N	N
	IC	NF4M	08 May 2021	1	<1	<1	0.0	N	N
	IC	NF4M[(c)]	08 May 2021	1	<1	<1	0.0	N	N
	IC	NF4T	08 May 2021	1	<1	<1	0.0	N	N
	IC	NF5B	25 Apr 2021	1	1.2	1.6	29	N	N
	IC	NF5M	25 Apr 2021	1	<1	1.5	40	N	N
	IC	NF5T	25 Apr 2021	1	<1	<1	0.0	N	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Nitrogen (µg-N/L)	IC	FF1-2M	20 Apr 2021	20	230	200	14	Y	N
	IC	FF2-2B	19 Apr 2021	20	260	250	3.9	Y	N
	IC	FF2-2M	19 Apr 2021	20	250	250	0.0	Y	N
	IC	FF2-2T	19 Apr 2021	20	280	280	0.0	Y	N
	IC	FF2-5B	19 Apr 2021	20	260	260	0.0	Y	N
	IC	FF2-5M	19 Apr 2021	20	210	210	0.0	Y	N
	IC	FF2-5T	19 Apr 2021	20	250	250	0.0	Y	N
	IC	FFD-1M	20 Apr 2021	20	140	180	25	Y	N
	IC	LDG-48	09 May 2021	20	250	130	63	Y	Y
	IC	MF1-1B	24 Apr 2021	20	160	200	22	Y	N
	IC	MF1-1M	24 Apr 2021	20	200	190	5.1	Y	N
	IC	MF1-1T	24 Apr 2021	20	210	220	4.7	Y	N
	IC	MF1-3B	24 Apr 2021	20	180	160	12	Y	N
	IC	MF1-3M	24 Apr 2021	20	190	200	5.1	Y	N
	IC	MF1-3T	24 Apr 2021	20	150	160	6.5	Y	N
	IC	MF1-5B	20 Apr 2021	20	300	310	3.3	Y	N
	IC	MF1-5M	20 Apr 2021	20	210	210	0.0	Y	N
	IC	MF1-5T	20 Apr 2021	20	180	200	11	Y	N
	IC	MF2-1B	07 May 2021	20	33[(a)]	320	163	Y	Y
	IC	MF2-1M	07 May 2021	20	260	230	12	Y	N
	IC	MF2-1T	07 May 2021	20	200	210	4.9	Y	N
	IC	MF2-3B	08 May 2021	20	410	310	28	Y	N
	IC	MF2-3M	08 May 2021	20	220	320	37	Y	N
	IC	MF2-3T	08 May 2021	20	220	180	20	Y	N
	IC	MF3-1B	08 May 2021	20	220	270	20	Y	N
	IC	MF3-1M	08 May 2021	20	250	240	4.1	Y	N
	IC	MF3-1T	08 May 2021	20	230	230	0.0	Y	N
	IC	MF3-2B	07 May 2021	20	240	260	8.0	Y	N
	IC	MF3-2M	07 May 2021	20	290	340	16	Y	N
	IC	MF3-2T	07 May 2021	20	210	220	4.7	Y	N
	IC	MF3-3B	07 May 2021	20	310	200	43	Y	Y
	IC	MF3-3M	07 May 2021	20	190	200	5.1	Y	N
	IC	MF3-3T	07 May 2021	20	140	140	0.0	Y	N
	IC	MF3-4B	02 May 2021	20	190	230	19	Y	N
	IC	MF3-4M	02 May 2021	20	160	190	17	Y	N
	IC	MF3-4T	02 May 2021	20	130	150	14	Y	N
	IC	MF3-5B	02 May 2021	20	160	170	6.1	Y	N
	IC	MF3-5M	02 May 2021	20	260	190	31	Y	N
	IC	MF3-5T	02 May 2021	20	280	170	49	Y	Y
	IC	MF3-6B	02 May 2021	20	120	120	0.0	Y	N
	IC	MF3-6B[(b)]	02 May 2021	20	150	160	6.5	Y	N
	IC	MF3-6M	02 May 2021	20	130	110	17	Y	N
	IC	MF3-6T	02 May 2021	20	170	140	19	Y	N
	IC	MF3-7B	23 Apr 2021	20	110	110	0.0	Y	N
	IC	MF3-7M	23 Apr 2021	20	86	93	7.8	N	N
	IC	MF3-7T	23 Apr 2021	20	89	99	11	N	N
	IC	NF1B	09 May 2021	20	320	300	6.5	Y	N
	IC	NF1M	09 May 2021	20	260	250	3.9	Y	N
	IC	NF1T	09 May 2021	20	240	250	4.1	Y	N
	IC	NF2B	25 Apr 2021	20	250	290	15	Y	N
	IC	NF2M	25 Apr 2021	20	200	220	9.5	Y	N
	IC	NF2T	25 Apr 2021	20	150	160	6.5	Y	N
	IC	NF3B	25 Apr 2021	20	220	240	8.7	Y	N
	IC	NF3M	25 Apr 2021	20	140	160	13	Y	N
	IC	NF3T	25 Apr 2021	20	220	180	20	Y	N
	IC	NF4B	08 May 2021	20	310	280	10	Y	N
	IC	NF4M	08 May 2021	20	270	250	7.7	Y	N
	IC	NF4M[(b)]	08 May 2021	20	280	230	20	Y	N
	IC	NF4T	08 May 2021	20	220	240	8.7	Y	N
	IC	NF5B	25 Apr 2021	20	250	280	11	Y	N
	IC	NF5M	25 Apr 2021	20	190	220	15	Y	N
	IC	NF5T	25 Apr 2021	20	190	170	11	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Dissolved Nitrogen (µg-N/L)	IC	FF1-2M	20 Apr 2021	20	160	170	6.1	Y	N
	IC	FF2-2B	19 Apr 2021	20	240	270	12	Y	N
	IC	FF2-2M	19 Apr 2021	20	270	260	3.8	Y	N
	IC	FF2-2T	19 Apr 2021	20	290	260	11	Y	N
	IC	FF2-5B	19 Apr 2021	20	230	210	9.1	Y	N
	IC	FF2-5M	19 Apr 2021	20	190	190	0.0	Y	N
	IC	FF2-5T	19 Apr 2021	20	200	220	9.5	Y	N
	IC	FFD-1M	20 Apr 2021	20	150	130	14	Y	N
	IC	LDG-48	09 May 2021	20	120	140	15	Y	N
	IC	MF1-1B	24 Apr 2021	20	170	170	0.0	Y	N
	IC	MF1-1M	24 Apr 2021	20	170	150	13	Y	N
	IC	MF1-1T	24 Apr 2021	20	170	160	6.1	Y	N
	IC	MF1-3B	24 Apr 2021	20	150	150	0.0	Y	N
	IC	MF1-3M	24 Apr 2021	20	170	150	13	Y	N
	IC	MF1-3T	24 Apr 2021	20	140	120	15	Y	N
	IC	MF1-5B	20 Apr 2021	20	270	280	3.6	Y	N
	IC	MF1-5M	20 Apr 2021	20	180	180	0.0	Y	N
	IC	MF1-5T	20 Apr 2021	20	180	130	32	Y	N
	IC	MF2-1B	07 May 2021	20	310	310	0.0	Y	N
	IC	MF2-1M	07 May 2021	20	180	170	5.7	Y	N
	IC	MF2-1T	07 May 2021	20	220	220	0.0	Y	N
	IC	MF2-3B	08 May 2021	20	320	390	2.0	Y	N
	IC	MF2-3M	08 May 2021	20	190	220	15	Y	N
	IC	MF2-3T	08 May 2021	20	190	200	5.1	Y	N
	IC	MF3-1B	08 May 2021	20	240	230	4.3	Y	N
	IC	MF3-1M	08 May 2021	20	240	230	4.3	Y	N
	IC	MF3-1T	08 May 2021	20	220	200	9.5	Y	N
	IC	MF3-2B	07 May 2021	20	260	210	21	Y	N
	IC	MF3-2M	07 May 2021	20	230	190	19	Y	N
	IC	MF3-2T	07 May 2021	20	180	200	11	Y	N
	IC	MF3-3B	07 May 2021	20	200	210	4.9	Y	N
	IC	MF3-3M	07 May 2021	20	230	230	0.0	Y	N
	IC	MF3-3T	07 May 2021	20	32[a]	160	133	Y	Y
	IC	MF3-4B	02 May 2021	20	150	150	0.0	Y	N
	IC	MF3-4M	02 May 2021	20	130	140	7.4	Y	N
	IC	MF3-4T	02 May 2021	20	120	86	33	Y	N
	IC	MF3-5B	02 May 2021	20	150	130	14	Y	N
	IC	MF3-5M	02 May 2021	20	100	130	26	Y	N
	IC	MF3-5T	02 May 2021	20	110	97	13	Y	N
	IC	MF3-6B	02 May 2021	20	120	110	8.7	Y	N
	IC	MF3-6B[b]	02 May 2021	20	110	110	0.0	Y	N
	IC	MF3-6M	02 May 2021	20	120	100	18	Y	N
	IC	MF3-6T	02 May 2021	20	110	120	8.7	Y	N
	IC	MF3-7B	23 Apr 2021	20	99	80	21	N	N
	IC	MF3-7M	23 Apr 2021	20	57	63	10	N	N
	IC	MF3-7T	23 Apr 2021	20	55	53	3.7	N	N
	IC	NF1B	09 May 2021	20	230	330	36	Y	N
	IC	NF1M	09 May 2021	20	260	280	7.4	Y	N
	IC	NF1T	09 May 2021	20	240	230	4.3	Y	N
	IC	NF2B	25 Apr 2021	20	230	210	9.1	Y	N
	IC	NF2M	25 Apr 2021	20	190	180	5.4	Y	N
	IC	NF2T	25 Apr 2021	20	140	140	0.0	Y	N
	IC	NF3B	25 Apr 2021	20	200	220	9.5	Y	N
	IC	NF3M	25 Apr 2021	20	120	140	15	Y	N
	IC	NF3T	25 Apr 2021	20	130	130	0.0	Y	N
	IC	NF4B	08 May 2021	20	260	290	11	Y	N
	IC	NF4M	08 May 2021	20	240	210	13	Y	N
	IC	NF4M[b]	08 May 2021	20	200	220	9.5	Y	N
	IC	NF4T	08 May 2021	20	240	220	8.7	Y	N
	IC	NF5B	25 Apr 2021	20	230	220	4.4	Y	N
	IC	NF5M	25 Apr 2021	20	170	170	0.0	Y	N
	IC	NF5T	25 Apr 2021	20	140	160	13	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Ammonia (µg-N/L) - ALS	IC	FF1-2M	20 Apr 2021	5	24	26	6.0	Y	N
	IC	FF2-2B	19 Apr 2021	5	<5	11	73	N	N
	IC	FF2-2M	19 Apr 2021	5	12	<5	82	N	N
	IC	FF2-2T	19 Apr 2021	5	32	30	4.8	Y	N
	IC	FF2-5B	19 Apr 2021	5	8.7	5.7	42	N	N
	IC	FF2-5M	19 Apr 2021	5	6.5	<5	26	N	N
	IC	FF2-5T	19 Apr 2021	5	30	28	9.0	Y	N
	IC	FFD-1M	20 Apr 2021	5	22	22	1.4	N	N
	IC	LDG-48	09 May 2021	5	18	18	2.8	N	N
	IC	MF1-1B	24 Apr 2021	5	9.4	6.7	34	N	N
	IC	MF1-1M	24 Apr 2021	5	11	12	8.8	N	N
	IC	MF1-1T	24 Apr 2021	5	30	24	22	Y	N
	IC	MF1-3B	24 Apr 2021	5	<5	6.2	21	N	N
	IC	MF1-3M	24 Apr 2021	5	13	12	10	N	N
	IC	MF1-3T	24 Apr 2021	5	26	31	18	Y	N
	IC	MF1-5B	20 Apr 2021	5	7.6	21	95	N	N
	IC	MF1-5M	20 Apr 2021	5	25	17	40	N	N
	IC	MF1-5T	20 Apr 2021	5	25	23	7.2	N	N
	IC	MF2-1B	07 May 2021	5	25	5.2	132	Y	Y
	IC	MF2-1M	07 May 2021	5	23	6.9	107	N	N
	IC	MF2-1T	07 May 2021	5	34	24	34	Y	N
	IC	MF2-3B	08 May 2021	5	12	5.5	71	N	N
	IC	MF2-3M	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF2-3T	08 May 2021	5	17	19	13	N	N
	IC	MF3-1B	08 May 2021	5	16	13	26	N	N
	IC	MF3-1B(b)	08 May 2021	5	6.6	12	57	N	N
	IC	MF3-1M	08 May 2021	5	15	8.0	58	N	N
	IC	MF3-1T	08 May 2021	5	33	12	93	Y	Y
	IC	MF3-2B	07 May 2021	5	<5	5.3	5.8	N	N
	IC	MF3-2M	07 May 2021	5	19	7.5	86	N	N
	IC	MF3-2T	07 May 2021	5	48	27	56	Y	Y
	IC	MF3-3B	07 May 2021	5	8.2	8.0	2.5	N	N
	IC	MF3-3M	07 May 2021	5	5.7	7.8	31	N	N
	IC	MF3-3T	07 May 2021	5	26	22	14	Y	N
	IC	MF3-4B	02 May 2021	5	8.2	9.5	15	N	N
	IC	MF3-4M	02 May 2021	5	6.3	6.7	6.2	N	N
	IC	MF3-4T	02 May 2021	5	23	27	16	Y	N
	IC	MF3-5B	02 May 2021	5	17	19	12	N	N
	IC	MF3-5M	02 May 2021	5	13	14	3.7	N	N
	IC	MF3-5T	02 May 2021	5	21	19	10	N	N
	IC	MF3-6B	02 May 2021	5	20	41	70	Y	Y
	IC	MF3-6B(b)	02 May 2021	5	22	38	55	Y	Y
	IC	MF3-6M	02 May 2021	5	20	25	25	N	N
	IC	MF3-6T	02 May 2021	5	22	44	67	Y	Y
	IC	MF3-7B	23 Apr 2021	5	21	32	40	Y	Y
	IC	MF3-7M	23 Apr 2021	5	21	21	1.9	N	N
	IC	MF3-7T	23 Apr 2021	5	19	20	6.6	N	N
	IC	NF1B	09 May 2021	5	30	15	68	Y	Y
	IC	NF1M	09 May 2021	5	9.6	6.7	36	N	N
	IC	NF1T	09 May 2021	5	<5	10	69	N	N
	IC	NF2B	25 Apr 2021	5	20	20	2.5	N	N
	IC	NF2M	25 Apr 2021	5	11	12	7.2	N	N
	IC	NF2T	25 Apr 2021	5	11	12	5.3	N	N
	IC	NF3B	25 Apr 2021	5	15	16	2.6	N	N
	IC	NF3M	25 Apr 2021	5	<5	<5	0.0	N	N
	IC	NF3T	25 Apr 2021	5	16	15	2.6	N	N
	IC	NF4B	08 May 2021	5	5.7	7.9	32	N	N
	IC	NF4M	08 May 2021	5	<5	9.7	64	N	N
	IC	NF4M(b)	08 May 2021	5	5.1	<5	2.0	N	N
	IC	NF4T	08 May 2021	5	19	14	29	N	N
	IC	NF5B	25 Apr 2021	5	11	15	35	N	N
	IC	NF5M	25 Apr 2021	5	9.4	10	8.2	N	N
	IC	NF5T	25 Apr 2021	5	26	26	1.5	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Ammonia (µg-N/L) - BV Labs	IC	FF1-2M	20 Apr 2021	5	68	24	96	Y	Y
	IC	FF2-2B	19 Apr 2021	5	100	99	1.0	Y	N
	IC	FF2-2M	19 Apr 2021	5	160	110	37	Y	N
	IC	FF2-2T	19 Apr 2021	5	210	120	55	Y	Y
	IC	FF2-5B	19 Apr 2021	5	<5	<5	0.0	N	N
	IC	FF2-5M	19 Apr 2021	5	110	58	62	Y	Y
	IC	FF2-5T	19 Apr 2021	5	25	61	84	Y	Y
	IC	FFD-1M	20 Apr 2021	5	110	28	119	Y	Y
	IC	LDG-48	09 May 2021	5	19	18	5.4	N	N
	IC	MF1-1B	24 Apr 2021	5	11	8.2	30	N	N
	IC	MF1-1M	24 Apr 2021	5	17	240	174	Y	Y
	IC	MF1-1T	24 Apr 2021	5	31	68	75	Y	Y
	IC	MF1-3B	24 Apr 2021	5	26	6.5	120	Y	Y
	IC	MF1-3M	24 Apr 2021	5	7.3	19	89	N	N
	IC	MF1-3T	24 Apr 2021	5	160	28	140	Y	Y
	IC	MF1-5B	20 Apr 2021	5	270	12	183	Y	Y
	IC	MF1-5M	20 Apr 2021	5	130	130	0.0	Y	N
	IC	MF1-5T	20 Apr 2021	5	34	170	133	Y	Y
	IC	MF2-1B	07 May 2021	5	<5	<5	0.0	N	N
	IC	MF2-1M	07 May 2021	5	23	6.7	110	N	N
	IC	MF2-1T	07 May 2021	5	<5	<5	0.0	N	N
	IC	MF2-3B	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF2-3B[c]	08 May 2021	5	7.4	6.9	7.0	N	N
	IC	MF2-3M	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF2-3M[c]	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF2-3T	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF2-3T[c]	08 May 2021	5	65	36	57	Y	Y
	IC	MF3-1B	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-1B[b]	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-1M	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-1T	08 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-2B	07 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-2B[c]	07 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-2M	07 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-2M[c]	07 May 2021	5	5.5	28	134	Y	Y
	IC	MF3-2T	07 May 2021	5	<5	8.2	49	N	N
	IC	MF3-2T[c]	07 May 2021	5	74	22	108	Y	Y
	IC	MF3-3B	07 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-3M	07 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-3T	07 May 2021	5	13	13	0.0	N	N
	IC	MF3-4B	02 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-4B[c]	02 May 2021	5	290	240	19	Y	N
	IC	MF3-4M	02 May 2021	5	<5	<5	0.0	N	N
	IC	MF3-4M[c]	02 May 2021	5	230	320	33	Y	N
	IC	MF3-4T	02 May 2021	5	16	26	48	Y	Y
	IC	MF3-4T[c]	02 May 2021	5	480	270	56	Y	Y
	IC	MF3-5B	02 May 2021	5	11	8.7	23	N	N
	IC	MF3-5B[c]	02 May 2021	5	270	13	182	Y	Y
	IC	MF3-5M	02 May 2021	5	<5	7.8	44	N	N
	IC	MF3-5M[c]	02 May 2021	5	12	66	139	Y	Y
	IC	MF3-5T	02 May 2021	5	18	14	25	N	N
	IC	MF3-5T[c]	02 May 2021	5	40	680	178	Y	Y
	IC	MF3-6B	02 May 2021	5	82	62	28	Y	N
	IC	MF3-6B[b]	02 May 2021	5	310	84	115	Y	Y
	IC	MF3-6M	02 May 2021	5	530	310	52	Y	Y
	IC	MF3-6T	02 May 2021	5	1100	1200	8.7	Y	N
	IC	MF3-7B	23 Apr 2021	5	35	450	171	Y	Y
	IC	MF3-7M	23 Apr 2021	5	45	26	54	Y	Y
	IC	MF3-7T	23 Apr 2021	5	31	620	181	Y	Y
	IC	NF1B	09 May 2021	5	7.6	<5	41	N	N
	IC	NF1B[c]	09 May 2021	5	11	40	114	Y	Y
	IC	NF1M	09 May 2021	5	<5	<5	0.0	N	N
	IC	NF1M[c]	09 May 2021	5	34	56	49	Y	Y
	IC	NF1T	09 May 2021	5	9.8	7.1	32	N	N
	IC	NF1T[c]	09 May 2021	5	12	20	50	N	N
	IC	NF2B	25 Apr 2021	5	23	22	162	Y	Y
	IC	NF2M	25 Apr 2021	5	12	16	29	N	N
	IC	NF2T	25 Apr 2021	5	520	560	7.4	Y	N
	IC	NF3B	25 Apr 2021	5	22	190	159	Y	Y
	IC	NF3M	25 Apr 2021	5	97	69	34	Y	N
	IC	NF3T	25 Apr 2021	5	29	15	64	Y	Y
	IC	NF4B	08 May 2021	5	<5	<5	0.0	N	N
	IC	NF4M	08 May 2021	5	<5	<5	0.0	N	N
	IC	NF4M[b]	08 May 2021	5	<5	<5	0.0	N	N
	IC	NF4T	08 May 2021	5	7.3	7.2	1.4	N	N
	IC	NF5B	25 Apr 2021	5	8.3	8.4	1.2	N	N
	IC	NF5M	25 Apr 2021	5	240	130	60	Y	Y
	IC	NF5T	25 Apr 2021	5	64	93	37	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Nitrate (µg-N/L)	IC	FF1-2M	20 Apr 2021	2	13	12	8.0	Y	N
	IC	FF2-2B	19 Apr 2021	2	100	100	0.0	Y	N
	IC	FF2-2M	19 Apr 2021	2	87	83	4.7	Y	N
	IC	FF2-2T	19 Apr 2021	2	52	57	9.2	Y	N
	IC	FF2-5B	19 Apr 2021	2	83	87	4.7	Y	N
	IC	FF2-5M	19 Apr 2021	2	61	67	9.4	Y	N
	IC	FF2-5T	19 Apr 2021	2	26	20	26	Y	N
	IC	FFD-1M	20 Apr 2021	2	10	6.7	40	N	N
	IC	LDG-48	09 May 2021	2	7.0	3.1	77	N	N
	IC	MF1-1B	24 Apr 2021	2	96	88	8.7	Y	N
	IC	MF1-1M	24 Apr 2021	2	88	88	0.0	Y	N
	IC	MF1-1T	24 Apr 2021	2	62	63	1.6	Y	N
	IC	MF1-3B	24 Apr 2021	2	88	86	2.3	Y	N
	IC	MF1-3M	24 Apr 2021	2	82	78	5.0	Y	N
	IC	MF1-3T	24 Apr 2021	2	41	41	0.0	Y	N
	IC	MF1-5B	20 Apr 2021	2	150	140	6.9	Y	N
	IC	MF1-5M	20 Apr 2021	2	57	56	1.8	Y	N
	IC	MF1-5T	20 Apr 2021	2	4.0	5.0	22	N	N
	IC	MF2-1B	07 May 2021	2	160	150	6.5	Y	N
	IC	MF2-1M	07 May 2021	2	67	82	20	Y	N
	IC	MF2-1T	07 May 2021	2	70	64	9.0	Y	N
	IC	MF2-3B	08 May 2021	2	140	140	0.0	Y	N
	IC	MF2-3M	08 May 2021	2	<2	<2	0.0	N	N
	IC	MF2-3T	08 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-1B	08 May 2021	2	110	120	8.7	Y	N
	IC	MF3-1M	08 May 2021	2	110	100	9.5	Y	N
	IC	MF3-1T	08 May 2021	2	82	62	28	Y	N
	IC	MF3-2B	07 May 2021	2	86	89	3.4	Y	N
	IC	MF3-2M	07 May 2021	2	90	88	2.2	Y	N
	IC	MF3-2T	07 May 2021	2	55	54	1.8	Y	N
	IC	MF3-3B	07 May 2021	2	53	60	12	Y	N
	IC	MF3-3M	07 May 2021	2	74	76	2.7	Y	N
	IC	MF3-3T	07 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-4B	02 May 2021	2	52	53	1.9	Y	N
	IC	MF3-4M	02 May 2021	2	52	57	9.2	Y	N
	IC	MF3-4T	02 May 2021	2	6.6	6.2	6.2	N	N
	IC	MF3-5B	02 May 2021	2	57	53	7.3	Y	N
	IC	MF3-5M	02 May 2021	2	31	26	18	Y	N
	IC	MF3-5T	02 May 2021	2	<2	<2	0.0	N	N
	IC	MF3-6B[(b)]	02 May 2021	2	15	18	18	Y	N
	IC	MF3-6B	02 May 2021	2	18	15	18	Y	N
	IC	MF3-6B[(b)]	02 May 2021	2	17	22	26	Y	N
	IC	MF3-6M	02 May 2021	2	11	7.5	38	Y	N
	IC	MF3-6T	02 May 2021	2	5.1	< 2	87	N	N
	IC	MF3-7B	23 Apr 2021	2	23	26	12	Y	N
	IC	MF3-7M	23 Apr 2021	2	3.2	<2	46	N	N
	IC	MF3-7T	23 Apr 2021	2	<2	<2	0.0	N	N
	IC	NF1B	09 May 2021	2	150	180	18	Y	N
	IC	NF1M	09 May 2021	2	110	110	0.0	Y	N
	IC	NF1T	09 May 2021	2	76	77	1.3	Y	N
	IC	NF2B	25 Apr 2021	2	140	150	6.9	Y	N
	IC	NF2M	25 Apr 2021	2	110	100	9.5	Y	N
	IC	NF2T	25 Apr 2021	2	64	64	0.0	Y	N
	IC	NF3B	25 Apr 2021	2	130	130	0.0	Y	N
	IC	NF3M	25 Apr 2021	2	68	78	14	Y	N
	IC	NF3T	25 Apr 2021	2	53	59	11	Y	N
	IC	NF4B	08 May 2021	2	150	150	0.0	Y	N
	IC	NF4M[(b)]	08 May 2021	2	95	86	9.9	Y	N
	IC	NF4M	08 May 2021	2	97	99	2.0	Y	N
	IC	NF4M[(b)]	08 May 2021	2	84	91	8.0	Y	N
	IC	NF4T	08 May 2021	2	57	58	1.7	Y	N
	IC	NF5B	25 Apr 2021	2	140	140	0.0	Y	N
	IC	NF5M	25 Apr 2021	2	110	110	0.0	Y	N
	IC	NF5T	25 Apr 2021	2	51	54	5.7	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Nitrite (µg-N/L)	IC	FF1-2M	20 Apr 2021	1	1.4	1.9	30	N	N
	IC	FF2-2B	19 Apr 2021	1	<1	<1	0.0	N	N
	IC	FF2-2M	19 Apr 2021	1	<1	<1	0.0	N	N
	IC	FF2-2T	19 Apr 2021	1	1.8	1.7	5.7	N	N
	IC	FF2-5B	19 Apr 2021	1	<1	1.2	18	N	N
	IC	FF2-5M	19 Apr 2021	1	1.2	<1	18	N	N
	IC	FF2-5T	19 Apr 2021	1	1.1	<1	9.5	N	N
	IC	FFD-1M	20 Apr 2021	1	3.0	1.7	55	N	N
	IC	LDG-48	09 May 2021	1	<1	<1	0.0	N	N
	IC	MF1-1B	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-1M	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-1T	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-3B	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-3M	24 Apr 2021	1	<1	1.4	33	N	N
	IC	MF1-3T	24 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-5B	20 Apr 2021	1	<1	<1	0.0	N	N
	IC	MF1-5M	20 Apr 2021	1	1.4	1.3	7.4	N	N
	IC	MF1-5T	20 Apr 2021	1	2.5	1.9	27	N	N
	IC	MF2-1B	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF2-1M	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF2-1T	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF2-3B	08 May 2021	1	2.8	2.7	3.6	N	N
	IC	MF2-3M	08 May 2021	1	<1	1.7	52	N	N
	IC	MF2-3T	08 May 2021	1	2.9	1.7	52	N	N
	IC	MF3-1B	08 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-1M	08 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-1T	08 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-2B	07 May 2021	1	1.2	1.6	29	N	N
	IC	MF3-2M	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-2T	07 May 2021	1	<1	1.8	57	N	N
	IC	MF3-3B	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-3M	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-3T	07 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-4B	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-4M	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-4T	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-5B	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-5M	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-5T	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6B[(b)]	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6B	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6B[(b)]	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6M	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-6T	02 May 2021	1	<1	<1	0.0	N	N
	IC	MF3-7B	23 Apr 2021	1	1.5	2.6	54	N	N
	IC	MF3-7M	23 Apr 2021	1	1.6	2.5	44	N	N
	IC	MF3-7T	23 Apr 2021	1	<1	<1	0.0	N	N
	IC	NF1B	09 May 2021	1	1.3	1.1	17	N	N
	IC	NF1M	09 May 2021	1	< 1	< 1	0.0	N	N
	IC	NF1T	09 May 2021	1	1.8	1.4	25	N	N
	IC	NF2B	25 Apr 2021	1	2.0	1.5	29	N	N
	IC	NF2M	25 Apr 2021	1	1.2	1.3	8.0	N	N
	IC	NF2T	25 Apr 2021	1	<1	<1	0.0	N	N
	IC	NF3B	25 Apr 2021	1	1.2	1.7	35	N	N
	IC	NF3M	25 Apr 2021	1	<1	<1	0.0	N	N
	IC	NF3T	25 Apr 2021	1	1.9	<1	62	N	N
	IC	NF4B	08 May 2021	1	<1	2.3	79	N	N
	IC	NF4M[(b)]	08 May 2021	1	<1	<1	0.0	N	N
	IC	NF4M	08 May 2021	1	1.4	<1	33	N	N
	IC	NF4M[(b)]	08 May 2021	1	<1	<1	0.0	N	N
	IC	NF4T	08 May 2021	1	1.6	1.5	6.5	N	N
	IC	NF5B	25 Apr 2021	1	1.3	1.1	17	N	N
	IC	NF5M	25 Apr 2021	1	1.4	<1	33	N	N
	IC	NF5T	25 Apr 2021	1	3.5	<1	111	N	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Nitrate + Nitrite (µg-N/L)	IC	FF1-2M	20 Apr 2021	2.2	15	14	6.9	Y	N
	IC	FF2-2B	19 Apr 2021	2.2	100	100	0.0	Y	N
	IC	FF2-2M	19 Apr 2021	2.2	88	83	5.8	Y	N
	IC	FF2-2T	19 Apr 2021	2.2	54	59	8.8	Y	N
	IC	FF2-5B	19 Apr 2021	2.2	83	88	5.8	Y	N
	IC	FF2-5M	19 Apr 2021	2.2	62	67	7.8	Y	N
	IC	FF2-5T	19 Apr 2021	2.2	27	20	30	Y	N
	IC	FFD-1M	20 Apr 2021	2.2	13	8.4	43	Y	Y
	IC	LDG-48	09 May 2021	2.2	7.0	3.1	77	N	N
	IC	MF1-1B	24 Apr 2021	2.2	96	88	8.7	Y	N
	IC	MF1-1M	24 Apr 2021	2.2	88	88	0.0	Y	N
	IC	MF1-1T	24 Apr 2021	2.2	62	63	1.6	Y	N
	IC	MF1-3B	24 Apr 2021	2.2	88	86	2.3	Y	N
	IC	MF1-3M	24 Apr 2021	2.2	82	79	3.7	Y	N
	IC	MF1-3T	24 Apr 2021	2.2	42	41	2.4	Y	N
	IC	MF1-5B	20 Apr 2021	2.2	150	140	6.9	Y	N
	IC	MF1-5M	20 Apr 2021	2.2	58	57	1.7	Y	N
	IC	MF1-5T	20 Apr 2021	2.2	6.6	6.9	4.4	N	N
	IC	MF2-1B	07 May 2021	2.2	160	150	6.5	Y	N
	IC	MF2-1M	07 May 2021	2.2	68	82	19	Y	N
	IC	MF2-1T	07 May 2021	2.2	70	64	9.0	Y	N
	IC	MF2-3B	08 May 2021	2.2	150	140	6.9	Y	N
	IC	MF2-3M	08 May 2021	2.2	<2.2	<2.2	0.0	N	N
	IC	MF2-3T	08 May 2021	2.2	2.9	<2.2	28	N	N
	IC	MF3-1B	08 May 2021	2.2	110	120	8.7	Y	N
	IC	MF3-1M	08 May 2021	2.2	110	100	9.5	Y	N
	IC	MF3-1T	08 May 2021	2.2	82	62	28	Y	N
	IC	MF3-2B	07 May 2021	2.2	87	91	4.5	Y	N
	IC	MF3-2M	07 May 2021	2.2	90	88	2.2	Y	N
	IC	MF3-2T	07 May 2021	2.2	55	56	1.8	Y	N
	IC	MF3-3B	07 May 2021	2.2	53	60	12	Y	N
	IC	MF3-3M	07 May 2021	2.2	74	76	2.7	Y	N
	IC	MF3-3T	07 May 2021	2.2	<2.2	10	128	N	N
	IC	MF3-4B	02 May 2021	2.2	52	53	1.9	Y	N
	IC	MF3-4M	02 May 2021	2.2	52	57	9.2	Y	N
	IC	MF3-4T	02 May 2021	2.2	6.6	6.2	6.2	N	N
	IC	MF3-5B	02 May 2021	2.2	57	53	7.3	Y	N
	IC	MF3-5M	02 May 2021	2.2	31	26	18	Y	N
	IC	MF3-5T	02 May 2021	2.2	<2.2	<2.2	0.0	N	N
	IC	MF3-6B[(b)]	02 May 2021	2.2	15	18	18	Y	N
	IC	MF3-6B	02 May 2021	2.2	18	15	18	Y	N
	IC	MF3-6B[(b)]	02 May 2021	2.2	17	22	26	Y	N
	IC	MF3-6M	02 May 2021	2.2	11	7.5	38	N	N
	IC	MF3-6T	02 May 2021	2.2	5.1	<2.2	80	N	N
	IC	MF3-7B	23 Apr 2021	2.2	25	29	15	Y	N
	IC	MF3-7M	23 Apr 2021	2.2	4.8	2.5	63	N	N
	IC	MF3-7T	23 Apr 2021	2.2	<2.2	<2.2	0.0	N	N
	IC	NF1B	09 May 2021	2.2	150	180	18	Y	N
	IC	NF1M	09 May 2021	2.2	110	110	0.0	Y	N
	IC	NF1T	09 May 2021	2.2	78	78	0.0	Y	N
	IC	NF2B	25 Apr 2021	2.2	140	150	6.9	Y	N
	IC	NF2M	25 Apr 2021	2.2	110	100	9.5	Y	N
	IC	NF2T	25 Apr 2021	2.2	64	64	0.0	Y	N
	IC	NF3B	25 Apr 2021	2.2	130	130	0.0	Y	N
	IC	NF3M	25 Apr 2021	2.2	68	78	14	Y	N
	IC	NF3T	25 Apr 2021	2.2	55	59	7.0	Y	N
	IC	NF4B	08 May 2021	2.2	150	150	0.0	Y	N
	IC	NF4M[(b)]	08 May 2021	2.2	95	86	9.9	Y	N
	IC	NF4M	08 May 2021	2.2	98	99	1.0	Y	N
	IC	NF4M[(c)]	08 May 2021	2.2	84	91	8.0	Y	N
	IC	NF4T	08 May 2021	2.2	59	60	1.7	Y	N
	IC	NF5B	25 Apr 2021	2.2	140	140	0.0	Y	N
	IC	NF5M	25 Apr 2021	2.2	110	110	0.0	Y	N
	IC	NF5T	25 Apr 2021	2.2	54	54	0.0	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Kjeldahl Nitrogen (µg-N/L)	IC	FF1-2M	20 Apr 2021	20	212	183	15	Y	N
	IC	FF2-2B	19 Apr 2021	20	161	148	8.4	Y	N
	IC	FF2-2M	19 Apr 2021	20	161	168	4.3	Y	N
	IC	FF2-2T	19 Apr 2021	20	230	217	5.8	Y	N
	IC	FF2-5B	19 Apr 2021	20	172	169	1.8	Y	N
	IC	FF2-5M	19 Apr 2021	20	147	147	0.0	Y	N
	IC	FF2-5T	19 Apr 2021	20	225	235	4.3	Y	N
	IC	FFD-1M	20 Apr 2021	20	128	167	26	Y	N
	IC	LDG-48	09 May 2021	20	240	127	62	Y	Y
	IC	MF1-1B	24 Apr 2021	20	69	111	47	Y	Y
	IC	MF1-1M	24 Apr 2021	20	111	103	7.5	Y	N
	IC	MF1-1T	24 Apr 2021	20	153	162	5.7	Y	N
	IC	MF1-3B	24 Apr 2021	20	94	76	21	N	N
	IC	MF1-3M	24 Apr 2021	20	110	120	8.7	Y	N
	IC	MF1-3T	24 Apr 2021	20	107	115	7.2	Y	N
	IC	MF1-5B	20 Apr 2021	20	156	169	8.0	Y	N
	IC	MF1-5M	20 Apr 2021	20	156	150	3.9	Y	N
	IC	MF1-5T	20 Apr 2021	20	173	191	9.9	Y	N
	IC	MF2-1B	07 May 2021	20	<20[(a)]	173	159	Y	Y
	IC	MF2-1M	07 May 2021	20	191	151	23	Y	N
	IC	MF2-1T	07 May 2021	20	128	149	15	Y	N
	IC	MF2-3B	08 May 2021	20	261	167	44	Y	Y
	IC	MF2-3M	08 May 2021	20	215	319	39	Y	N
	IC	MF2-3T	08 May 2021	20	216	182	17	Y	N
	IC	MF3-1B	08 May 2021	20	103	148	36	Y	N
	IC	MF3-1M	08 May 2021	20	139	135	2.9	Y	N
	IC	MF3-1T	08 May 2021	20	151	172	13	Y	N
	IC	MF3-2B	07 May 2021	20	153	168	9.3	Y	N
	IC	MF3-2M	07 May 2021	20	198	254	25	Y	N
	IC	MF3-2T	07 May 2021	20	157	166	5.6	Y	N
	IC	MF3-3B	07 May 2021	20	255	141	58	Y	Y
	IC	MF3-3M	07 May 2021	20	118	127	7.3	Y	N
	IC	MF3-3T	07 May 2021	20	140	132	5.9	Y	N
	IC	MF3-4B	02 May 2021	20	140	175	22	Y	N
	IC	MF3-4M	02 May 2021	20	109	129	17	Y	N
	IC	MF3-4T	02 May 2021	20	124	145	16	Y	N
	IC	MF3-5B	02 May 2021	20	101	113	11	Y	N
	IC	MF3-5M	02 May 2021	20	233	163	35	Y	N
	IC	MF3-5T	02 May 2021	20	275	166	49	Y	Y
	IC	MF3-6B	02 May 2021	20	105	102	2.9	Y	N
	IC	MF3-6B[(b)]	02 May 2021	20	131	138	5.2	Y	N
	IC	MF3-6M	02 May 2021	20	117	107	8.9	Y	N
	IC	MF3-6T	02 May 2021	20	160	138	15	Y	N
	IC	MF3-7B	23 Apr 2021	20	84	85	1.2	N	N
	IC	MF3-7M	23 Apr 2021	20	81	90	11	N	N
	IC	MF3-7T	23 Apr 2021	20	89	99	11	N	N
	IC	NF1B	09 May 2021	20	170	120	35	Y	N
	IC	NF1M	09 May 2021	20	141	140	0.7	Y	N
	IC	NF1T	09 May 2021	20	158	177	11	Y	N
	IC	NF2B	25 Apr 2021	20	114	143	23	Y	N
	IC	NF2M	25 Apr 2021	20	95	114	18	Y	N
	IC	NF2T	25 Apr 2021	20	89	97	8.6	N	N
	IC	NF3B	25 Apr 2021	20	88	110	22	Y	N
	IC	NF3M	25 Apr 2021	20	73	82	12	N	N
	IC	NF3T	25 Apr 2021	20	169	123	32	Y	N
	IC	NF4B	08 May 2021	20	167	128	26	Y	N
	IC	NF4M	08 May 2021	20	168	150	11	Y	N
	IC	NF4M[(b)]	08 May 2021	20	193	140	32	Y	N
	IC	NF4T	08 May 2021	20	159	180	12	Y	N
	IC	NF5B	25 Apr 2021	20	109	144	28	Y	N
	IC	NF5M	25 Apr 2021	20	79	108	31	Y	N
	IC	NF5T	25 Apr 2021	20	132	121	8.7	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Dissolved Kjeldahl Nitrogen (µg-N/L)	IC	FF1-2M	20 Apr 2021	20	149	154	3.3	Y	N
	IC	FF2-2B	19 Apr 2021	20	139	167	18	Y	N
	IC	FF2-2M	19 Apr 2021	20	183	176	3.9	Y	N
	IC	FF2-2T	19 Apr 2021	20	232	200	15	Y	N
	IC	FF2-5B	19 Apr 2021	20	151	122	21	Y	N
	IC	FF2-5M	19 Apr 2021	20	128	126	1.6	Y	N
	IC	FF2-5T	19 Apr 2021	20	173	201	15	Y	N
	IC	FFD-1M	20 Apr 2021	20	141	120	16	Y	N
	IC	LDG-48	09 May 2021	20	112	134	18	Y	N
	IC	MF1-1B	24 Apr 2021	20	78	84	7.4	N	N
	IC	MF1-1M	24 Apr 2021	20	78	63	21	N	N
	IC	MF1-1T	24 Apr 2021	20	108	94	14	Y	N
	IC	MF1-3B	24 Apr 2021	20	66	60	9.5	N	N
	IC	MF1-3M	24 Apr 2021	20	85	71	18	N	N
	IC	MF1-3T	24 Apr 2021	20	94	79	17	N	N
	IC	MF1-5B	20 Apr 2021	20	118	134	13	Y	N
	IC	MF1-5M	20 Apr 2021	20	121	118	2.5	Y	N
	IC	MF1-5T	20 Apr 2021	20	175	120	37	Y	N
	IC	MF2-1B	07 May 2021	20	151	157	3.9	Y	N
	IC	MF2-1M	07 May 2021	20	114	85	29	Y	N
	IC	MF2-1T	07 May 2021	20	149	156	4.6	Y	N
	IC	MF2-3B	08 May 2021	20	179	244	31	Y	N
	IC	MF2-3M	08 May 2021	20	191	220	14	Y	N
	IC	MF2-3T	08 May 2021	20	191	198	3.6	Y	N
	IC	MF3-1B	08 May 2021	20	126	111	13	Y	N
	IC	MF3-1M	08 May 2021	20	130	130	0.0	Y	N
	IC	MF3-1T	08 May 2021	20	135	141	4.3	Y	N
	IC	MF3-2B	07 May 2021	20	170	114	39	Y	N
	IC	MF3-2M	07 May 2021	20	135	105	25	Y	N
	IC	MF3-2T	07 May 2021	20	123	149	19	Y	N
	IC	MF3-3B	07 May 2021	20	149	148	0.7	Y	N
	IC	MF3-3M	07 May 2021	20	156	151	3.3	Y	N
	IC	MF3-3T	07 May 2021	20	32[a]	149	129	Y	Y
	IC	MF3-4B	02 May 2021	20	102	99	3.0	Y	N
	IC	MF3-4M	02 May 2021	20	75	80	6.5	N	N
	IC	MF3-4T	02 May 2021	20	115	80	36	Y	N
	IC	MF3-5B	02 May 2021	20	89	81	9.4	N	N
	IC	MF3-5M	02 May 2021	20	74	105	35	Y	N
	IC	MF3-5T	02 May 2021	20	111	97	14	Y	N
	IC	MF3-6B	02 May 2021	20	98	99	1.0	N	N
	IC	MF3-6B[b]	02 May 2021	20	93	90	3.3	N	N
	IC	MF3-6M	02 May 2021	20	105	94	11	Y	N
	IC	MF3-6T	02 May 2021	20	108	120	11	Y	N
	IC	MF3-7B	23 Apr 2021	20	75	51	38	N	N
	IC	MF3-7M	23 Apr 2021	20	53	60	12	N	N
	IC	MF3-7T	23 Apr 2021	20	55	53	3.7	N	N
	IC	NF1B	09 May 2021	20	74	155	71	Y	Y
	IC	NF1M	09 May 2021	20	145	163	12	Y	N
	IC	NF1T	09 May 2021	20	160	150	6.5	Y	N
	IC	NF2B	25 Apr 2021	20	92	60	42	N	N
	IC	NF2M	25 Apr 2021	20	81	79	2.5	N	N
	IC	NF2T	25 Apr 2021	20	76	72	5.4	N	N
	IC	NF3B	25 Apr 2021	20	69	86	22	N	N
	IC	NF3M	25 Apr 2021	20	52	67	25	N	N
	IC	NF3T	25 Apr 2021	20	79	68	15	N	N
	IC	NF4B	08 May 2021	20	119	144	19	Y	N
	IC	NF4M	08 May 2021	20	137	107	25	Y	N
	IC	NF4M[b]	08 May 2021	20	118	128	8.1	Y	N
	IC	NF4T	08 May 2021	20	179	155	14	Y	N
	IC	NF5B	25 Apr 2021	20	89	85	4.6	N	N
	IC	NF5M	25 Apr 2021	20	59	57	3.4	N	N
	IC	NF5T	25 Apr 2021	20	88	107	20	Y	N

Table B-4 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Soluble Reactive Silica (µg/L)	IC	FF1-2M	20 Apr 2021	10	122	122	0.0	Y	N
	IC	FF2-2B	19 Apr 2021	10	202	206	2.0	Y	N
	IC	FF2-2M	19 Apr 2021	10	148	147	0.7	Y	N
	IC	FF2-2T	19 Apr 2021	10	144	142	1.4	Y	N
	IC	FF2-5B	19 Apr 2021	10	244	260	6.3	Y	N
	IC	FF2-5M	19 Apr 2021	10	120	121	0.8	Y	N
	IC	FF2-5T	19 Apr 2021	10	298	294	1.4	Y	N
	IC	FFD-1M	20 Apr 2021	10	90	90	0.0	Y	N
	IC	LDG-48	09 May 2021	10	76	74	2.7	Y	N
	IC	MF1-1B	24 Apr 2021	10	231	224	3.1	Y	N
	IC	MF1-1M	24 Apr 2021	10	173	174	0.6	Y	N
	IC	MF1-1T	24 Apr 2021	10	137	135	1.5	Y	N
	IC	MF1-3B	24 Apr 2021	10	213	214	0.5	Y	N
	IC	MF1-3M	24 Apr 2021	10	159	156	1.9	Y	N
	IC	MF1-3T	24 Apr 2021	10	129	133	3.1	Y	N
	IC	MF1-5B	20 Apr 2021	50	1030	1070	3.8	Y	N
	IC	MF1-5M	20 Apr 2021	10	187	199	6.2	Y	N
	IC	MF1-5T	20 Apr 2021	10	81	87	7.1	Y	N
	IC	MF2-1B	07 May 2021	50	528	497	6.0	Y	N
	IC	MF2-1M	07 May 2021	10	131	123	6.3	Y	N
	IC	MF2-1T	07 May 2021	10	107	105	1.9	Y	N
	IC	MF2-3B	08 May 2021	10	348	346	0.6	Y	N
	IC	MF2-3M	08 May 2021	10	105	113	7.3	Y	N
	IC	MF2-3T	08 May 2021	10	92	93	1.1	Y	N
	IC	MF3-1B	08 May 2021	10	470	458	2.6	Y	N
	IC	MF3-1M	08 May 2021	10	313	274	13	Y	N
	IC	MF3-1T	08 May 2021	10	179	178	0.6	Y	N
	IC	MF3-2B	07 May 2021	10	229	240	4.7	Y	N
	IC	MF3-2M	07 May 2021	10	221	224	1.3	Y	N
	IC	MF3-2T	07 May 2021	10	134	139	3.7	Y	N
	IC	MF3-3B	07 May 2021	10	145	141	2.8	Y	N
	IC	MF3-3M	07 May 2021	10	142	143	0.7	Y	N
	IC	MF3-3T	07 May 2021	10	141	143	1.4	Y	N
	IC	MF3-4B	02 May 2021	10	141	138	2.2	Y	N
	IC	MF3-4M	02 May 2021	10	114	114	0.0	Y	N
	IC	MF3-4T	02 May 2021	10	74	77	4.0	Y	N
	IC	MF3-5B	02 May 2021	10	245	232	5.5	Y	N
	IC	MF3-5M	02 May 2021	10	93	88	5.5	Y	N
	IC	MF3-5T	02 May 2021	10	67	68	1.5	Y	N
	IC	MF3-6B	02 May 2021	10	72	69	4.3	Y	N
	IC	MF3-6B(b)	02 May 2021	10	<10	<10	0.0	N	N
	IC	MF3-6M	02 May 2021	10	97	95	2.1	Y	N
	IC	MF3-6T	02 May 2021	10	98	97	1.0	Y	N
	IC	MF3-7B	23 Apr 2021	10	124	125	0.8	Y	N
	IC	MF3-7M	23 Apr 2021	10	79	77	2.6	Y	N
	IC	MF3-7T	23 Apr 2021	10	61	61	0.0	Y	N
	IC	NF1B	09 May 2021	50	763	659	15	Y	N
	IC	NF1M	09 May 2021	10	297	316	6.2	Y	N
	IC	NF1T	09 May 2021	10	174	178	2.3	Y	N
	IC	NF2B	25 Apr 2021	50	810	839	3.5	Y	N
	IC	NF2M	25 Apr 2021	50	492	515	4.6	Y	N
	IC	NF2T	25 Apr 2021	10	165	157	5.0	Y	N
	IC	NF3B	25 Apr 2021	50	726	712	1.9	Y	N
	IC	NF3M	25 Apr 2021	10	133	152	13	Y	N
	IC	NF3T	25 Apr 2021	10	145	151	4.1	Y	N
	IC	NF4B	08 May 2021	50	610	643	5.3	Y	N
	IC	NF4M	08 May 2021	10	244	229	6.3	Y	N
	IC	NF4M(b)	08 May 2021	10	196	199	1.5	Y	N
	IC	NF4T	08 May 2021	10	133	133	0.0	Y	N
	IC	NF5B	25 Apr 2021	50	592	598	1.0	Y	N
	IC	NF5M	25 Apr 2021	10	405	457	12	Y	N
	IC	NF5T	25 Apr 2021	10	172	159	7.9	Y	N

Note: "Y" in "QC Fail?" column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.
a) Value removed from dataset as a result of data QA/QC.
b) Duplicate sample collected for QA/QC purposes (Field Duplicate).
c) Samples stored in the black capped ammonia vials
µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; µg/L = micrograms per litre; DL = detection limit; < = less than; > = greater than; × = times; QC = quality control; IC = ice-cover; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes.

Table B-5 Summary of Duplicate Results for Nutrient Variables, Open-water Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Phosphorus (µg - P/L)	OW	FF1-2	11 Sep 2021	2	<2	<2	0.0	N	N
	OW	FF2-2	13 Sep 2021	2	3.0	2.1	35	N	N
	OW	FF2-5	13 Sep 2021	2	<2	2.4	18	N	N
	OW	FFD-1	14 Sep 2021	2	<2	2.3	14	N	N
	OW	LDG-48	15 Aug 2021	2	<2	<2	0.0	N	N
	OW	LDS-4	15 Aug 2021	2	5.3	5.5	3.7	N	N
	OW	MF1-1	03 Sep 2021	2	2.3	<2	14	N	N
	OW	MF1-3	02 Sep 2021	2	<2	2.1	4.9	N	N
	OW	MF1-5	02 Sep 2021	2	2.2	<2	9.5	N	N
	OW	MF2-1	03 Sep 2021	2	<2	3.2	46	N	N
	OW	MF2-3	03 Sep 2021	2	2.3	2.3	0.0	N	N
	OW	MF3-1	06 Sep 2021	2	3.6	<2	57	N	N
	OW	MF3-2	06 Sep 2021	2	<2	2.3	14	N	N
	OW	MF3-3	13 Sep 2021	2	3.2	2.9	9.8	N	N
	OW	MF3-4	13 Sep 2021	2	2.2	2.6	17	N	N
	OW	MF3-5	10 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-6	10 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-7	14 Sep 2021	2	2.1	<2	4.9	N	N
	OW	NF1	01 Sep 2021	2	2.5	3.1	21	N	N
	OW	NF2	27 Aug 2021	2	2.2	<2	9.5	N	N
	OW	NF3	06 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF4	06 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF5	27 Aug 2021	2	5.9	<2	99	N	N
Total Dissolved Phosphorus (µg - P/L)	OW	FF1-2	11 Sep 2021	2	50[a]	<2	185	Y	Y
	OW	FF2-2	13 Sep 2021	2	<2	<2	0.0	N	N
	OW	FF2-5	13 Sep 2021	2	<2	<2	0.0	N	N
	OW	FFD-1	14 Sep 2021	2	<2	<2	0.0	N	N
	OW	LDG-48	15 Aug 2021	2	<2	<2	0.0	N	N
	OW	LDS-4	15 Aug 2021	2	<2	<2	0.0	N	N
	OW	MF1-1	03 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF1-3	02 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF1-5	02 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF2-1	03 Sep 2021	2	2.7	2.3	16	N	N
	OW	MF2-3	03 Sep 2021	2	2.7	<2	30	N	N
	OW	MF3-1	06 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-2	06 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-3	13 Sep 2021	2	<2	2.8	33	N	N
	OW	MF3-4	13 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-5	10 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-6	10 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-7	14 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF1	01 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF2	27 Aug 2021	2	<2	<2	0.0	N	N
	OW	NF3	06 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF4	06 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF5	27 Aug 2021	2	<2	<2	0.0	N	N
Soluble Reactive Phosphorus (µg - P/L)	OW	FF1-2	11 Sep 2021	1	<1	<1	0.0	N	N
	OW	FF2-2	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	FF2-5	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	FFD-1	14 Sep 2021	1	<1	<1	0.0	N	N
	OW	LDG-48	15 Aug 2021	1	<1	<1	0.0	N	N
	OW	LDS-4	15 Aug 2021	1	<1	<1	0.0	N	N
	OW	MF1-1	03 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF1-3	02 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF1-5	02 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF2-1	03 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF2-3	03 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-1	06 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-2	06 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-3	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-4	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-5	10 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-6	10 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-7	14 Sep 2021	1	<1	<1	0.0	N	N
	OW	NF1	01 Sep 2021	1	<1	<1	0.0	N	N
	OW	NF2	27 Aug 2021	1	<1	<1	0.0	N	N
	OW	NF3	06 Sep 2021	1	<1	<1	0.0	N	N
	OW	NF4	06 Sep 2021	1	1.1	<1	9.5	N	N
	OW	NF5	27 Aug 2021	1	<1	<1	0.0	N	N
Total Nitrogen (µg-N/L)	OW	FF1-2	11 Sep 2021	20	150	150	0.0	Y	N
	OW	FF2-2	13 Sep 2021	20	190	220	15	Y	N
	OW	FF2-5	13 Sep 2021	20	230	230	0.0	Y	N
	OW	FFD-1	14 Sep 2021	20	140	140	0.0	Y	N
	OW	LDG-48	15 Aug 2021	20	160	130	21	Y	N
	OW	LDS-4	15 Aug 2021	20	220	190	15	Y	N
	OW	MF1-1	03 Sep 2021	20	200	200	0.0	Y	N
	OW	MF1-3	02 Sep 2021	20	160	170	6.1	Y	N
	OW	MF1-5	02 Sep 2021	20	140	120	15	Y	N
	OW	MF2-1	03 Sep 2021	20	200	220	9.5	Y	N
	OW	MF2-3	03 Sep 2021	20	210	210	0.0	Y	N
	OW	MF3-1	06 Sep 2021	20	210	190	10	Y	N
	OW	MF3-2	06 Sep 2021	20	170	210	21	Y	N
	OW	MF3-3	13 Sep 2021	20	180	180	0.0	Y	N
	OW	MF3-4	13 Sep 2021	20	140	140	0.0	Y	N
	OW	MF3-5	10 Sep 2021	20	140	130	7.4	Y	N
	OW	MF3-6	10 Sep 2021	20	130	130	0.0	Y	N
	OW	MF3-7	14 Sep 2021	20	140	170	19	Y	N
	OW	NF1	01 Sep 2021	20	200	200	0.0	Y	N
	OW	NF2	27 Aug 2021	20	260	430	49	Y	Y
	OW	NF3	06 Sep 2021	20	220	220	0.0	Y	N
	OW	NF4	06 Sep 2021	20	230	210	9.1	Y	N
	OW	NF5	27 Aug 2021	20	210	200	4.9	Y	N

Table B-5 Summary of Duplicate Results for Nutrient Variables, Open-water Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Dissolved Nitrogen (µg-N/L)	OW	FF1-2	11 Sep 2021	20	93	94	1.1	N	N
	OW	FF2-2	13 Sep 2021	200	<200	<200	0.0	N	N
	OW	FF2-5	13 Sep 2021	200	<200	<200	147	N	N
	OW	FFD-1	14 Sep 2021	200	<200	<200	0.0	N	N
	OW	LDG-48	15 Aug 2021	20	110	140	24	Y	N
	OW	LDS-4	15 Aug 2021	20	140	140	0.0	Y	N
	OW	MF1-1	03 Sep 2021	100	<100	<100	133	N	N
	OW	MF1-3	02 Sep 2021	200	20	20	0.0	N	N
	OW	MF1-5	02 Sep 2021	200	20	20	0.0	N	N
	OW	MF2-1	03 Sep 2021	200	20	20	0.0	N	N
	OW	MF2-3	03 Sep 2021	200	20	20	0.0	N	N
	OW	MF3-1	06 Sep 2021	200	20	20	0.0	N	N
	OW	MF3-2	06 Sep 2021	100	<100	140	33	N	N
	OW	MF3-3	13 Sep 2021	20	200	180	11	Y	N
	OW	MF3-4	13 Sep 2021	200	<200	<200	0.0	N	N
	OW	MF3-5	10 Sep 2021	20	88	93	5.5	N	N
	OW	MF3-6	10 Sep 2021	20	120	150	22	Y	N
	OW	MF3-7	14 Sep 2021	100	110	<100	139	N	N
	OW	NF1	01 Sep 2021	200	<200	220	44	N	N
	OW	NF2	27 Aug 2021	20	200	210	4.9	Y	N
	OW	NF3	06 Sep 2021	20	170	200	16	Y	N
	OW	NF4	06 Sep 2021	200	<200	<200	0.0	N	N
	OW	NF5	27 Aug 2021	200	<200	<200	0.0	N	N
Total Ammonia (µg-N/L) – ALS	OW	FF1-2	11 Sep 2021	5	<5	<5	0.0	N	N
	OW	FF2-2	13 Sep 2021	5	15	9.9	38	N	N
	OW	FF2-5	13 Sep 2021	5	11	8.5	26	N	N
	OW	FFD-1	14 Sep 2021	5	6.9	5.7	19	N	N
	OW	LDG-48	15 Aug 2021	5	<5	<5	0.0	N	N
	OW	LDS-4	15 Aug 2021	5	<5	<5	0.0	N	N
	OW	MF1-1	03 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF1-3	02 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF1-5	02 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF2-1	03 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF2-3	03 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF3-1	06 Sep 2021	5	6.8	9.7	35	N	N
	OW	MF3-2	06 Sep 2021	5	<5	19	116	N	N
	OW	MF3-3	13 Sep 2021	5	12	13	3.2	N	N
	OW	MF3-4	13 Sep 2021	5	5.8	6.2	6.7	N	N
	OW	MF3-5	10 Sep 2021	5	<5	6.3	23	N	N
	OW	MF3-6	10 Sep 2021	5	<5	6.8	31	N	N
	OW	MF3-7	14 Sep 2021	5	<5	<5	0.0	N	N
	OW	NF1	01 Sep 2021	5	17	26	43	Y	Y
	OW	NF2	27 Aug 2021	5	9.3	12	29	N	N
	OW	NF3	06 Sep 2021	5	8.9	33	115	Y	Y
	OW	NF4	06 Sep 2021	5	8.0	12	37	N	N
	OW	NF5	27 Aug 2021	5	7.4	8.7	16	N	N
Total Ammonia (µg-N/L) - BV Labs	OW	FF1-2	11 Sep 2021	5	8.7	8.1	7.1	N	N
	OW	FF2-2	13 Sep 2021	5	18	11	48	N	N
	OW	FF2-5	13 Sep 2021	5	14	15	6.9	N	N
	OW	FFD-1	14 Sep 2021	5	9.7	10	3.0	N	N
	OW	LDG-48	15 Aug 2021	5	<5	<5	0.0	N	N
	OW	LDS-4	15 Aug 2021	5	11	7.3	40	N	N
	OW	MF1-1	03 Sep 2021	5	9.7	8	19	N	N
	OW	MF1-3	02 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF1-5	02 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF2-1	03 Sep 2021	5	7.3	7.2	1.4	N	N
	OW	MF2-3	03 Sep 2021	5	8.5	6.9	21	N	N
	OW	MF3-1	06 Sep 2021	5	<5	<5	0.0	N	N
	OW	MF3-2	06 Sep 2021	5	8.3	8.6	3.6	N	N
	OW	MF3-3	13 Sep 2021	5	15	13	14	N	N
	OW	MF3-4	13 Sep 2021	5	7.1	7.6	6.8	N	N
	OW	MF3-5	10 Sep 2021	5	9.2	14	41	N	N
	OW	MF3-6	10 Sep 2021	5	9.0	9.3	3.3	N	N
	OW	MF3-7	14 Sep 2021	5	8.1	8.9	9.4	N	N
	OW	NF1	01 Sep 2021	5	18	15	18	N	N
	OW	NF2	27 Aug 2021	5	9.7	8.1	18	N	N
	OW	NF3	06 Sep 2021	5	25	25	0.0	N	N
	OW	NF4	06 Sep 2021	5	18	18	0.0	N	N
	OW	NF5	27 Aug 2021	5	8.9	13	37	N	N
Nitrate (µg-N/L)	OW	FF1-2	11 Sep 2021	2	<2	<2	0.0	N	N
	OW	FF2-2	13 Sep 2021	2	32	32	0.0	Y	N
	OW	FF2-5	13 Sep 2021	2	41	44	7.1	Y	N
	OW	FFD-1	14 Sep 2021	2	3.0	5.0	57	N	N
	OW	LDG-48	15 Aug 2021	2	<2	<2	0.0	N	N
	OW	LDS-4	15 Aug 2021	2	3.0	<2	12	N	N
	OW	MF1-1	03 Sep 2021	2	11	13	17	Y	N
	OW	MF1-3	02 Sep 2021	2	19	19	0.0	Y	N
	OW	MF1-5	02 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF2-1	03 Sep 2021	2	24	27	12	Y	N
	OW	MF2-3	03 Sep 2021	2	31	30	3.3	Y	N
	OW	MF3-1	06 Sep 2021	2	12	14	15	Y	N
	OW	MF3-2	06 Sep 2021	2	7.0	5.0	28	N	N
	OW	MF3-3	13 Sep 2021	2	7.0	7.0	0.0	N	N
	OW	MF3-4	13 Sep 2021	2	5.0	5.0	3.8	N	N
	OW	MF3-5	10 Sep 2021	2	<2	<2	4.9	N	N
	OW	MF3-6	10 Sep 2021	2	4.0	8.0	52	N	N
	OW	MF3-7	14 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF1	01 Sep 2021	2	42	42	0.0	Y	N
	OW	NF2	27 Aug 2021	2	59	66	11	Y	N
	OW	NF3	06 Sep 2021	2	25	25	0.0	Y	N
	OW	NF4	06 Sep 2021	2	25	24	4.1	Y	N
	OW	NF5	27 Aug 2021	2	26	25	3.9	Y	N

Table B-5 Summary of Duplicate Results for Nutrient Variables, Open-water Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Nitrite (µg-N/L)	OW	FF1-2	11 Sep 2021	1	<1	<1	0.0	N	N
	OW	FF2-2	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	FF2-5	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	FFD-1	14 Sep 2021	1	<1	<1	0.0	N	N
	OW	LDG-48	15 Aug 2021	1	<1	<1	0.0	N	N
	OW	LDS-4	15 Aug 2021	1	<1	2.0	43	N	N
	OW	MF1-1	03 Sep 2021	1	<1	<1	8.0	N	N
	OW	MF1-3	02 Sep 2021	1	<1	<1	8.0	N	N
	OW	MF1-5	02 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF2-1	03 Sep 2021	1	2.0	2.0	6.1	N	N
	OW	MF2-3	03 Sep 2021	1	<1	<1	33	N	N
	OW	MF3-1	06 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-2	06 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-3	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-4	13 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-5	10 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-6	10 Sep 2021	1	<1	<1	0.0	N	N
	OW	MF3-7	14 Sep 2021	1	<1	<1	0.0	N	N
	OW	NF1	01 Sep 2021	1	2.0	2.0	17	N	N
	OW	NF2	27 Aug 2021	1	4.0	4.0	7.8	N	N
	OW	NF3	06 Sep 2021	1	2.0	<1	52	N	N
	OW	NF4	06 Sep 2021	1	2.0	2.0	29	N	N
	OW	NF5	27 Aug 2021	1	3.0	2.0	30	N	N
Nitrate + Nitrite (µg-N/L)	OW	FF1-2	11 Sep 2021	2	<2	<2	0.0	N	N
	OW	FF2-2	13 Sep 2021	2	32	32	0.0	Y	N
	OW	FF2-5	13 Sep 2021	2	41	44	7.1	Y	N
	OW	FFD-1	14 Sep 2021	2	3.0	5.0	57	N	N
	OW	LDG-48	15 Aug 2021	2	<2	<2	0.0	N	N
	OW	LDS-4	15 Aug 2021	2	4.0	4.0	10	N	N
	OW	MF1-1	03 Sep 2021	2	13	14	7.4	Y	N
	OW	MF1-1	03 Sep 2021	2	12	13	8.0	Y	N
	OW	MF1-3	02 Sep 2021	2	20	21	4.9	Y	N
	OW	MF1-5	02 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF2-1	03 Sep 2021	2	26	28	7.4	Y	N
	OW	MF2-3	03 Sep 2021	2	31	32	3.2	Y	N
	OW	MF3-1	06 Sep 2021	2	12	14	15	Y	N
	OW	MF3-2	06 Sep 2021	2	7.0	5.0	28	N	N
	OW	MF3-3	13 Sep 2021	2	7.0	7.0	0.0	N	N
	OW	MF3-4	13 Sep 2021	2	5.0	5.0	3.8	N	N
	OW	MF3-5	10 Sep 2021	2	<2	<2	0.0	N	N
	OW	MF3-6	10 Sep 2021	2	4.0	8.0	52	N	N
	OW	MF3-7	14 Sep 2021	2	<2	<2	0.0	N	N
	OW	NF1	01 Sep 2021	2	44	44	0.0	Y	N
	OW	NF2	27 Aug 2021	2	63	70	11	Y	N
	OW	NF3	06 Sep 2021	2	27	25	7.7	Y	N
	OW	NF4	06 Sep 2021	2	26	26	0.0	Y	N
	OW	NF5	27 Aug 2021	2	29	27	7.1	Y	N
Total Kjeldahl Nitrogen (µg-N/L)	OW	FF1-2	11 Sep 2021	20	150	151	0.7	Y	N
	OW	FF2-2	13 Sep 2021	20	156	190	20	Y	N
	OW	FF2-5	13 Sep 2021	20	187	182	2.7	Y	N
	OW	FFD-1	14 Sep 2021	20	140	131	6.6	Y	N
	OW	LDG-48	15 Aug 2021	20	161	126	24	Y	N
	OW	LDS-4	15 Aug 2021	20	214	187	14	Y	N
	OW	MF1-1	03 Sep 2021	20	190	184	3.2	Y	N
	OW	MF1-3	02 Sep 2021	20	141	147	4.2	Y	N
	OW	MF1-5	02 Sep 2021	20	140	116	19	Y	N
	OW	MF2-1	03 Sep 2021	20	172	195	13	Y	N
	OW	MF2-3	03 Sep 2021	20	177	180	1.7	Y	N
	OW	MF3-1	06 Sep 2021	20	195	176	10	Y	N
	OW	MF3-2	06 Sep 2021	20	165	204	21	Y	N
	OW	MF3-3	13 Sep 2021	20	172	177	2.9	Y	N
	OW	MF3-4	13 Sep 2021	20	139	137	1.4	Y	N
	OW	MF3-5	10 Sep 2021	20	144	130	10	Y	N
	OW	MF3-6	10 Sep 2021	20	130	118	9.7	Y	N
	OW	MF3-7	14 Sep 2021	20	135	168	22	Y	N
	OW	NF1	01 Sep 2021	20	153	157	2.6	Y	N
	OW	NF2	27 Aug 2021	20	196	356	58	Y	Y
	OW	NF3	06 Sep 2021	20	191	193	1.0	Y	N
	OW	NF4	06 Sep 2021	20	201	188	6.7	Y	N
	OW	NF5	27 Aug 2021	20	185	174	6.1	Y	N
Dissolved Kjeldahl Nitrogen (µg-N/L)	OW	FF1-2	11 Sep 2021	20	93	94	1.1	N	N
	OW	FF2-2	13 Sep 2021	200	<200	<200	0.0	N	N
	OW	FF2-5	13 Sep 2021	200	<200	<200	0.0	N	N
	OW	FFD-1	14 Sep 2021	200	<200	<200	0.0	N	N
	OW	LDG-48	15 Aug 2021	20	110	135	20	Y	N
	OW	LDS-4	15 Aug 2021	20	137	140	2.2	Y	N
	OW	MF1-1	03 Sep 2021	100	<100	<100	0.0	N	N
	OW	MF1-3	02 Sep 2021	200	<200	<200	0.0	N	N
	OW	MF1-5	02 Sep 2021	200	<200	<200	0.0	N	N
	OW	MF2-1	03 Sep 2021	200	<200	<200	0.0	N	N
	OW	MF2-3	03 Sep 2021	200	<200	<200	0.0	N	N
	OW	MF3-1	06 Sep 2021	200	<200	<200	0.0	N	N
	OW	MF3-2	06 Sep 2021	100	<100	130	147	N	N
	OW	MF3-3	13 Sep 2021	20	193	176	9.2	Y	N
	OW	MF3-4	13 Sep 2021	200	<200	<200	0.0	N	N
	OW	MF3-5	10 Sep 2021	20	88	93	5.5	N	N
	OW	MF3-6	10 Sep 2021	20	120	143	18	Y	N
	OW	MF3-7	14 Sep 2021	100	110	<100	139	N	N
	OW	NF1	01 Sep 2021	200	<200	<200	133	N	N
	OW	NF2	27 Aug 2021	20	134	141	5.1	Y	N
	OW	NF3	06 Sep 2021	20	147	171	15	Y	N
	OW	NF4	06 Sep 2021	200	<200	<200	0.0	N	N
	OW	NF5	27 Aug 2021	200	<200	<200	0.0	N	N

Table B-5 Summary of Duplicate Results for Nutrient Variables, Open-water Season, 2021

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Soluble Reactive Silica (µg/L)	OW	FF1-2	11 Sep 2021	10	44	41	7.1	N	N
	OW	FF2-2	13 Sep 2021	10	53	51	3.8	Y	N
	OW	FF2-5	13 Sep 2021	10	50	49	2.0	N	N
	OW	FFD-1	14 Sep 2021	10	32	33	3.1	N	N
	OW	LDG-48	15 Aug 2021	10	33	35	5.9	N	N
	OW	LDS-4	15 Aug 2021	10	225	236	4.8	Y	N
	OW	MF1-1	03 Sep 2021	10	31	28	10	N	N
	OW	MF1-3	02 Sep 2021	10	18	17	5.7	N	N
	OW	MF1-5	02 Sep 2021	10	39	38	2.6	N	N
	OW	MF2-1	03 Sep 2021	10	54	54	0.0	Y	N
	OW	MF2-3	03 Sep 2021	10	44	45	2.2	N	N
	OW	MF3-1	06 Sep 2021	10	46	47	2.2	N	N
	OW	MF3-2	06 Sep 2021	10	35	34	2.9	N	N
	OW	MF3-3	13 Sep 2021	10	38	39	2.6	N	N
	OW	MF3-4	13 Sep 2021	10	36	33	8.7	N	N
	OW	MF3-5	10 Sep 2021	10	31	30	3.3	N	N
	OW	MF3-6	10 Sep 2021	10	30	32	6.5	N	N
	OW	MF3-7	14 Sep 2021	10	31	29	6.7	N	N
	OW	NF1	01 Sep 2021	10	63	66	4.7	Y	N
	OW	NF2	27 Aug 2021	10	121	127	4.8	Y	N
	OW	NF3	06 Sep 2021	10	54	54	0.0	Y	N
	OW	NF4	06 Sep 2021	10	52	60	14	Y	N
	OW	NF5	27 Aug 2021	10	63	68	7.6	Y	N

Note: “Y” in “QC Fail?” column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.
a) Value removed from dataset as a result of data QA/QC.
b) Duplicate sample collected for QA/QC purposes (Field Duplicate).
µg/L = micrograms per litre; DL = detection limit; < = less than; > = greater than; × = times; % = percent; QC = quality control; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows); N = no; Y = yes.

Total Versus Dissolved Forms

The differences between TP and TDP concentrations were within DQOs except for one sample collected during the open-water season (Table B-6). The reported TDP value for FF1-2 collected during the open-water season was 49.8 µg-P/L, which was higher than its corresponding TP value (2 µg-P/L) with an RPD of 185% (Table B-6). The value was not considered representative of the station because the duplicate was both lower (2 µg P/L) and consistent with other TP and TDP concentrations at nearby stations. This TDP value was thus removed from the dataset.

There was one sample that had a high RPD but did not fail DQO. The reported TDP value of 6 µg/L for MF1-1T-4 collected during the ice-cover season was higher than its corresponding TP value with an RPD of 89% (Table B-6). It was initially identified as a potentially anomalous value (see Section 2.4.1). However, the TDP value was within five times the DL (i.e., the range of analytical uncertainty) and the average concentration of the two duplicates was 3.5 µg/L, which was within the range of TDP values that could reasonably occur at this station. Therefore, it was retained in the dataset for generating plots and statistical analysis

Given the lack of DQO failures for TDP in both seasons (with the exception of the one open-water sample), the data were considered acceptable.

Table B-6 Comparison of Total and Dissolved Phosphorus Concentrations, 2021

Season	Sample Name	Sampling Date	DL (µg-P/L)	Total Phosphorus (µg-P/L)	Total Dissolved Phosphorus (µg-P/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
OW	FF1-2-4	11 Sep 2021	2	<2	50[(a)]	185	Y	Y
IC	FF1-2M-4	20 Apr 2021	2	<2	3.4	52	N	N
IC	FF2-2B-4	19 Apr 2021	2	<2	3.0	40	N	N
IC	FF2-2M-5	19 Apr 2021	2	<2	3.7	60	N	N
IC	FF2-5M-5	19 Apr 2021	2	<2	2.2	9.5	N	N
IC	MF1-1T-4	24 Apr 2021	2	2.3	6.0	89	N	N
OW	MF1-1T-5	03 Sep 2021	2	<2	3.0	49	N	N
OW	MF2-1-4	03 Sep 2021	2	<2	3.0	30	N	N
OW	MF2-3-4	03 Sep 2021	2	<2	3.0	16	N	N
IC	MF2-3T-5	08 May 2021	2	2.4	3.3	32	N	N
IC	NF4M-4-5	08 May 2021	2	<2	3.0	40	N	N

Notes: Only cases where the total dissolved phosphorus was greater than total phosphorus are presented in this table.

Results were evaluated using the criterion of relative percent difference (RPD) greater than 20%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

a) Value removed from dataset as a result of data QA/QC; see also previous section on nutrient duplicates.

µg-P/L = micrograms phosphorus per litre; DL = detection limit; QC = quality control; IC = ice-cover; OW = open-water; NF = near-field; MF = mid-field; LDG-48 = Lac de Gras outlet; N = no; Y = yes.

Due to issues with field contamination that were observed in 2018, samples for TDN and DKN analysis have been filtered at the analytical laboratory in subsequent years. This change has improved the quality of the dataset, such that fewer DQO failures were observed in 2021 compared to years when field-filtering was done (Tables B-7 and B-8). The differences between TN and TDN, and between TKN and DKN, exceeded the DQO of 20% in two and six samples (out of 173 samples), or 1.2% and 3.5% of samples, respectively. The affected samples were collected during the ice-cover season on a variety of sampling days, and thus DQO failures appeared to be sporadic and random. Overall, the low frequency of DQO failures indicate that the data quality was acceptable.

In concert with the QC results of field duplicates, some results were removed from the dataset based on the following rationale:

- The reported TN and TKN values of 33 µg-N/L and 20 µg-N/L for MF2-1B-4 collected during the ice-cover season were lower than their corresponding TDN and DKN values of 310 µg-N/L and 151 µg-N/L, and thus failed the DQO with RPDs of 162% and 153% (Tables B-7 and B-8). These TN and TKN values were also lower than their duplicates and inconsistent with concentrations measured at other depths and were, therefore, not considered representative of the station and were removed from the dataset.
- Although not a DQO failure for the total versus dissolved assessment, because total concentrations were higher than dissolved, the TDN and DKN values of 32 µg/L for MF3-3T-4 were removed from the dataset. These values were lower than their duplicates and inconsistent with concentrations measured at other depths. Thus they were not considered representative of the station and were removed from the dataset.

Given the lack of DQO failures for TN, TDN, TKN, DKN in both seasons, with only these exceptions, the data were considered acceptable.

Table B-7 Comparison of Total and Dissolved Nitrogen Concentration, 2021

Season	Sample Name	Sampling Date	Total Nitrogen DL (µg-N/L)	Dissolved Nitrogen DL (µg-N/L)	Total Nitrogen (µg-N/L)	Total Dissolved Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	FF2-2B-5	19 Apr 2021	20	20	250	270	7.7	Y	N
IC	FF2-2M-4	19 Apr 2021	20	20	250	270	7.7	Y	N
IC	FF2-2M-5	19 Apr 2021	20	20	250	260	3.9	Y	N
IC	FF2-2T-4	19 Apr 2021	20	20	280	290	3.5	Y	N
IC	FFD-1M-4	20 Apr 2021	20	20	140	150	6.9	Y	N
IC	LDG48-5	09 May 2021	20	20	130	140	7.4	Y	N
OW	LDG48-5	15 Aug 2021	20	20	130	140	7.4	Y	N
IC	MF1-1B-4	24 Apr 2021	20	20	160	170	6.1	Y	N
IC	MF2-1B-4	07 May 2021	20	20	33[(a)]	310	162	Y	Y
IC	MF2-1T-4	07 May 2021	20	20	200	220	9.5	Y	N
IC	MF2-1T-5	07 May 2021	20	20	210	220	4.7	Y	N
IC	MF2-3B-5	08 May 2021	20	20	310	390	23	Y	Y
IC	MF2-3T-5	08 May 2021	20	20	180	200	11	Y	N
IC	MF3-1B-4	08 May 2021	20	20	220	240	8.7	Y	N

Table B-7 Comparison of Total and Dissolved Nitrogen Concentration, 2021

Season	Sample Name	Sampling Date	Total Nitrogen DL (µg-N/L)	Dissolved Nitrogen DL (µg-N/L)	Total Nitrogen (µg-N/L)	Total Dissolved Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	MF3-2B-4	07 May 2021	20	20	240	260	8.0	Y	N
OW	MF3-3-4	13 Sep 2021	20	20	180	200	11	Y	N
IC	MF3-3B-5	07 May 2021	20	20	200	210	4.9	Y	N
IC	MF3-3M-4	07 May 2021	20	20	190	230	19	Y	N
IC	MF3-3M-5	07 May 2021	20	20	200	230	14	Y	N
IC	MF3-3T-5	07 May 2021	20	20	140	160	13	Y	N
OW	MF3-6-5	10 Sep 2021	20	20	130	150	14	Y	N
OW	NF1-5	01 Sep 2021	20	200	200	220	9.5	Y	N
IC	NF1B-5	09 May 2021	20	20	300	330	9.5	Y	N
IC	NF1M-5	09 May 2021	20	20	250	280	11	Y	N
IC	NF4B-5	08 May 2021	20	20	280	290	3.5	Y	N
IC	NF4T-4	08 May 2021	20	20	220	240	8.7	Y	N

Notes: Only cases where the total dissolved nitrogen was greater than the total nitrogen are presented in this table. “Y” in “QC Fail?” column indicates a QC flag for relative percent difference (RPD) values that were greater than 20%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

a) Value removed from dataset as a result of data QA/QC; see also section on nutrient duplicates.

µg-N/L = micrograms nitrogen per litre; DL = detection limit; QC = quality control; IC = ice-cover; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Table B-8 Comparison of Total and Dissolved Kjeldahl Nitrogen Concentrations, 2021

Season	Sample Name	Sampling Date	DL (µg-N/L)	Total Kjeldahl Nitrogen (µg-N/L)	Dissolved Kjeldahl Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	FF2-2B-5	19 Apr 2021	20	148	167	12	Y	N
IC	FF2-2M-4	19 Apr 2021	20	161	183	13	Y	N
IC	FF2-2M-5	19 Apr 2021	20	168	176	4.7	Y	N
IC	FF2-2T-4	19 Apr 2021	20	230	232	0.9	Y	N
IC	FFD-1M-4	20 Apr 2021	20	128	141	9.7	Y	N
IC	FFD-1M-5	20 Apr 2021	20	167	120	33	Y	Y
IC	LDG48-5	09 May 2021	20	127	134	5.4	Y	N
OW	LDG48-5	15 Aug 2021	20	126	135	6.9	Y	N
IC	MF1-1B-4	24 Apr 2021	20	69	78	12	N	N
IC	MF1-5T-4	20 Apr 2021	20	173	175	1.1	Y	N
IC	MF2-1B-4	07 May 2021	20	<20[(a)]	151	153	Y	Y
IC	MF2-1T-4	07 May 2021	20	128	149	15	Y	N
IC	MF2-1T-5	07 May 2021	20	149	156	4.6	Y	N
IC	MF2-3B-5	08 May 2021	20	167	244	38	Y	Y
IC	MF2-3T-5	08 May 2021	20	182	198	8.4	Y	N

Table B-8 Comparison of Total and Dissolved Kjeldahl Nitrogen Concentrations, 2021

Season	Sample Name	Sampling Date	DL (µg-N/L)	Total Kjeldahl Nitrogen (µg-N/L)	Dissolved Kjeldahl Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	MF3-1B-4	08 May 2021	20	103	126	20	Y	Y
IC	MF3-2B-4	07 May 2021	20	153	170	11	Y	N
OW	MF3-3-4	13 Sep 2021	20	172	193	12	Y	N
IC	MF3-3B-5	07 May 2021	20	141	148	4.8	Y	N
IC	MF3-3M-4	07 May 2021	20	118	156	28	Y	Y
IC	MF3-3M-5	07 May 2021	20	127	151	17	Y	N
IC	MF3-3T-5	07 May 2021	20	132	149	12	Y	N
OW	MF3-6-5	10 Sep 2021	20	118	143	19	Y	N
IC	NF1B-5	09 May 2021	20	120	155	26	Y	Y
IC	NF1M-4	09 May 2021	20	141	145	2.8	Y	N
IC	NF1M-5	09 May 2021	20	140	163	15	Y	N
IC	NF1T-4	09 May 2021	20	158	160	1.3	Y	N
IC	NF4B-5	08 May 2021	20	128	144	12	Y	N
IC	NF4T-4	08 May 2021	20	159	179	12	Y	N

Notes: Only cases where the total dissolved Kjeldahl nitrogen was greater than the total Kjeldahl nitrogen are presented in this table.
“Y” in “QC Fail?” column indicates a QC flag for relative percent difference (RPD) values that were greater than 20%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

a) Value removed from dataset as a result of data QA/QC; see also section on nutrient duplicates.

µg-N/L = micrograms nitrogen per litre; DL = detection limit; QC = quality control; IC = ice-cover; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Chlorophyll a Duplicate Samples

None of the 23 pairs of chlorophyll *a* duplicate samples exceeded the DQO of less than 40% RPD while having concentrations greater than five times the DL in at least one of the samples (Table B-9). Therefore, the analytical precision for the chlorophyll *a* samples was rated as high.

Table B-9 Summary of Duplicate Sample Results for Chlorophyll *a*, 2021

Season	Station	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 x DL?	QC Fail?
OW	FF1-2	0.04	1.18	1.20	1.7	Y	N
OW	FF2-2	0.04	1.80	1.85	2.7	Y	N
OW	FF2-5	0.04	1.96	2.16	9.7	Y	N
OW	FFD-1	0.04	0.94	1.07	12.9	Y	N
OW	LDG-48	0.04	0.86	0.86	0.0	Y	N
OW	LDS-4	0.04	0.88	0.93	5.5	Y	N
OW	MF1-1	0.04	3.51	3.48	0.9	Y	N
OW	MF1-3	0.04	3.64	3.49	4.2	Y	N
OW	MF1-5	0.04	1.75	1.57	10.8	Y	N
OW	MF2-1	0.04	2.42	2.35	2.9	Y	N
OW	MF2-3	0.04	2.50	2.42	3.3	Y	N
OW	MF3-1	0.04	1.40	1.37	2.2	Y	N
OW	MF3-2	0.04	1.44	1.35	6.5	Y	N
OW	MF3-3	0.04	1.22	1.12	8.5	Y	N
OW	MF3-4	0.04	1.14	1.10	3.6	Y	N
OW	MF3-5	0.04	1.00	1.04	3.9	Y	N
OW	MF3-6	0.04	0.84	0.89	5.8	Y	N
OW	MF3-7	0.04	0.95	1.03	8.1	Y	N
OW	NF1	0.04	3.32	3.61	8.4	Y	N
OW	NF2	0.04	1.81	1.88	3.8	Y	N
OW	NF3	0.04	1.88	1.77	6.0	Y	N
OW	NF4	0.04	1.89	1.69	11.2	Y	N
OW	NF5	0.04	1.88	1.94	3.1	Y	N

Note: "Y" in "QC Fail?" column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

µg/L = micrograms per litre; DL = detection limit; > = greater than; × = times; QC = quality control; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows); N = no; Y = yes.

Zooplankton Biomass (as AFDM) Duplicate Samples

One of the zooplankton biomass duplicate samples exceeded the DQO of less than 40% RPD (Table B-10). The greater than five times the DL criterion does not apply to zooplankton biomass because the DL is undefined. Since less than 10% of the duplicate pairs were notably different from one another, the analytical precision for the zooplankton biomass samples was rated as high.

Table B-10 Summary of Duplicate Sample Results for Zooplankton Biomass as Ash-Free Dry Mass, 2021

Season	Station	Result 1 (mg/m^3)	Result 2 (mg/m^3)	Relative Percent Difference (%)	QC Fail?
OW	FF1-2[(a)]	62.5	58.9	6	N
OW	FF2-2	68.3	58.9	15	N
OW	FF2-5	83.3	77.1	8	N
OW	FFD-1	50.8	46.4	9	N
OW	MF1-1	134	149	10	N
OW	MF1-3	84.3	83.3	1	N
OW	MF1-5	55.9	63.0	12	N
OW	MF2-1	97.4	102	5	N
OW	MF2-3	76.6	117	41	Y
OW	MF3-1	85.2	78.4	8	N
OW	MF3-2	59.0	58.8	0	N
OW	MF3-3[(a)]	56.1	54.2	3	N
OW	MF3-4[(a)]	62.7	55.4	12	N
OW	MF3-5	62.9	56.79	10	N
OW	MF3-6	44.0	47.4	8	N
OW	MF3-7	41.7	43.2	4	N
OW	NF1	111	90.9	20	N
OW	NF2	55.7	51.5	8	N
OW	NF3	112	104	8	N
OW	NF4	94.0	86.4	8	N
OW	NF5	35.2	47.6	30	N

Note: "Y" in "QC Fail?" column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%.

(a) Station did not have recorded haul depth on the field data sheets. Therefore, DDMI provided haul depths for these three stations (i.e., FF1-2 = 18 m, MF3-3 = 16 m, and MF3-4 = 18 m).

mg/m^3 = milligrams per cubic metre; QC = quality control; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes.

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ATTACHMENT C

PERCENT CHANGE FROM BASELINE AND PREVIOUS YEAR

Percent Change from Baseline and Previous Year

Tables C-1 to C-10 provide percent change values for each eutrophication indicator from the baseline median and the previous year (i.e., 2020) median value, by area (i.e., NF, MF1, MF2, MF3, and LDG-48) and season (i.e., ice-cover and open-water) as required by Directive 2B from the WLWB review of the *2017 AEMP Annual Report*.

The results indicate that median values of eutrophication indicators have generally increased in the NF area relative to baseline (Table C-1 and Table C-6), consistent with EA predictions and interpretation of AEMP data during annual reporting. Further discussion of these results is provided below.

In the NF area, the eutrophication indicator that had the highest percent difference since baseline during the ice-cover season was nitrate (Table C-1). The highest increase relative to baseline was measured in the bottom depth samples (Table C-1), reflecting the discharge of effluent to this area and the likely position of the effluent plume in the water column. Large percent changes from baseline in nitrate and nitrate + nitrite were observed across all three MF areas, with decreasing median concentrations with distance from diffuser (Table C-2 [MF1], Table C-3 [MF2-FF2], and Table C-4 [MF3]), which is consistent with the results discussed in Section 3.

During the open-water season, nitrate + nitrite had the highest percent increase in the NF area (Table C-6). Increased median nitrate + nitrite concentrations relative to baseline were also observed in the MF areas during the open-water season (Tables C-7 to C-9).

The percent change from baseline was greater than observed in the NF area for MF2 nitrate and nitrate + nitrite concentrations during the ice-cover season, MF1 and MF2 chlorophyll *a* during the open-water season, and MF1 and LDG-48 phytoplankton biomass during the open-water season.

Percent changes from the previous year (i.e., 2020) generally indicated similar or lower concentrations of nitrogen species during the ice-cover season in 2021. The exceptions were nitrate and nitrate + nitrite concentrations in the MF3 area and at LDG-48 (Tables C-4 and C-5), which also had a higher magnitude of change from the previous year than the NF area. In the NF area, ice-cover TP concentrations were higher in 2021 than in 2020 (Table C-1). The percent change from the previous year was greater than observed in the NF area for SRP in all MF areas (Tables C-2 to C-4).

During the open-water season in the NF area, the percent changes in nutrient concentrations from the previous year were generally negative in magnitude (Table C-6). In contrast, nitrate and nitrate + nitrate concentrations were greater in 2021 compared to 2020 in the MF areas, and these increases were greater than those observed in the NF area (Tables C-7 to C-9). Similarly, TDP concentrations in MF2 area and TP concentrations in MF3 area were greater in 2021, and in comparison to the NF area.

Less change from the previous year was observed in the biomass indicators in the NF area. There was a 25% increase in chlorophyll *a* from the previous year, a 64% decrease in phytoplankton biomass, and no change in zooplankton biomass (Table C-6). However, there was a higher increase in chlorophyll *a* in the MF1 and MF2 areas, and at LDG-48 compared to that in the NF area (Tables C-7 and C-8). Phytoplankton and zooplankton biomass was similar to the previous year and reduced in all areas compared to 2020, except at LDG-48, where phytoplankton biomass was greater (Table C-10).

Table C-1 Percent Change from Baseline and Previous Year Data in the Near-field Area for Eutrophication Indicators during the Ice-cover Season in 2021

Variable	Unit	Baseline Median[b]	Previous Year Median			Current Year Median			% Change from Baseline			% Change from Previous Year		
			Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
Nutrients														
Total phosphorus	µg-P/L	3.6	1.7	1.5	1.0	3.7	1.0	2.9	3%	-72%	-19%	124%	-33%	190%
Total dissolved phosphorus	µg-P/L	2.0	1.0	1.0	1.0	1.0	1.0	1.0	-50%	-50%	-50%	0%	0%	0%
Soluble reactive phosphorus[a]	µg-P/L	0.5	0.9	0.9	1.0	0.75	0.80	1.4	50%	60%	180%	-17%	-11%	40%
Total nitrogen	µg-N/L	152	245	340	395	200	210	270	32%	39%	78%	-18%	-38%	-32%
Total dissolved nitrogen	µg-N/L	143	230	285	325	150	185	225	5%	29%	57%	-35%	-35%	-31%
Total Kjeldahl nitrogen	µg-N/L	-	205	210	215	146	105	129	-	-	-	-29%	-50%	-40%
Dissolved Kjeldahl nitrogen	µg-N/L	-	190	170	165	98	80	87	-	-	-	-49%	-53%	-47%
Total ammonia	µg-N/L	14	24	26	35	15	8.2	16	10%	-42%	11%	-34%	-68%	-55%
Nitrate	µg-N/L	3.4	35	120	160	58	105	145	1591%	2988%	4165%	64%	-13%	-9%
Nitrite[a]	µg-N/L	1.0	0.9	1.8	1.8	1.6	0.95	1.4	55%	-5%	40%	72%	-47%	-22%
Nitrate + nitrite	µg-N/L	6.5	42	125	160	59.5	105	145	815%	1515%	2131%	43%	-16%	-9%
Soluble reactive silica	µg/L	-	120	402	937	161	307	711	-	-	-	34%	-24%	-24%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*.

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table C-2 Percent Change from Baseline and Previous Year Data in the Mid-field (MF1) Area for Eutrophication Indicators during the Ice-cover Season in 2021

Variable	Unit	Baseline Median[b]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	2.3	1.0	-72%	-56%
Total dissolved phosphorus	µg-P/L	2.0	1.0	1.0	-50%	0%
Soluble reactive phosphorus[a]	µg-P/L	0.5	0.5	0.80	60%	60%
Total nitrogen	µg-N/L	152	250	195	29%	-22%
Total dissolved nitrogen	µg-N/L	143	230	160	12%	-30%
Total Kjeldahl nitrogen	µg-N/L	-	185	115	-	-38%
Dissolved Kjeldahl nitrogen	µg-N/L	-	175	87	-	-51%
Total ammonia	µg-N/L	14	24	15	4%	-39%
Nitrate	µg-N/L	3.4	62	80	2253%	29%
Nitrite[a]	µg-N/L	1.0	1.4	0.50	-50%	-64%
Nitrate + nitrite	µg-N/L	6.5	64	81	1138%	26%
Soluble reactive silica	µg/L	-	163	174	-	7%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*.

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table C-3 Percent Change from Baseline and Previous Year Data in the Mid-field 2 (MF2) Area for Eutrophication Indicators during the Ice-cover Season in 2021

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	1.4	1.6	-56%	19%
Total dissolved phosphorus	µg-P/L	2.0	1.0	1.6	-23%	55%
Soluble reactive phosphorus[(a)]	µg-P/L	0.5	0.5	0.93	85%	85%
Total nitrogen	µg-N/L	152	288	253	67%	-12%
Total dissolved nitrogen	µg-N/L	143	250	220	54%	-12%
Total Kjeldahl nitrogen	µg-N/L	-	220	172	-	-22%
Dissolved Kjeldahl nitrogen	µg-N/L	-	200	167	-	-17%
Total ammonia	µg-N/L	14	24	12	-16%	-52%
Nitrate	µg-N/L	3.4	59	71	1982%	20%
Nitrite[(a)]	µg-N/L	1.0	0.7	0.83	-18%	22%
Nitrate + nitrite	µg-N/L	6.5	60	71	992%	18%
Soluble reactive silica	µg/L	-	103	145	-	41%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table C-4 Percent Change from Baseline and Previous Year Data in the Mid-field 3 (MF3) Area for Eutrophication Indicators during the Ice-cover Season in 2021

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	2.2	1.9	-49%	-16%
Total dissolved phosphorus	µg-P/L	2.0	1.0	0.50	-75%	-50%
Soluble reactive phosphorus[(a)]	µg-P/L	0.5	0.5	1.0	100%	100%
Total nitrogen	µg-N/L	152	185	195	29%	5%
Total dissolved nitrogen	µg-N/L	143	180	140	-2%	-22%
Total Kjeldahl nitrogen	µg-N/L	-	175	136	-	-22%
Dissolved Kjeldahl nitrogen	µg-N/L	-	155	104	-	-33%
Total ammonia	µg-N/L	14	19	20	40%	1%
Nitrate	µg-N/L	3.4	15	53	1444%	262%
Nitrite[(a)]	µg-N/L	1.0	2.5	0.50	-50%	-80%
Nitrate + nitrite	µg-N/L	6.5	15.5	53	708%	239%
Soluble reactive silica	µg/L	-	99	137	-	38%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table C-5 Percent Change from Baseline and Previous Year Data at LDG-48 for Eutrophication Indicators during the Ice-cover Season in 2021

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	2.2	2.2	-39%	2%
Total dissolved phosphorus	µg-P/L	2.0	2.1	1.0	-50%	-52%
Soluble reactive phosphorus[(a)]	µg-P/L	0.5	0.5	0.50	0%	0%
Total nitrogen	µg-N/L	152	215	190	25%	-12%
Total dissolved nitrogen	µg-N/L	143	200	130	-9%	-35%
Total Kjeldahl nitrogen	µg-N/L	-	215	184	-	-15%
Dissolved Kjeldahl nitrogen	µg-N/L	-	200	123	-	-39%
Total ammonia	µg-N/L	14	16	18	30%	12%
Nitrate	µg-N/L	3.4	1.0	5.1	49%	405%
Nitrite[(a)]	µg-N/L	1.0	0.5	0.50	-50%	0%
Nitrate + nitrite	µg-N/L	6.5	1.0	5.1	-22%	405%
Soluble reactive silica	µg/L	-	64	75	-	17%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*

LDG = Lac de Gras; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table C-6 Percent Change from Baseline and Previous Year Data in the Near-field Area for Eutrophication Indicators during the Open-water Season in 2021

Variable	Unit	Baseline Median[b]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	1.48	1.8	293%	25%
Phytoplankton biomass as biovolume	mg/m^3	163	464	165	1%	-64%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	87	90	259%	4%
Nutrients						
Total phosphorus	µg-P/L	3.3	2.0	1.6	-52%	-18%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	0.5	0.50	-50%	0%
Total nitrogen	µg-N/L	138	225	220	59%	-2%
Total dissolved nitrogen	µg-N/L	119	220	180	51%	-18%
Total Kjeldahl nitrogen	µg-N/L	-	175	192	-	10%
Dissolved Kjeldahl nitrogen	µg-N/L	-	160	55	-	-66%
Total ammonia[a]	µg-N/L	1.0	11	17	1550%	50%
Nitrate[a]	µg-N/L	1.0	50	26	2450%	-48%
Nitrite[a]	µg-N/L	1.0	2.6	1.8	75%	-31%
Nitrate + nitrite[a]	µg-N/L	0.5	52	28	5500%	-46%
Soluble reactive silica	µg/L	-	163	65	-	-60%

Notes:

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*

µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table C-7 Percent Change from Baseline and Previous Year Data in the Mid-field 1 (MF1) Area for Eutrophication Indicators during the Open-water Season in 2021

Variable	Unit	Baseline Median[b]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	1.65	3.50	644%	112%
Phytoplankton biomass as biovolume	mg/m^3	163	353	336	106%	-5%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	99	84	234%	-15%
Nutrients						
Total phosphorus	µg-P/L	3.3	2.1	1.6	-52%	-24%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	0.5	0.50	-50%	0%
Total nitrogen	µg-N/L	138	220	165	19%	-25%
Total dissolved nitrogen	µg-N/L	119	140	10	-92%	-93%
Total Kjeldahl nitrogen	µg-N/L	-	210	144	-	-31%
Dissolved Kjeldahl nitrogen	µg-N/L	-	140	10	-	-93%
Total ammonia[a]	µg-N/L	1.0	7.3	2.5	150%	-66%
Nitrate[a]	µg-N/L	1.0	5.9	12	1100%	105%
Nitrite[a]	µg-N/L	1.0	0.5	1.3	25%	150%
Nitrate + nitrite[a]	µg-N/L	0.5	5.9	14	2600%	131%
Soluble reactive silica	µg/L	-	118	30	-	-75%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*

µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table C-8 Percent Change from Baseline and Previous Year Data in the Mid-field 2 (MF2) Area for Eutrophication Indicators during the Open-water Season in 2021

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	1.22	2.2	373%	82%
Phytoplankton biomass as biovolume	mg/m^3	163	229	179	10%	-22%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	81	88	252%	9%
Nutrients						
Total phosphorus	µg-P/L	3.3	1.8	2.2	-33%	24%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.4	43%	43%
Soluble reactive phosphorus	µg-P/L	1.0	0.5	0.50	-50%	0%
Total nitrogen	µg-N/L	138	200	210	52%	5%
Total dissolved nitrogen	µg-N/L	119	182.5	10	-92%	-95%
Total Kjeldahl nitrogen	µg-N/L	-	170	181	-	6%
Dissolved Kjeldahl nitrogen	µg-N/L	-	165	10	-	-94%
Total ammonia[(a)]	µg-N/L	1.0	17	11	1010%	-35%
Nitrate[(a)]	µg-N/L	1.0	18.5	31	3025%	69%
Nitrite[(a)]	µg-N/L	1.0	0.5	0.73	-28%	45%
Nitrate + nitrite[(a)]	µg-N/L	0.5	19.0	32	6250%	67%
Soluble reactive silica	µg/L	-	139	51	-	-63%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*

µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table C-9 Percent Change from Baseline and Previous Year Data in the Mid-field 3 (MF3) Area for Eutrophication Indicators during the Open-water Season in 2021

Variable	Unit	Baseline Median(b)	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	0.89	1.1	138%	27%
Phytoplankton biomass as biovolume	mg/m^3	163	273	148	-10%	-46%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	49	59	135%	20%
Nutrients						
Total phosphorus	µg-P/L	3.3	1.0	1.7	-50%	65%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	0.5	0.50	-50%	0%
Total nitrogen	µg-N/L	138	145	155	12%	7%
Total dissolved nitrogen	µg-N/L	119	135	91	-24%	-33%
Total Kjeldahl nitrogen	µg-N/L	-	145	152	-	4%
Dissolved Kjeldahl nitrogen	µg-N/L	-	130	70	-	-46%
Total ammonia(a)	µg-N/L	1.0	11.4	8.5	750%	-25%
Nitrate(a)	µg-N/L	1.0	1.0	6.0	495%	495%
Nitrite(a)	µg-N/L	1.0	0.5	0.50	-50%	0%
Nitrate + nitrite(a)	µg-N/L	0.5	1.1	6.0	1090%	441%
Soluble reactive silica	µg/L	-	79	35	-	-56%

Notes:
Values below detection limit were substituted with one half the detection limit prior to median calculations.
% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.
(a) Baseline median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.
(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*
µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table C-10 Percent Change from Baseline and Previous Year Data at LDG-48 for Eutrophication Indicators during the Open-water Season in 2021

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	0.48	0.86	83%	79%
Phytoplankton biomass as biovolume	mg/m³	163	183	315	93%	72%
Zooplankton biomass as ash-free dry mass	mg/m³	25	-	-	-	-
Nutrients						
Total phosphorus	µg-P/L	3.3	1.0	1.0	-70%	0%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	0.5	0.50	-50%	0%
Total nitrogen	µg-N/L	138	125	145	5%	16%
Total dissolved nitrogen	µg-N/L	119	125	125	5%	0%
Total Kjeldahl nitrogen	µg-N/L	-	125	144	-	15%
Dissolved Kjeldahl nitrogen	µg-N/L	-	125	123	-	-2%
Total ammonia[(a)]	µg-N/L	1.0	2.5	2.5	150%	0%
Nitrate[(a)]	µg-N/L	1.0	1.0	1.0	0%	0%
Nitrite[(a)]	µg-N/L	1.0	0.5	0.50	-50%	0%
Nitrate + nitrite[(a)]	µg-N/L	0.5	1.1	1.0	100%	-9%
Soluble reactive silica	µg/L	-	136	34	-	-75%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

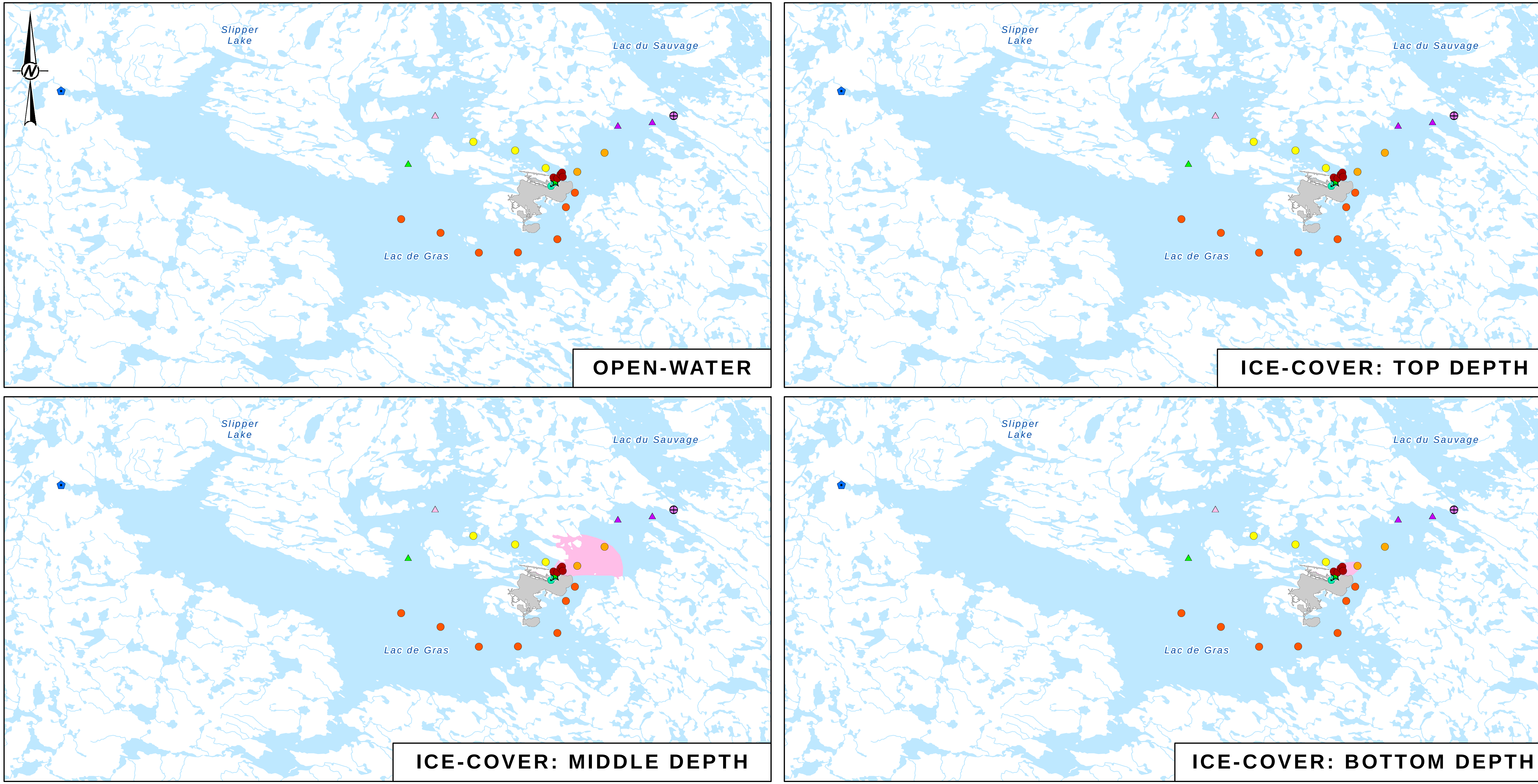
(a) Baseline median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4*, so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *Golder. 2019. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.*

LDG = Lac de Gras; µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

ATTACHMENT D

SUPPLEMENTAL EXTENT OF EFFECT FIGURES



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD
- WATERCOURSE
- AFFECTED AREA[1]
- DIAVIK FOOTPRINT
- WATERBODY

0 10 20
1:350,000 KILOMETRES

NOTE(S)

FOR THE EXTENT OF EFFECT CALCULATION, IT WAS ASSUMED ALL STATIONS IN THE NF AREA HAD TOTAL PHOSPHORUS CONCENTRATIONS AT THE UPPER RANGE OF THE NORMAL RANGE. AS THE AVERAGE CONCENTRATION IN THE NF AREA WAS LOWER THAN NORMAL RANGE, THIS ASSUMPTION LIKELY OVERESTIMATES THE AREA AFFECTED.

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

CONSULTANT
WSP GOLDER

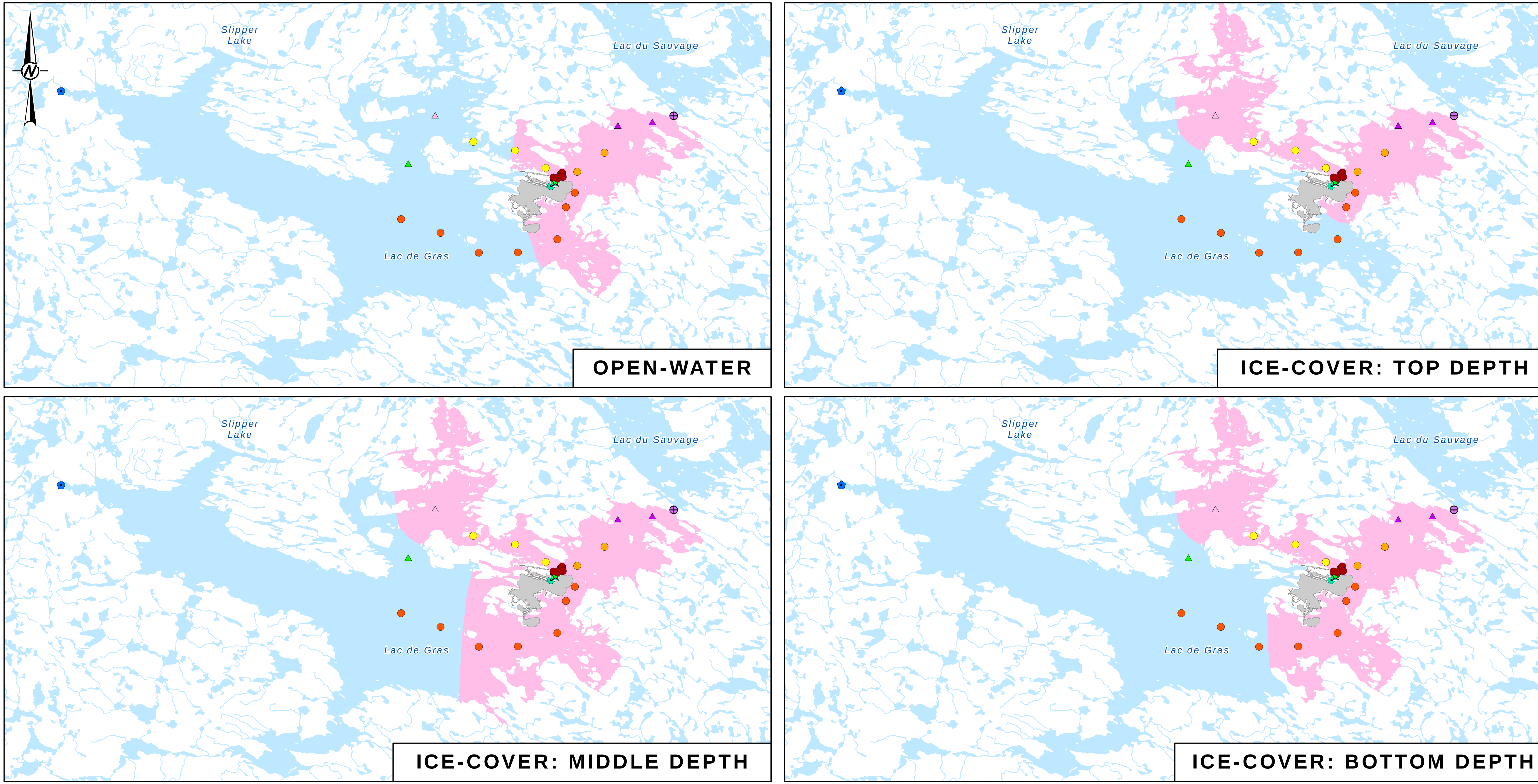
YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

TITLE
TOTAL PHOSPHORUS AFFECTED AREA IN LAC DE GRAS BY SEASON AND DEPTH, 2021

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	D-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm



LEGEND

- DIFFUSERS
- SURVEILLANCE NETWORK PROGRAM
- AFFECTED AREA
- DIAVIK FOOTPRINT
- WATERBODY

STATION LOCATIONS

- FAR-FIELD 1
- FAR-FIELD 2
- FAR-FIELD D
- LAC DE GRAS OUTLET
- LAC DU SAUVAGE OUTLET
- MID-FIELD 1
- MID-FIELD 2
- MID-FIELD 3
- NEAR-FIELD
- WATERCOURSE

0 10 20

1:350,000 KILOMETRES

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT: RioTinto

PROJECT: DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT: WSP GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	AF
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

TITLE: **TOTAL NITROGEN AFFECTED AREA IN LAC DE GRAS BY SEASON AND DEPTH, 2021**

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	D-2

ATTACHMENT E

ASSESSMENT OF TOTAL PHOSPHORUS DEPOSITION TO LAC DE GRAS

Introduction

Lac de Gras is an oligotrophic lake characterized by very low concentrations of nutrients. Phosphorus is delivered naturally to Lac de Gras directly via atmospheric deposition and indirectly via runoff from the watershed. In the region of the Diavik Diamond Mine (the Mine), the background rate of atmospheric deposition of phosphorus is typically low and rock weathering rates are slow. As a result, the aquatic ecosystem in Lac de Gras is expected to be phosphorus-limited, consistent with the findings of the Aquatic Effects Monitoring Program (AEMP). Land and aquatic retention and recycling rates of phosphorus in the region are largely unknown.

The *AEMP Design Plan Version 5.2* (Golder 2020a) for the Mine requires annual analysis of phosphorus loads from the Diavik Diamond Mine (Mine) and from other sources to Lac de Gras. The methods used to compute total phosphorus (TP) loads to Lac de Gras from relevant sources and a discussion of the results of the analysis are presented herein.

Methods

In addition to natural sources, Mine effluent and atmospheric deposition of phosphorus contained in Mine-related fugitive dust can contribute additional anthropogenic phosphorus to Lac de Gras. In this document, the relative magnitudes of phosphorus delivered to Lac de Gras in 2021 from the following sources are estimated:

- natural (i.e., background) atmospheric deposition of TP directly to Lac de Gras
- natural (i.e., background) atmospheric deposition of TP to the Lac de Gras watershed delivered indirectly through runoff to Lac de Gras
- anthropogenic TP delivered directly to Lac de Gras via the Mine effluent
- anthropogenic TP delivered directly to Lac de Gras via atmospheric deposition of fugitive dust
- anthropogenic TP delivered indirectly to Lac de Gras via atmospheric deposition of fugitive dust to the Lac de Gras watershed

Estimation of the above quantities used the same approach as described previously in the *2020 AEMP Annual Report* (Golder 2021) and the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b). The data used and methods implemented herein are summarized below:

- The 2021 dustfall monitoring program included three monitoring components: dustfall gauges, dustfall from snow surveys, and snow water chemistry from snow surveys (see Dust Deposition Report, Appendix I). Dustfall gauges were placed at 14 stations (including two control stations), which collected dustfall year-round. Dustfall snow surveys were performed at 27 stations (i.e., 24 monitoring stations and 3 reference stations referred to as “control stations”), along five transects around the Mine, on land and on the ice.
- Snow water chemistry was analyzed in snow core samples collected from 16 on-ice monitoring stations and 3 control stations. The TP concentrations (in mg/L) in snow data from the snow water chemistry samples were used in the analysis.

- Ancillary data collected with the snow cores enabled the conversion of concentration in snow water (in mg/L) to an areal deposition rate (in milligrams per square decimetre per year; $mg/dm^2/yr$). The formula used to perform the conversion was as follows:

  $$D = (C \times V \times 365)/(N \times A \times T)$$

  where:

  D = TP deposition rate ($mg/dm^2/yr$)

  C = concentration of TP in snow water (mg/L)

  V = snow water volume (L)

  N = number of snow cores

  A = area of snow core tube (0.2922 dm^2)

  T = number of exposure days

  During the 2021 snow sampling program, there were missing snow water volume data for twelve out of twenty-two snow samples including duplicates. Since the snow water volume is needed for converting TP concentrations into areal deposition rate, the average of snow water volume (i.e., 3,419 millilitres [mL]) from the 2021 snow sampling program, with a standard deviation of 199 mL, was used as a surrogate for the missing snow water volume.

- The land-based snow sample exposure days were calculated as the days between the first snowfall date (01 October 2020) and the snow sample collection date at the land station. The over-water or "on-ice" snow sample exposure days were calculated as the days between the freeze-up date (30 October 2020) and the snow sample collection date at individual stations.
- The geometric mean of TP concentrations measured in samples collected at the control stations were used to calculate natural background TP deposition.
- The surface area of Lac de Gras (573 km^2) and the Lac de Gras watershed area (3,542 km^2) were multiplied by the background rates of TP deposition to estimate the magnitude of the TP load from natural atmospheric deposition to Lac de Gras and the watershed.
- Observed rates of anthropogenic TP deposition in 2021 were calculated using TP concentrations measured in snow samples in the dust monitoring program. The relationship between the wintertime TP deposition and the wintertime dust deposition was robust in 2021 (r^2 = 0.884).
- The observed TP deposition data at the on-ice snow stations and the calculated TP deposition data at the on-land snow sampling stations and dustfall gauges were then spatially interpolated using kriging, and integrated to estimate anthropogenic TP loads from fugitive Mine dust.
- The annual TP load from Mine effluent in 2021 was 297 kg.
- For the spatial interpolation of anthropogenic TP loading:
  - Spatial interpolation of the dust deposition data was carried out for a 105.7 km x 80 km domain centred on the Mine. The grid resolution inside the domain was set to 20 by 20 m, but excluded the area of the domain occupied by the Mine footprint.

- There were 19 valid TP observations from snow survey transects in 2021 (N_{obs} = 19). TP deposition rates as a function of distance from the Mine centroid were evaluated for 2021. Spatial trends in TP deposition as a function of distance from the centroid were fit using a first-order decay function, whose goodness-of-fit was evaluated using the coefficient of determination (r^2) from the least-squares regression. An r^2 larger than 0.5 indicates a robust fit of the dust deposition as a function of distance from the centroid.
- A TP deposition zone of influence (ZOI) was delineated by examining the distance from which the TP deposition would be reduced to the level of natural background.
- The observed and calculated areal deposition rates were excluded from the spatial interpolation when the stations were outside of the TP deposition ZOI or the TP deposition rates were less than the background TP deposition rate.
- Prior to spatial interpolation in QGIS, TP deposition rates at the edges of TP deposition ZOI were set equal to the background rate of TP deposition observed in 2021.
- Prior to spatial interpolation, the observed and calculated areal deposition rates were log-transformed to better capture the steep gradients observed in dust deposition as a function of distance from the Mine boundary. Mass loads (in tonnes/year [t/yr]) were calculated by integrating the spatially interpolated areal loads (mg/dm^2/yr) across the domain, and then back-transforming the results. This procedure is described by the following equation where the “sum of dust deposition data” represents the sum of the areal loads interpolated for each 20 by 20 m grid cell within the domain:

$$Mass\ Loading\left(\frac{t}{yr}\right) = sum\ of\ dust\ deposition\ data\left(\frac{mg}{dm^2 \cdot yr}\right) \times \frac{100\ dm^2}{m^2} \times 20\ m \times 20\ m\ \times\ \frac{t}{10^9\ mg}$$

- The “zonal statistics table” tool in QGIS was used to calculate 2021 mass loads for three separate regions. These three regions correspond to: (1) the Mine footprint (excluded from analysis); (2) Lac de Gras; and, (3) the Lac de Gras watershed excluding Lac de Gras. Total loads to the Lac de Gras watershed can be obtained by summing deposition to Lac de Gras and the Lac de Gras watershed.

The following assumptions were implicit to the analysis of TP loading to Lac de Gras and its watershed:

- Chemical weathering of local rocks is a potential source of TP to Lac de Gras; however, this weathering is typically slow and was not considered due to a lack of relevant data.
- TP deposition, as derived from TP concentrations measured in snow, is assumed to represent all TP deposition over the winter period.
- TP concentrations in snow water are a reasonable surrogate for TP concentrations in dustfall throughout the year. This also assumes weak dustfall seasonality and constant TP fraction in the dust. Analysis of seasonal trends of dust deposition from multiple years of dustfall monitoring at the Mine has indicated that dust deposition is lowest in the fall and similar in magnitude in the other three seasons (Golder 2020b).
- There are no seasonal differences in the source of TP in dust (i.e., TP concentrations in dust are similar between the open-water and ice-cover seasons).

- The control stations are unaffected by atmospheric deposition of fugitive Mine dust (i.e., they are assumed to be representative of the regional background rate of TP deposition).
- Atmospheric deposition of natural TP is spatially homogeneous throughout the Lac de Gras watershed (i.e., the mean/median background values are assumed to be valid and spatially representative).
- All atmospheric deposition of TP in the Lac de Gras watershed reports to Lac de Gras. This explicitly ignores uptake of TP on land, its storage, and eventual release. In other words, steady-state is assumed where the mass of TP deposited to the landscape is assumed to be in equilibrium with the mass of TP being delivered to the lake via runoff during a single calendar year.

Results

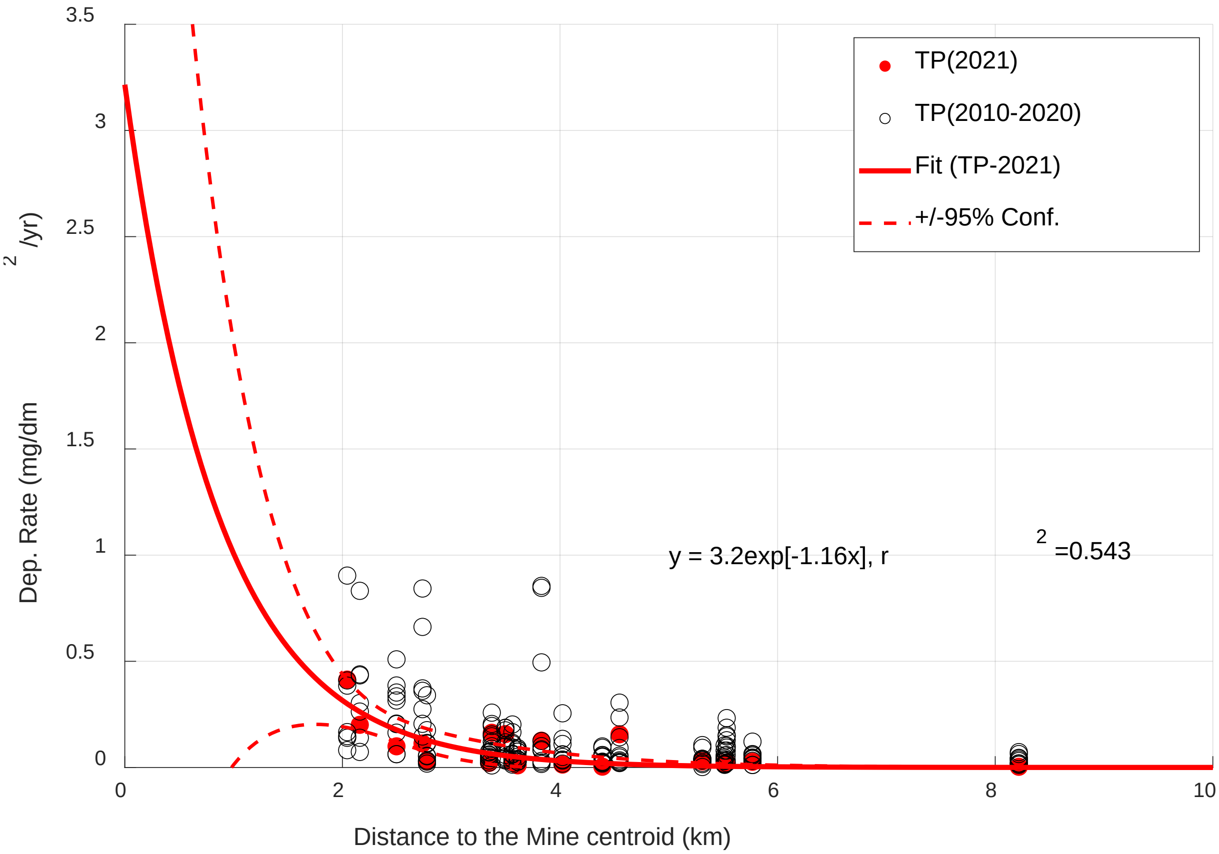
TP Deposition Rates

Figure E-1 shows TP deposition measured in 2021 as a function of distance from the Mine centroid. Also included in the figure are the data collected at the same locations from 2010 until 2020. Results of the fit to a first-order decay function for 2021 are plotted as a solid line, with the 95% confidence interval limits plotted as dashed lines. The first order decay function resulted in a robust fit (r^2 = 0.543), which suggests there is relatively limited spatial variability in dust deposition among the snow survey transects.

Table E-1 compares background TP deposition rate in 2021 with the historical background TP deposition rates. The last re-evaluation report estimated TP background deposition rates for three time periods, i.e., 2010 to 2013, 2014 to 2016, and 2017 to 2019. The 2021 background TP deposition rate was lower than the background deposition rate of previous time periods and 2020 (Table E-1).

The TP deposition zone of influence in 2021 was estimated to be approximately 4.8 km from the Mine centroid. This distance was consistent with the dust zone of influence (i.e., 4.8 km) for the 2017 to 2019 time period as estimated in the re-evaluation report (Golder 2020b).

Figure E-1 Total Phosphorus Deposition as a Function of Distance to the Diavik Mine Centroid



TP = total phosphorus; r^2 = coefficient of determination; mg/dm²/yr = milligrams per square decimetre per year.

Table E-1 Background Total Phosphorus Deposition Rates in Snow from 2010 to 2021

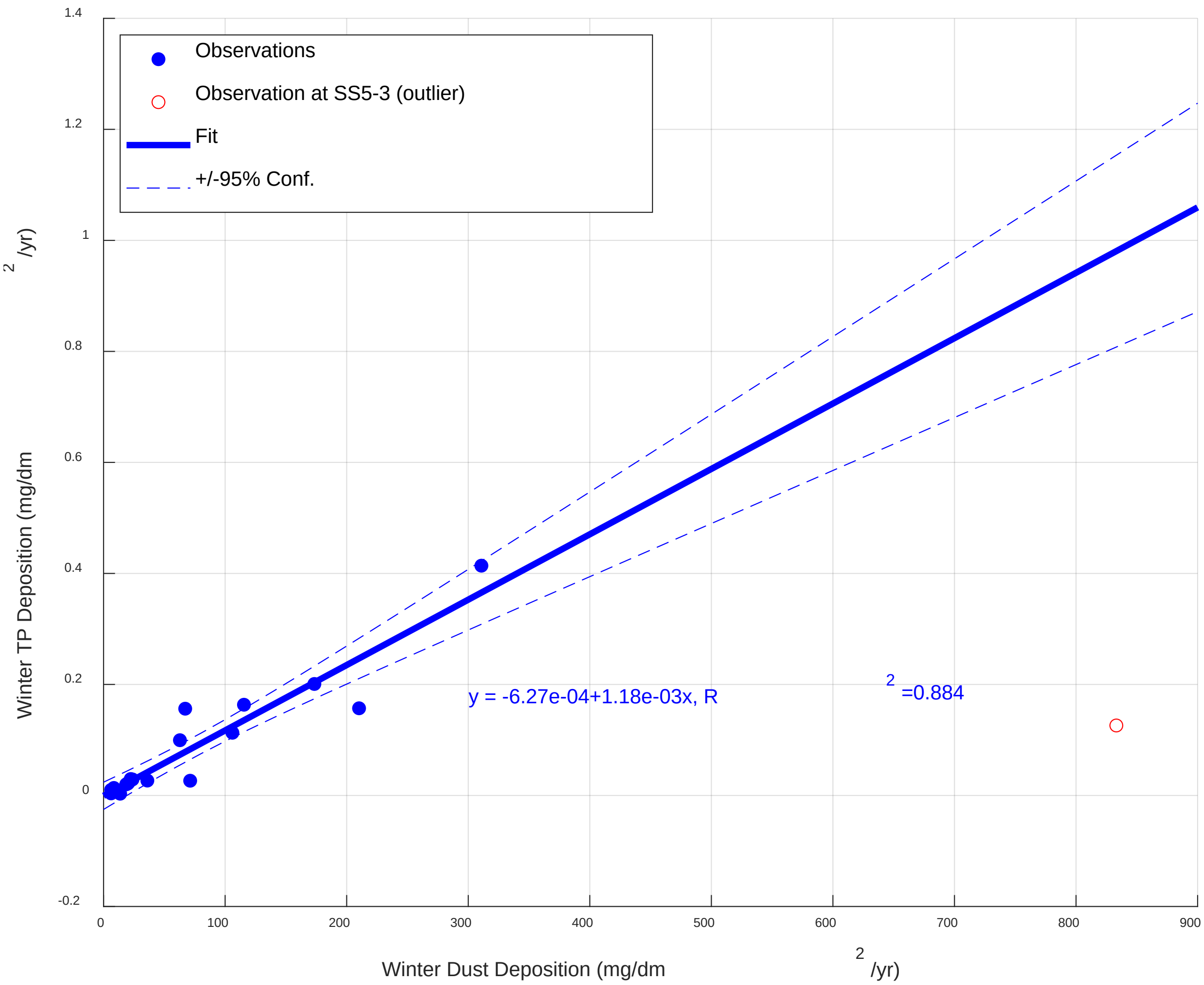
Year	Background TP Deposition (mg/dm²/yr)
2021	0.013
2020	0.056
2017-2019	0.051
2014-2016	0.044
2010-2013	0.037

mg/dm²/yr = milligrams per square decimetre per year; TP = total phosphorus.

The determination of background versus Mine-related TP loading depends on spatial integration of TP deposition over a large area. Annual phosphorus deposition was estimated using the more numerous whole-year quarterly dust deposition data. This required employing Type-II linear regression of TP versus dust deposition from the snow sample data. The results of the 2021 regression are shown in Figure E-2. The dust deposition observed at station SS5-3 was as high as 833 mg/dm²/yr while the TP deposition rate was 0.126 mg/dm²/yr. This data point was considered as an outlier for determining the TP content of dust and was removed from the regression to provide a conservative estimate of TP in dust.

This relationship was a very robust fit (r^2 = 0.884), supporting the hypothesis that TP was likely particulate-bound and being emitted as fugitive dust from the Mine. The robust fit also indicated the validity of using this relationship to calculate the TP deposition rates from dust deposition rates for the on-land snow sampling stations and dustfall gauge stations.

Figure E-2: Linear Regressions of Wintertime TP versus Dust Deposition



TP = total phosphorus; r^2 = coefficient of determination; mg/dm²/yr = milligrams per square decimetre per year.

TP Loads

Natural TP loads to Lac de Gras, and to the Lac de Gras watershed (excluding Lac de Gras and the Mine), were computed using the geometric mean deposition rate from the control stations (0.013 mg/dm^2/yr). The direct natural TP load to the lake is estimated at 0.72 t/yr and the natural TP load to the watershed (excluding the lake and Mine) is 4.5 t/y, for a total watershed load of 5.2 t/yr (Table E-2). These natural TP loads were lower than those estimated in 2021 and in the 2017 to 2019 period in the re-evaluation report.

The anthropogenic TP load from Mine effluent was 0.30 t/yr in 2021. Effluent is assumed to include TP captured in runoff collected on-site that may be affected by the local deposition of fugitive dust within the Mine footprint.

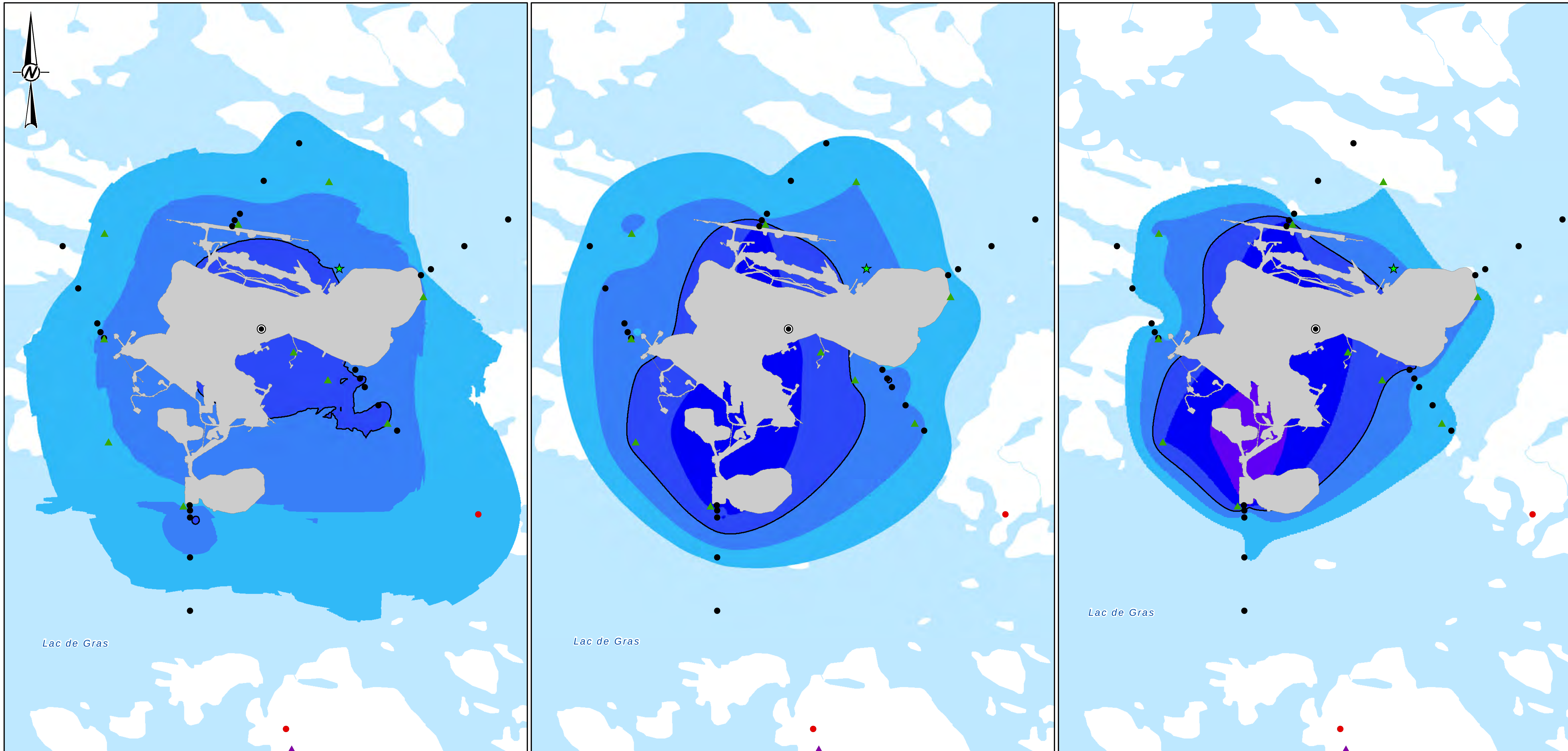
Results of the spatial interpolation of TP deposition around the Mine footprint for 2021, 2020, and 2017 to 2019 in the re-evaluation report are illustrated in Figure E-3. The distribution of TP around the Mine footprint in 2021 was similar to that of 2020.

The anthropogenic TP loads were calculated by subtracting the natural background load from the total TP load. As summarized in Table E-2, the anthropogenic TP loads to Lac de Gras directly and to the watershed (excluding Lac de Gras and the Mine) were 0.63 and 0.46 t/yr, respectively, for a total load (including Mine effluent) of 1.4 t in 2021. The anthropogenic TP loads to Lac de Gras and the watershed are consistent with the values estimated in the re-evaluation report for the 2017 to 2019 period and in 2020. The contribution of anthropogenic TP loads to the total TP loads to the watershed, and eventually to Lac de Gras, was 27%, which is higher than the percentages of 2017 to 2019 period and 2020. This higher proportion is due to the low background TP deposition rate observed in 2021.

Table E-2 Summary of Total Annual Phosphorus Loads to Lac de Gras for 2017 to 2019, 2020, and 2021

Total Phosphorus Source		Area (km^2)	2017 to 2019		2020		2021	
			TP Load (t/yr)[b]	Percent contributing to the total TP load	TP Load (t/yr)	Percent contributing to the total TP load	TP Load (t/yr)	Percent contributing to the total TP load
Natural Background TP	Deposition to Lac de Gras	573	2.9	13%	3.2	13%	0.72	11%
	Deposition to watershed excluding Lac de Gras and the Mine	3,542	18	81%	20	81%	4.5	68%
	Watershed Subtotal[a]	**4,115**	**21**	**94%**	**23**	**95%**	**5.2**	**79%**
Anthropogenic TP	Diavik Mine effluent	n/a	0.36	1.6%	0.29	1.1%	0.30	4.5%
	Deposition to Lac de Gras	573	0.65	2.9%	0.69	2.8%	0.63	12%
	Deposition to watershed excluding Lac de Gras and the Mine	3,530	0.33	1.5%	0.35	1.4%	0.46	8.9%
	Watershed Subtotal[a]	**4,115**	**1.3**	**6.0%**	**1.3**	**5.4%**	**1.4**	**27%**
Total[a]		**4,115**	**22**	n/a	**24**	n/a	**6.6**	n/a

(a) Values may not sum up to subtotal or total due to rounding.
(b) Diavik Mine Effluent was the average effluent in 2017 to 2019.
n/a = not applicable; TP = total phosphorus; t/yr = tonnes per year.



TOTAL PHOSPHORUS (2017-2019)

TOTAL PHOSPHORUS (2020)

TOTAL PHOSPHORUS (2021)

LEGEND

- DIFFUSERS
- DIAVIK FOOTPRINT CENTROID
- WATERCOURSE
- DIAVIK FOOTPRINT
- WATERBODY
- DUSTFALL GAUGE STATION
- DUSTFALL GAUGE CONTROL STATION
- SNOW SURVEY STATION
- SNOW SURVEY CONTROL STATION
- CONTOUR - 0.4 mg/dm²/yr

TOTAL PHOSPHORUS - ANNUAL DEPOSITION RATE (mg/dm²/yr)

- <0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.4
- 6.4 - 11.5
- >11.5

0 2 4

1:75,000 KILOMETRES

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT: RioTinto

PROJECT: DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT: wsp GOLDER

YYYY-MM-DD	2022-03-28
DESIGNED	ZY
PREPARED	LMS
REVIEWED	RS
APPROVED	ZK

TITLE: **SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS DEPOSITION AROUND THE MINE**

PROJECT NO.	PHASE	REV.	FIGURE
21452119	12000	0	E-3

PATH: I:\CLIENTS\DIAVIK\21452119\Mapping\Fish\AEMP_2021\FigE-3_21452119_AEMP_TP_Deposition_Rev0.mxd PRINTED ON: 2022-03-28 AT: 2:27:15 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
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Summary and Discussion

The key findings from the 2021 assessment are as follows:

- The background TP deposition rate estimated as the geometric mean of the deposition rates from the three control stations in 2021 was 0.013 mg/dm^2/yr, which was lower than the background TP deposition rates estimated for 2020 and the 2017 to 2019 period in the re-evaluation report (Golder 2020b).
- The 2021 TP zone of influence was estimated to be approximately 4.8 km from Mine centroid which is comparable to the dust zone of influence for 2020 (Golder 2021) and the 2017 to 2019 period in the re-evaluation report (Golder 2020b).
- The 2021 anthropogenic TP loads for Lac de Gras and the watershed (excluding the Mine and lake) were 0.63 and 0.460 t/yr, respectively, for a total (including Mine effluent) of 1.4 t in 2021. The 2021 anthropogenic TP loads to Lac de Gras (direct and indirect) were consistent with those of 2020 (Golder 2021) and the 2017 to 2019 period in the re-evaluation report (Golder 2020b).
- The contribution of anthropogenic sources to the total TP load to Lac de Gras was 27% (the rest was contributed from natural TP loads), which was higher than the previous years due to low background TP deposition rate in 2021.

The dust sampling program was not designed to be as precise as the AEMP effluent monitoring for measuring TP loads to Lac de Gras. The estimate of TP load from dust is considered to have low precision, with an order of magnitude uncertainty. Therefore, low confidence should be placed in the estimate of the TP load from dust and it should not be directly compared to the TP load from effluent, which is based on direct measurements of effluent volume and TP concentrations. The effect on lake water quality and biological effects of nutrient inputs from all Mine-related sources are being monitored directly by the AEMP.

References

Golder. 2020a. Diavik Diamond Mine Inc. – Aquatic Effects Monitoring Program Design Plan Version 5.2. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. June 2020.

Golder. 2020b. AEMP 2017 to 2019 Aquatic Effects Re-evaluation Report Version 1.1. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. December 2020.

Golder. 2021. Eutrophication Indicators Report in Support of the 2020 AEMP Annual Report for the Diavik Diamond Mine, Northwest Territories. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. April 2021.

ATTACHMENT F

EUTROPHICATION INDICATORS RAW DATA

These data are provided electronically as an Excel file.

APPENDIX XIV

TRADITIONAL KNOWLEDGE STUDY

The appendix is still pending and will be provided in the next AEMP Annual Report.

APPENDIX XV

WEIGHT-OF-EVIDENCE REPORT

No information was available for this appendix in 2021; this component is only collected during comprehensive years.