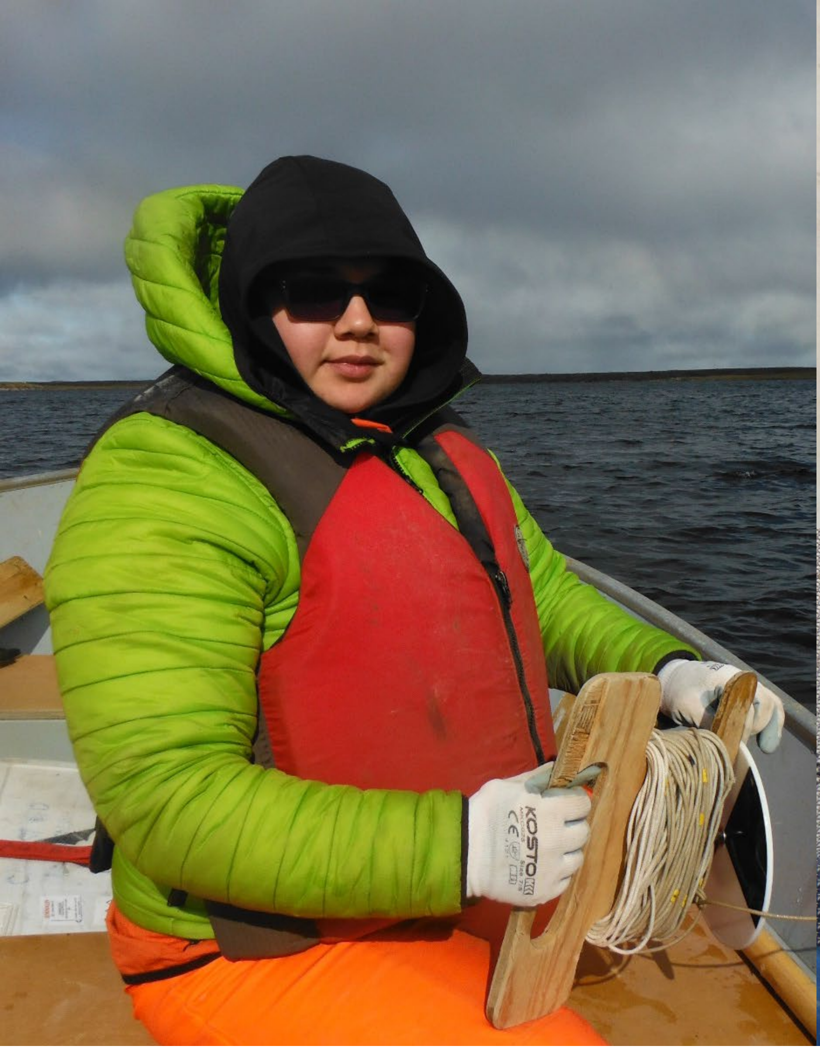
Appendix C-4

Hope Bay Project: 2019 Aquatic Effects Monitoring Program Report



Hope Bay Project

2019 Aquatic Effects Monitoring Program Report

March 2020

Project No. 0510704-0002

The business of sustainability

March 2020

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2019 Aquatic Effects Monitoring Program Report

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EXECUTIVE SUMMARY

The Hope Bay Project (the Project) is a gold mining development owned by TMAC Resources Inc. (TMAC) in the West Kitikmeot region of mainland Nunavut. The Project property is approximately 153 km southwest of Cambridge Bay on the southern shore of Melville Sound and contains a greenstone belt (the Belt) that runs 80 km in a north-south direction varying in width between 7 km and 20 km.

The Project consists of three developments: Doris, Madrid, and Boston. Construction of the Doris Mine and associated infrastructure began in 2010, and commercial operations began in 2017. Construction of mining infrastructure at the Madrid North development began in April 2019, followed by a transition to operations in August 2019 with mining of the Naartok East Crown Pillar trench. As of December 2019, construction had not begun at the Madrid South or Boston developments.

This report presents the results of the 2019 Aquatic Effects Monitoring Program (AEMP), the first year of implementation of the approved Belt-wide *Hope Bay Project: Aquatic Effects Monitoring Plan* (the Plan; TMAC 2018). The primary goals of the AEMP are to evaluate potential Project effects on the surrounding freshwater environment during the construction and operation of the Project, verify predictions from the Madrid-Boston *Final Environmental Impact Statement* (FEIS; TMAC 2017b), support current and future Fisheries Authorizations, and provide a mechanism to respond to potential Project effects in the freshwater environment through the Response Framework. This framework sets environmental thresholds that, if exceeded, would trigger further investigation and/or mitigation.

The 2019 AEMP includes lakes adjacent to proposed infrastructure that have the greatest potential to receive non-point-source inputs such as runoff or dust (e.g., Doris and Patch lakes) and lakes that could be affected by water loss due to permitted water withdrawal and groundwater seepage into the mines through underground workings (e.g., Doris, Little Roberts, Patch, Glenn, and Windy lakes). Aquatic components evaluated in 2019 included the following: water level and ice thickness, under-ice dissolved oxygen concentration, water temperature, water and sediment quality, phytoplankton biomass, and benthic invertebrates. Statistical and/or graphical analyses were undertaken to determine whether there were any apparent effects of Project activities on these aquatic components in the monitored lakes.

Table 1 presents a summary of the overall findings of the evaluation of effects for the 2019 AEMP, as well as the corresponding section in this report in which to find the discussion of the evaluation of effects for each monitoring component. No adverse Project-related effects to under-ice water level, under-ice dissolved oxygen concentrations, water temperature, sediment quality, phytoplankton biomass, or benthic invertebrate community indicators were detected in the exposure lakes (i.e., lakes with the potential to be influenced by the Project). The evaluation of effects concluded that there were potential Project-related effects to under-ice total ammonia and under-ice total molybdenum concentrations in the water column of Doris Lake, as both water quality variables increased relative to baseline levels and increasing trends were not apparent in the reference lake. Concentrations of these variables remained below CCME guidelines for the protection of freshwater aquatic life, indicating that concentrations of total ammonia and total molybdenum remain protective of aquatic life in Doris Lake. Low action level responses under the Response Framework were not triggered for these variables.

There were no Project-related effects identified in Patch Lake; therefore, the unauthorized release of sediment that occurred in June 2019 did not result in any residual adverse changes to water quality, sediment quality, or to the biological communities (sampled two months after the incident in August 2019) in this lake.

Table 1: Summary of Evaluation of Effects for 2019 AEMP

Variable	Exposure Lakes Included in Evaluation of Effects	Conclusion of Effect	Low Action Level Triggered?	Report Section
Water Level and Ice Thickness	Windy Lake, Glenn Lake, Patch Lake, Doris Lake, Little Roberts Lake	No Effect	No	3.1
Physical Limnology (Dissolved Oxygen and Temperature)	Windy Lake, Patch Lake, Doris Lake	No Effect	No	3.2
Water Quality	Windy Lake, Patch Lake, Doris Lake	Possible Effect on Under-ice Total Ammonia and Under-ice Total Molybdenum Concentrations in Doris Lake	No	3.3
Sediment Quality	Patch Lake, Doris Lake	No Effect	No	3.4
Phytoplankton Biomass (as Chlorophyll *a*)	Windy Lake, Patch Lake, Doris Lake	No Effect	No	3.5
Benthic Invertebrates	Patch Lake, Doris Lake	No Effect	No	3.6

ACKNOWLEDGEMENTS

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ACRONYMS AND ABBREVIATIONS

AEMP	Aquatic Effects Monitoring Program
ALS	ALS Laboratory Group
ANFO	Ammonium nitrate fuel oil
BA	Before-After
BACI	Before-After/Control-Impact
the Belt	Hope Bay Belt
Benthos	Benthic invertebrates
CCME	Canadian Council of Ministers of the Environment
Censored value	A value that is only partially known, e.g., a variable concentration that is reported as being below a specified detection limit, although the actual concentration is not known.
Chl *a*	Chlorophyll *a*
Chlorophyll *a*	An essential light-harvesting pigment for photosynthetic organisms including phytoplankton. Because of the difficulty involved in the direct measurement of plant carbon, chlorophyll *a* is routinely used as a ‘proxy’ estimate for plant biomass in aquatic studies.
CTD	Conductivity, temperature, depth probe
Ds	Secchi depth
DL	Detection limit
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DQO	Data quality objective
EEM	Environmental Effects Monitoring
ERM	ERM Consultants Canada Ltd.
Exposure site	Site potentially influenced by Project-related activities (e.g., Doris Lake, Patch Lake, Windy Lake).
FEIS	Final Environmental Impact Statement
GLMM	Generalized linear mixed effects model
ISQG	Interim sediment quality guideline
k	Light extinction coefficient
LME	Linear mixed effects
LOESS	Local regression
MDMER	Metal and Diamond Mining Effluent Regulations
NIRB	Nunavut Impact Review Board
NTU	Nephelometric turbidity units
NWB	Nunavut Water Board

PEL	Probable effects level
the Plan	Hope Bay Project: Aquatic Effects Monitoring Plan
the Project	the Hope Bay Project
QA/QC	Quality assurance/quality control
Reference site	Site located beyond any Project influence (i.e., Reference Lake B).
RPD	Relative percent difference
SD	Standard deviation
TMAC	TMAC Resources Inc.
TOC	Total organic carbon
TSS	Total suspended solids
$Z_{1\%}$	The 1% euphotic depth, i.e., the depth of the water column at which 1% of the surface irradiance reaches.

1. INTRODUCTION

1.1 Background

The Hope Bay Project (the Project) is a gold mining development owned by TMAC Resources Inc. (TMAC) in the West Kitikmeot region of mainland Nunavut. The Project property is approximately 153 km southwest of Cambridge Bay on the southern shore of Melville Sound and contains a greenstone belt (the Belt) that runs 80 km in a north-south direction varying in width between 7 km and 20 km.

The Project area consists of three developments: Doris, Madrid (North and South), and Boston (Figure 1.1-1). Doris is the northernmost development situated near Roberts Bay and contains the Doris North Gold Mine (Doris Mine) that operates under amended Project Certificate No. 003 (last amended in September 2016). Construction of the Doris Mine and associated infrastructure began in 2010, and commercial operations began in 2017. The Madrid and Boston developments are in the north-central and southernmost parts of the Belt. TMAC submitted the Madrid-Boston *Final Environmental Impact Statement* (FEIS; TMAC 2017b) to the Nunavut Impact Review Board (NIRB) and corresponding application for a Type A Water Licence to the Nunavut Water Board (NWB) in December 2017. The NIRB issued Project Certificate No. 009 in November 2018 following their review of the FEIS. In January 2019, a new Type A Water Licence 2AM-BOS1835 for the Boston development and an amendment to the Type A Water Licence 2AM-DOH1335 (Amendment 2) for the Doris and Madrid developments was approved by the NWB. Construction of mining infrastructure at the Madrid North development began in April 2019, followed by a transition to operations in August 2019 with mining of the Naartok East Crown Pillar trench. As of December 2019, construction had not begun at the Madrid South or Boston developments.

The *Hope Bay Project: Aquatic Effects Monitoring Plan* (the Plan; TMAC 2018) describes the Aquatic Effects Monitoring Program (AEMP) for the freshwater environment over the entire Project area. The Plan is Belt-wide in scope, integrating the monitoring proposed for the Madrid-Boston developments (TMAC 2017a) with the monitoring conducted as part of the Doris Aquatic Effects Monitoring Plan (TMAC 2016). The Plan also harmonizes the AEMP and Environment Effects Monitoring (EEM) requirements under the *Metal and Diamond Mining Effluent Regulations* (MDMER; SOR/2002-222), and includes an adaptive management component through the Response Framework. The Response Framework sets environmental threshold levels that, if exceeded, would trigger further investigation and/or mitigation. Implementation of the Plan was one of the conditions of the new and amended Type A Water Licences (thus superseding the Doris Aquatic Effects Monitoring Plan (TMAC 2016)).

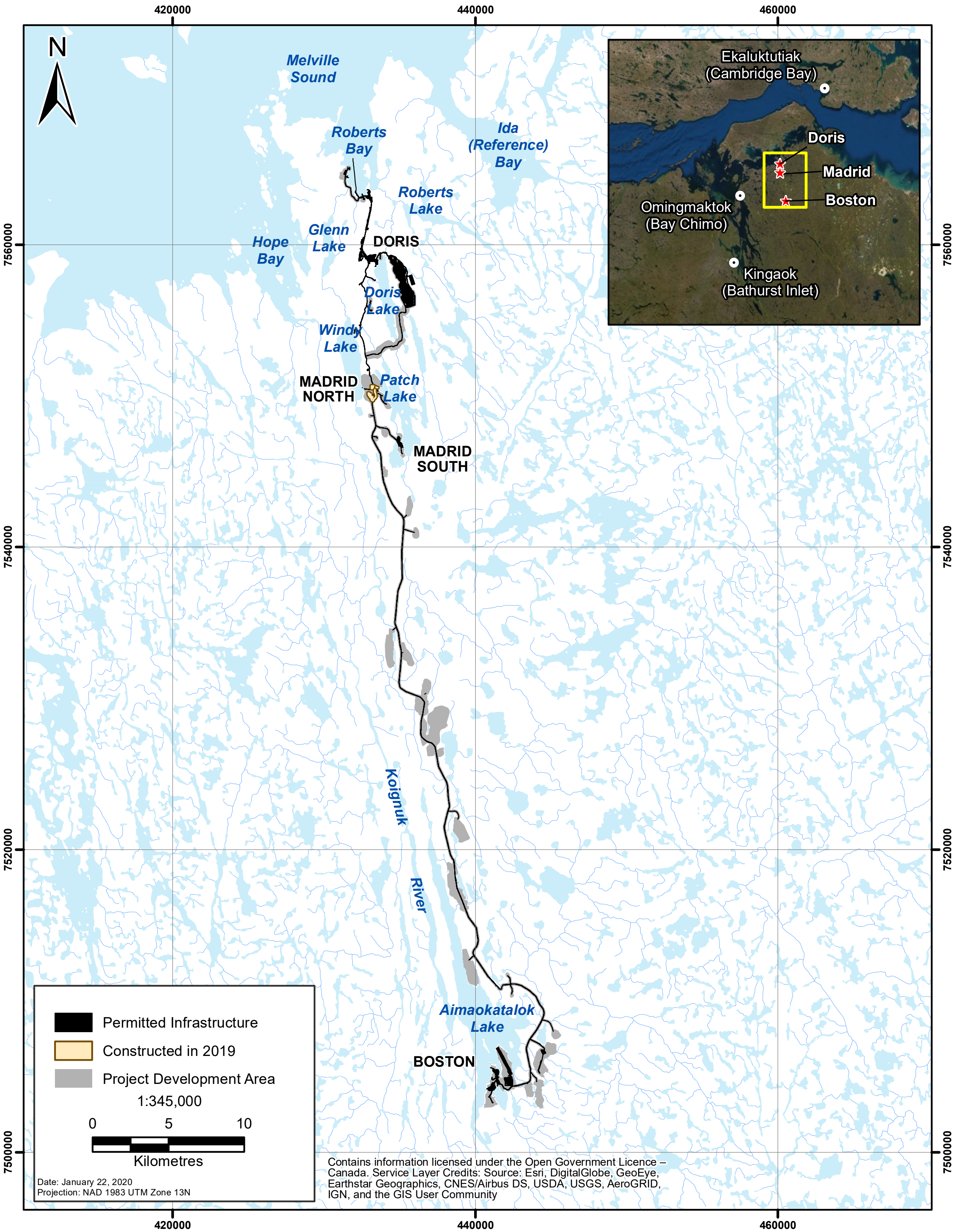
This report presents the results of the 2019 AEMP, the first year of implementation of the approved Belt-wide Plan (TMAC 2018).

1.2 Objectives

The primary goals of the AEMP are to evaluate potential Project effects on the surrounding freshwater environment during the construction and operation of the Project, verify predictions from the Madrid-Boston FEIS (TMAC 2017b), support current and future Fisheries Authorizations, and provide a mechanism to respond to potential Project effects in the freshwater environment through mitigation and management actions. The 2019 AEMP includes lakes adjacent to proposed infrastructure that have the greatest potential to receive non-point-source inputs such as runoff or dust (e.g., Doris and Patch lakes) and lakes that could be affected by water loss due to permitted water withdrawal and groundwater seepage into the mines through underground workings (e.g., Doris, Little Roberts, Patch, Glenn, and Windy lakes). The 2019 AEMP evaluates potential effects of Project activities on the following components of the freshwater environment in the Project area:

- water level and ice thickness;

Figure 1.1-1
Hope Bay Project Location



- physical limnology (dissolved oxygen and water temperature);
- water quality;
- sediment quality;
- phytoplankton biomass; and
- benthic invertebrates.

1.3 2019 Project Activities

Infrastructure associated with the Hope Bay Project is shown in Figure 1.1-1. Project activities occurring in and around this infrastructure have the potential to affect the freshwater environment through the generation of dust and/or runoff of site and mine contact water, which can settle onto or flow into lakes and streams in the Project area. The following list summarizes the Project activities that occurred in 2019 by development area:

Doris

- Underground mining operations continued at Doris Mine.
- Added one dorm to allow an additional 48 bed spaces at Doris Camp.
- Completed access road and outfall berm for Roberts Bay ocean discharge line.
- Installed ocean discharge line with diffuser and recirculation line in Roberts Bay.
- Began construction of Water Treatment Plant to treat underground mine water for total suspended solids (TSS) prior to discharge.
- Completed Doris Connector Vent Raise construction and fan installation.
- Completed backfill of Doris Crown Pillar Trench.
- Quarried rock for construction and crushed material for construction in Quarry 2.
- Conducted geological sediment sampling program through the ice in Doris Lake.
- Completed successful sealift operation in fall of 2019 with the delivery of heavy equipment, supplies, diesel fuel, explosives, and reagents to support construction, mining, and milling activities.

Madrid North

- Completed construction of Madrid North access roads and Madrid North Contact Water Pond.
- Completed construction of a laydown space for a shop and facilities to support activities at Madrid North.
- Began construction of Madrid North Waste Rock Pad.
- Quarried rock for construction in Quarry D.
- Conducted on-ice surface exploration program in Patch Lake and geological sediment sampling program through the ice in Patch Lake.
- Began mining of the Naartok East Crown Pillar trench in August 2019, overburden stripped from the trench area was stored in a designated overburden pile at Madrid North.
- Conducted drilling and blasting to access waste rock and ore.
- Began collaring Madrid North Portal in December 2019.

1.4 2019 Spill Incident

During overburden stripping at the Naartok East Crown Pillar Recovery area, an unknown quantity of water containing high concentrations of suspended sediments was released to the shoreline of Patch Lake on June 15, 2019. This runoff of high sediment water was localized to the edge of shoreline due to the presence of ice over most of Patch Lake.

This incident was reported to the Nunavut Spill line, and follow up investigations were undertaken including the collection of samples for water quality characterization and acute lethality testing, as well as an incident investigation to determine the root cause, and identify and implement corrective and preventative actions. Details of this investigation are provided in TMAC (2019). Follow-up actions included the enhancement of existing sediment controls, the installation of two silt curtains near the shoreline of Patch Lake, and the construction of a rock berm around the perimeter of the stripping area to contain the runoff.

The water quality characterization of the runoff collected on the day of the spill as well as one and two days following the spill were compared to the MDMER Schedule 4 – Authorized Limits of Deleterious Substances. All variables were below both the Maximum Authorized Monthly Mean Concentration and the Maximum Authorized Concentration in a Grab Sample, with the exception of TSS. The maximum recorded TSS concentration in the runoff was 93.7 mg/L on the day of the spill, and concentrations dropped to less than 5 mg/L within two days. The acute lethality test indicated that the runoff was not acutely lethal, with a 100% survival rate for both rainbow trout (96-hour LC_{50} test) and Daphnia magna (48-hour LC_{50} test; TMAC 2019).

This spill incident was considered in the evaluation of effects for Patch Lake to determine if there was any evidence of adverse changes to water quality, sediment quality, or biological communities that could be attributed to the spill.

1.5 Report Structure

This document presents the methodology, results, and conclusions of the evaluation of effects of the 2019 Hope Bay AEMP. Detailed sampling and data analysis methodology, the quality assurance and quality control (QA/QC) program, and results of the 2019 AEMP (including ice thickness, temperature and dissolved oxygen (DO) profiles, water and sediment quality, phytoplankton biomass, and benthic invertebrate community) are provided in Appendix A. Water level and streamflow monitoring results and conclusions are provided in Appendix B. Supplemental information relevant to the 2019 analysis of effects (i.e., rationale for inclusion/exclusion of historical data, detailed statistical analysis methodology and results) is provided in Appendix C.

2. METHODS

2.1 Study Design

The 2019 program was conducted in accordance with the Plan (TMAC 2018). The study design is summarized in the following sections, and full details of the 2019 AEMP sampling methods are provided in Appendix A.

2.1.1 Sampling Locations

AEMP sampling locations were selected based on the potential for Project effects to occur during specific Project development and operational phases (TMAC 2018). Table 2.1-1 describes the Project Phases that sequentially ‘trigger’ or mark the beginning of monitoring in specific study lakes identified as being potentially affected by those Project phases (TMAC 2018). In 2019, mining operations continued at the Doris development, and construction began at the Madrid North development in April followed by a transition to operations in August. Construction had not commenced at the Madrid South or Boston developments as of 2019. Accordingly, sampling locations for the 2019 AEMP were only those sites triggered by Doris and Madrid North construction or operations activities (Table 2.1-1), with the exception of Wolverine Lake where water level monitoring was undertaken in 2019 to augment the baseline data for this lake. As described in the Plan, Wolverine Lake will only be included in the evaluation of effects once construction begins at Madrid South (TMAC 2018). Ice thickness data collected in April 2019 are relevant to a discussion of overwintering fish habitat from October 2018 to June 2019, which was before the start of Madrid North operations in August 2019. Therefore, the effects of Madrid North operations on overwintering fish habitat in the lakes triggered by Madrid North operations (Imniagut, P.O., and Ogama lakes; Table 2.1-1) will be evaluated in the 2020 AEMP for the 2019-2020 ice-covered season. The 2019 sites sampled, the aquatic components sampled, and Project infrastructure are shown in Figure 2.1-1 and summarized in Table 2.1-2.

2.1.2 2019 Sampling Schedule

Sampling in 2019 was conducted in accordance with the schedule outlined in the Plan (TMAC 2018). Specific sampling dates are provided in Table 2.1-3. In 2019, water levels in the study lakes were monitored continuously throughout the open-water season, with the exception of Doris Lake which was monitored year round. The sampling program included two sampling periods: under-ice sampling in April and open-water sampling in August. Temperature and dissolved oxygen profiles and water quality samples (e.g., nutrients and metals) were collected in both April and August, 2019. Phytoplankton biomass (as chlorophyll *a*), sediment quality, and benthic invertebrate samples were collected once in August.

2.2 Evaluation of Effects Methodology

For each variable subjected to an evaluation of effects, historical data collected in the Project area were incorporated into the analysis to determine if there are any apparent changes in the evaluated variables over time that might be attributable to Doris or Madrid North construction and operations activities. Trends in Reference Lake B were also examined alongside the trends in the exposure lakes (i.e., lakes potentially influenced by Project-related activities) to determine if detected changes over time are likely naturally occurring or Project-related.

Table 2.1-1: AEMP Sampling Locations, Monitoring Triggers, and Sampling Rationale, Hope Bay Project, 2019

Watershed	Study Area	Monitoring Trigger	Reason
Windy Watershed	Windy Lake	Doris, Madrid North, and Madrid South construction and operations	Water withdrawal for domestic use (potable water); drawdown from Madrid North mine groundwater inflow
	Glenn Lake	Doris, Madrid North, and Madrid South construction and operations	Glenn Lake is downstream of Windy Lake, therefore indirect effects may be observed in Glenn Lake as a result of drawdown and water withdrawal from Windy Lake
Doris Watershed	Wolverine Lake	Madrid South construction and operations	Drawdown from Madrid South mine groundwater inflow; inputs (e.g., dust deposition, runoff) due to proximity to infrastructure
	Patch Lake	Madrid North and South construction and operations	Drawdown from Madrid North and South mines groundwater inflow; inputs (e.g., dust deposition, runoff) due to proximity to infrastructure
	Imniagut Lake	Madrid North and South operations	Drawdown from Madrid North mine groundwater inflow
	P.O. Lake	Madrid North and South operations	Drawdown from Madrid North mine groundwater inflow
	Ogama Lake	Madrid North and South operations	Drawdown from Madrid North mine groundwater inflow
	Doris Lake	Doris, Madrid North, and Madrid South construction and operations; Boston operations	Water withdrawal for industrial use (e.g., dust suppression, wash bays and machine shops, process water); drawdown from Doris mine groundwater inflow; inputs (e.g., dust deposition, runoff) due to proximity to infrastructure
	Little Roberts Lake	Doris, Madrid North, and Madrid South construction and operations; Boston operations	Little Roberts Lake is downstream of Doris Lake Lake, therefore indirect effects may be observed in Little Roberts Lake as a result of drawdown and water withdrawal from Doris Lake
Aimaokatalok Watershed	Stickleback Lake	Boston construction and operations	Inputs (e.g., dust deposition, runoff) due to proximity to infrastructure
	Aimaokatalok Lake	Boston construction and operations	Inputs (e.g., dust deposition, runoff) due to proximity to infrastructure; permitted discharge
Reference Watershed	Reference Lake B	Doris, Madrid, and Boston construction and operations	Reference area for AEMP located outside of the zone of Project influence

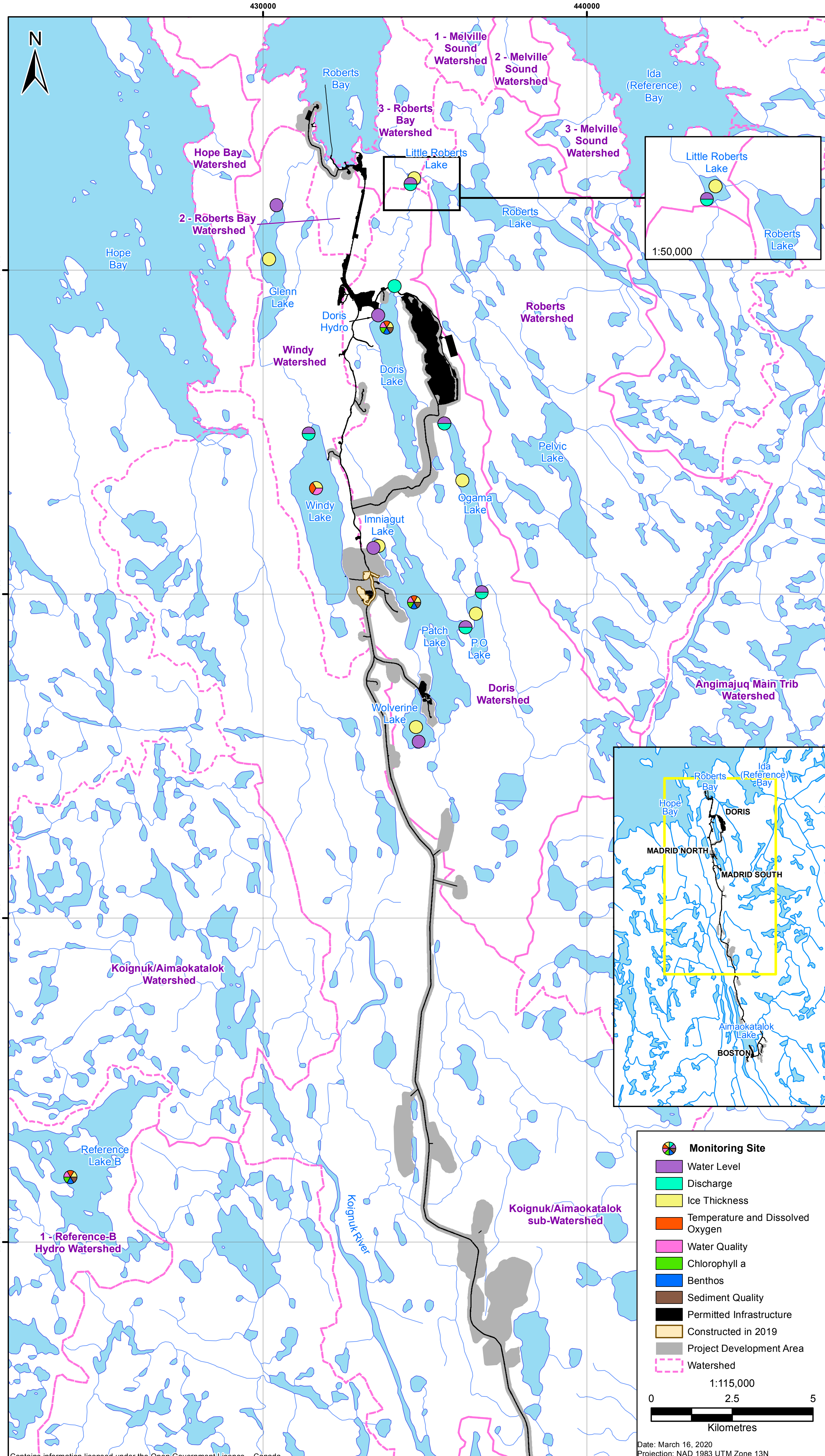


Figure 2.1-1: AEMP Sampling Locations, Hope Bay Project, 2019

Table 2.1-2: AEMP Sampling Locations and Monitoring Components, Hope Bay Project, 2019

Site	NAD83, UTM Zone 13N		Ice Thickness	Water Level	Discharge	Temperature and Dissolved Oxygen Profiles	Water Quality	Sediment Quality	Phytoplankton Biomass (as chlorophyll a)	Benthic Invertebrates
	Easting	Northing								
Windy Lake	431630	7553269	X			X	X			
Windy Outflow Hydro	431404	7554948		X	X					
Glenn Lake	430183	7560337	X							
Glenn Lake Hydro	430410	7562001		X						
Wolverine Lake	434720	7545890	X							
Wolverine Lake Hydro	434802	7545443		X						
Patch Lake	434660	7549739	X			X	X	X	X	X
Patch Outflow Hydro	436248	7548973		X	X					
Imniagut Lake	433559	7551490	X							
Imniagut Lake Hydro	433403	7551421		X						
P.O. Lake	436576	7549393	X							
P.O. Outflow Hydro	436749	7550055		X	X					
Ogama Lake	436148	7553517	X							
Ogama Outflow Hydro	435595	7555262		X	X					
Doris Lake	433815	7558222	X			X	X	X	X	X
Doris Lake-2 Hydro	433547	7558601		X						
Doris Creek TL-2 Hydro	434059	7559504			X					
Little Roberts Lake	434665	7562826	X							
Little Roberts Outflow Hydro	434548	7562652		X	X					
Reference Lake B	424050	7532000	X			X	X	X	X	X

Table 2.1-3: Sampling Schedule Summary, Hope Bay Project, 2019

Monitoring Component	Sampling Dates
Water Level	Continuous from June 2019 to September 2019 (except Doris Lake which was monitored year round)
Ice Thickness	April 6 to 18, 2019
Physical Limnology/Water Quality	April 13 to 14, 2019 August 15 to 18, 2019
Phytoplankton Biomass	August 15 to 18, 2019
Sediment Quality/Benthic Invertebrate Community	August 16 to 18, 2019

2.2.1 Variables Subjected to Effects Analysis

Table 2.2-1 presents the physical, chemical, and biological variables that were evaluated in 2019. Ice thickness and water level were included in the effects analysis to determine whether Project-related water use could affect overwintering fish populations and fish habitat, to confirm predictions from the Madrid-Boston FEIS, and to inform potential fisheries offsetting under applicable Fisheries Authorizations.

Table 2.2-1: Variables Subjected to Analysis of Effects, Hope Bay Project, 2019

Category	Variable
Water Level and Ice Thickness	Water Level Ice Thickness
Physical Limnology	Dissolved Oxygen Temperature
Water Quality	pH Total Suspended Solids (TSS) Turbidity Chloride Fluoride Total Ammonia Nitrate Nitrite Total Phosphorus Total Aluminum (Al) Total Arsenic (As) Total Boron (B) Total Cadmium (Cd) Total Chromium (Cr) Total Copper (Cu) Total Iron (Fe) Total Lead (Pb) Total Mercury (Hg) Total Molybdenum (Mo) Total Nickel (Ni) Total Selenium (Se) Total Silver (Ag) Total Thallium (Tl) Total Uranium (U) Dissolved Zinc (Zn)
Sediment Quality	Arsenic (As) Cadmium (Cd) Chromium (Cr) Copper (Cu) Lead (Pb) Mercury (Hg) Zinc (Zn)
Phytoplankton Biomass	Chlorophyll *a*
Benthic Invertebrates	Density Family Richness Simpson's Evenness Index Bray-Curtis Index

Water and sediment quality variables for which the Canadian Council of Ministers of the Environment (CCME) has established guidelines for the protection of aquatic life were included in the effects analysis (Table 2.2-1). The CCME issued a new water quality guideline for dissolved manganese in December 2019 (CCME 2019b). However, 2019 water quality samples were collected prior to the issuance of this manganese guideline, and dissolved manganese was not consistently measured in 2019. Dissolved manganese will be added to the list of water quality variables evaluated for the 2020 AEMP.

Biological variables commonly used as indicators of nutrient loading or other changes to freshwater environments such as phytoplankton biomass and benthic invertebrate community metrics were also evaluated (Table 2.2-1).

2.2.2 Overview of Assessment Methodology

For each variable subjected to an evaluation of effects, potential mine effects were assessed by a visual examination of graphical trends over time and, where possible, statistical analysis of trends over time. This section provides an overview of the statistical analysis methodology; a complete description of the statistical analyses, including detailed methodology and results, is presented in Appendix C. All statistical analyses were conducted using R version 3.6.1 (R Core Team 2019).

For Doris Lake and Little Roberts Lake, the large dataset (10+ years for most variables) and good temporal coverage allowed for the use of regression models to examine temporal trends over the monitoring period. Linear mixed effects (LME) regression or tobit regression analysis were used to test whether or not there was evidence of a temporal trend in an evaluated variable in Doris and Little Roberts lakes. Tobit regression was used when a moderate amount of data (between 10 and 50%) for a given variable within the study lake were below the analytical detection limit. The first step of the regression analysis was to determine whether there was evidence of a change in a given variable over time (i.e., is the slope of the trend over time significantly different from a slope of zero). This first step revealed whether or not there is a significant change in the variable over time, but did not give any information about the direction of the trend (e.g., increasing or decreasing). For most variables, only an increasing concentration over time would be considered an adverse mine effect (e.g., TSS, arsenic and copper in water or sediments), although for some variables, an increasing or decreasing trend would be considered adverse (e.g., phytoplankton biomass or pH in water). If the first step of the analysis determined that there was evidence of a significant change in a variable over time in Doris or Little Roberts lakes, the variable was carried forward to the second step of the statistical analysis where the exposure lake trend was compared to the trend in Reference Lake B. If the first step determined that the slope of the temporal trend was significantly different from zero, but the second step determined that the temporal trends in the exposure lake and Reference Lake B were not significantly different from each other, then it was concluded that the increasing or decreasing trend in Doris Lake or Little Roberts Lake was likely naturally occurring and not related to Project activities. If, on the other hand, the second step of the analysis revealed that the trend in Reference Lake B was significantly different from the trend in the exposure lake, the differential trend was carried forward as a potential mine effect and investigated further.

For the remaining exposure lakes including Patch and Windy lakes, there were fewer than 10 years of historical data available for most variables, and temporal coverage was more sporadic than Doris and Little Roberts lakes. For these lakes, the statistical analysis consisted of a two-step approach. The first step was to conduct a before-after analysis that compared a given variable’s mean concentration in the before (i.e., pre-2019) period to the after (i.e., 2019) period to determine whether there was a significant difference between time periods that could suggest a Project effect. If there was no significant difference between time periods, the analysis was concluded here; however, if there was a significant difference, the analysis proceeded to the second step: a before-after/control-impact (BACI) analysis. The BACI analysis compares the before-after trend at the exposure site with the before-after trend at a corresponding reference site.

If the BACI analysis determined that the before-after trends at the exposure and reference sites were not significantly different from each other, then the observed change was attributed to a natural process. However, if there was a significant difference in the before-after trends between reference and exposure sites, the differential trend was carried forward as a potential mine effect and investigated further.

There are several reasons unrelated to Project activities that there could be a significant, differential trend between exposure sites and the reference site. For example, trends over time could vary due to local differences in meteorological conditions, runoff from the natural landscape, or naturally variable inputs related to weathering and erosion. These changes would not necessarily affect all lakes in the region equally, and may not co-occur in exposure sites and Reference Lake B. A difference in trends between lakes may therefore not be conclusive evidence of a mine effect.

Statistical analysis can result in a type I error (finding a significant effect where an effect is not present, i.e., false positive) or a type II error (failing to find a significant effect where an effect is present, i.e., false negative). In the monitoring context, a false positive is more tolerable than a false negative. There is a direct trade-off between the two error rates, as reducing one type of error generally increases the other type of error. No correction for the large number of statistical tests was applied to the false positive (type I) error rate. Therefore, there may be false positives in the analyses that were conducted, which is a conservative and environmentally protective approach. For this AEMP, the unadjusted type I error rate (or significance level) was set to 0.05, indicating that approximately 5% of the time, statistical results will show a significant effect (i.e., p value of < 0.05) by random chance alone where an effect is not actually present.

For profile data (dissolved oxygen and temperature) and highly censored data (i.e., datasets in which greater than 50% of values were below detection limits), trends were evaluated using graphical analysis. Half of the analytical detection limit was substituted for values below detection limits for graphing purposes. If 100% of concentrations of a given variable were below the detection limit for the current assessment year (i.e., 2019), it was concluded that there was no evidence of an effect of the Project on that variable, and no further analyses were performed.

Any finding of a potential mine effect was interpreted using professional judgement and any other relevant information or supporting data to determine the likely cause of the effect. If the detected change was concluded to be a mine effect, the potential effect was screened against the conditions required to trigger a ‘low action level’ response through the Response Framework (see Section 2.2.3) to determine what follow-up actions may be needed. If the conditions for triggering a low action level response were not met, then there was concluded to be little to no apparent ecological risk to freshwater aquatic organisms, and monitoring would continue through the AEMP with no further follow-up action. However, if the conditions of a low action level response were met, follow-up actions would be triggered as described in the Response Framework (TMAC 2018). Figure 2.2-1 illustrates the steps of the AEMP analysis and how the AEMP analysis of effects feeds into the Response Framework.

2.2.3 Response Framework

Potential effects to the freshwater receiving environment are adaptively managed through the Response Framework described within the Plan (TMAC 2018). The Response Framework links the results of the AEMP effects analysis to management actions to avoid significant adverse effects arising from Project activities (Figure 2.2-1). The Response Framework acts as an early-warning system with defined action levels that initiate monitoring and/or management actions within an adequate timeframe to ensure that significant adverse effects to aquatic life do not occur (TMAC 2018).

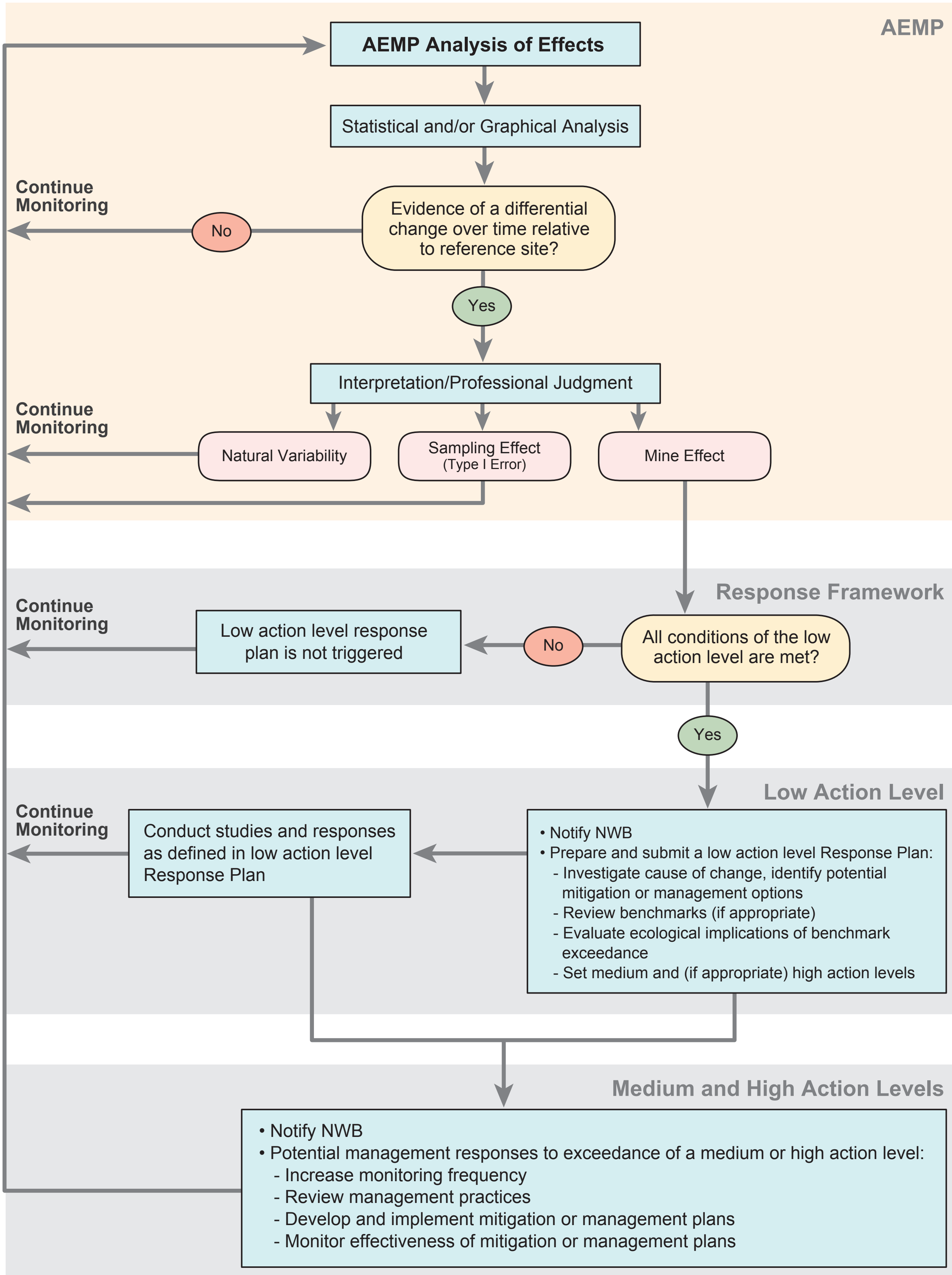


Figure 2.2-1: AEMP Analysis of Effects and Response Framework

Through the Response Framework, the results of the AEMP evaluation of effects are screened against a set of conditions that must be met to trigger a ‘low action level’ response. These conditions include comparisons of the magnitudes of the AEMP evaluated variables in the current assessment year (i.e., 2019) to baseline or reference conditions, as well as comparison to benchmarks that are considered to be protective of aquatic life. The following sections describe the low action level conditions by monitoring component.

2.2.3.1 Water and Sediment Quality

As described in the Response Framework (TMAC 2018), the four conditions that must be met to trigger a low action level response for water and sediment quality are:

1. identification of a statistically significant and potentially adverse change[1] from baseline conditions;
2. the concentration of the water or sediment quality variable is outside of the normal range based on baseline concentrations;
3. the concentration of the water or sediment quality variable exceeds 75% of a benchmark; and
4. if a potentially adverse change[1] is detected at the exposure site, there is an absence of a similar change at the reference site.

In some cases, it would not be possible for a given variable to meet all four conditions (e.g., because there is no information available for the reference site, or it is not possible to conduct a statistical analysis on the data). For this reason, in order to trigger a low action level, it is sufficient to show that all conditions are met excluding the ones that do not apply for a particular variable. For example, if all reference site concentrations of a particular variable are below the detection limit and it is not possible to statistically analyze the reference site data, Condition 4 would be excluded and a low action level would be triggered if the remaining conditions are met. Conversely, in order to conclude that a low action level is not triggered, it is sufficient to show that at least one condition is not met.

The benchmarks defined for water and sediment variables are the CCME water quality guidelines for the protection of aquatic life (Table 2.2-2; CCME 2019c) and the CCME sediment quality guidelines for the protection of aquatic life (Table 2.2-3; CCME 2019a). CCME guidelines are conservative benchmarks that are meant to be protective of all aquatic life (CCME 1999). Concentrations greater than the CCME guidelines are not necessarily indicative of an adverse ecological impact, as the derivation of a CCME guideline typically includes a safety factor to ensure that it is protective of even the most sensitive life stage of the most sensitive species over the long-term (CCME 2007). Setting the low action level condition to 75% of the water or sediment quality benchmark allows for adaptive management measures to be implemented before concentrations that could negatively affect the most sensitive freshwater life are reached.

2.2.3.2 Phytoplankton Biomass

Potential effects to phytoplankton biomass (as chlorophyll *a*) are evaluated against baseline and reference conditions. The following conditions must be met for an exceedance of the low action level for chlorophyll *a* concentration (TMAC 2018):

1. the identification of a statistically significant change from baseline concentrations;
2. the concentration of chlorophyll *a* is outside of the normal range based on baseline concentrations; and
3. if a change is detected at the exposure site, there is an absence of a similar change at the reference site.

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[1] For all evaluated sediment quality variables and most evaluated water quality variables, only an increase would be considered a potentially adverse change; however, for dissolved oxygen concentration, only a decrease would be considered potentially adverse, and for pH, a change in either direction would be considered potentially adverse.

Table 2.2-2: Long-term Water Quality Benchmarks for the Hope Bay Project

Water Quality Variable	Benchmark[a]
Dissolved Oxygen	9.5 mg/L (cold-water biota: early life stages); 6.5 mg/L (cold-water biota: other life stages)
Temperature	Thermal additions must not alter thermal stratification regime, turnover date(s), and maximum weekly temperature
pH	6.5 – 9.0
Total Suspended Solids (TSS)	Maximum average increase of 5 mg/L from background (for clear-flow waters; long-term exposure)
Turbidity	Maximum average increase of 2 NTUs from background (for clear-flow waters; long-term exposure)
Chloride	120 mg/L (long term)
Fluoride	0.12 mg/L
Total Ammonia-N	Temperature- and pH-dependent
Nitrate-N	3.0 mg/L (long term)
Nitrite-N	0.06 mg/L
Total Aluminum	0.005 mg/L (if pH < 6.5); 0.1 mg/L (if pH ≥ 6.5)
Total Arsenic	0.005 mg/L
Total Boron	1.5 mg/L
Total Cadmium	0.00004 mg/L for hardness (as $CaCO_3$) of < 17 mg/L; $10^{(0.83[\log(\text{hardness})]-2.46)}/1000$ mg/L for hardness of ≥ 17 to ≤ 280 mg/L; 0.00037 mg/L for hardness of > 280 mg/L (long term)
Total Chromium	0.001 mg/L for Cr (VI); 0.0089 mg/L for Cr (III)
Total Copper	0.002 mg/L for hardness (as $CaCO_3$) of < 82 mg/L; $e^{(0.8545[\ln(\text{hardness})]-1.465)}/1000$ mg/L for hardness of ≥ 82 to ≤ 180 mg/L; 0.004 mg/L for hardness of > 180 mg/L
Total Iron	0.3 mg/L
Total Lead	0.001 mg/L for hardness (as $CaCO_3$) of ≤ 60 mg/L; $e^{(1.273[\ln(\text{hardness})]-4.705)}/1000$ mg/L for hardness of > 60 to ≤ 180 mg/L; 0.007 mg/L for hardness of > 180 mg/L
Total Mercury	0.026 µg/L
Total Molybdenum	0.073 mg/L
Total Nickel	0.025 mg/L for hardness (as $CaCO_3$) of ≤ 60 mg/L; $e^{(0.76[\ln(\text{hardness})]+1.06)}/1000$ mg/L for hardness of > 60 to ≤ 180 mg/L; 0.15 mg/L for hardness of > 180 mg/L
Total Selenium	0.001 mg/L
Total Silver	0.00025 mg/L
Total Thallium	0.0008 mg/L
Total Uranium	0.015 mg/L
Dissolved Zinc	$e^{(0.947[\ln(\text{hardness})]-0.815[\text{pH}]+0.398[\ln(\text{DOC})]+4.625)}/1000$ mg/L for hardness of 23.4 to 399 mg/L, pH of 6.5 to 8.13, and DOC of 0.3 to 22.9 mg/L; 0.007 mg/L for hardness (as $CaCO_3$) of 50 mg/L, pH of 7.5, DOC of 0.5 mg/L

Notes:
[a] Source: CCME Freshwater Water Quality Guidelines for the Protection of Aquatic Life, Summary Table (CCME 2019c).

Table 2.2-3: Long-term Sediment Quality Benchmarks for the Hope Bay Project

Sediment Quality Variable	Benchmark[a] (mg/kg)	
	ISQG	PEL
Arsenic	5.90	17.0
Cadmium	0.60	3.50
Chromium	37.3	90.0
Copper	35.7	197
Lead	35.0	91.3
Mercury	0.170	0.486
Zinc	123	315

Notes:
ISQG = Interim Sediment Quality Guideline; PEL = Probable Effects Level
[a] Source: CCME Freshwater Sediment Quality Guidelines for the Protection of Aquatic Life, Summary Table (CCME 2019a).

2.2.3.3 Benthic Invertebrates

Potential effects to benthic invertebrate community indicators (i.e., total density, Simpson's evenness index, taxa richness, and Bray-Curtis similarity index) are evaluated against baseline and reference conditions, as well as a critical effects size as recommended by Environment Canada for Environmental Effects Monitoring (EEM) studies (Environment Canada 2012). The following conditions must be met to trigger a low action level response for benthic invertebrate community indicators (TMAC 2018):

1. the identification of a statistically significant decrease in density, evenness, richness, or similarity from baseline conditions;
2. the benthos indicator is less that the normal range based on baseline conditions;
3. if a decrease is detected at the exposure site, the absence of a similar decrease at the reference site; and
4. the magnitude of the decrease exceeds the critical effects size of ± 2 within-reference-area standard deviations (SD), as recommended by Environment Canada (2012).

2.2.4 Historical Data

Physical, chemical, and biological data have been collected in the Doris and Madrid development areas of the Hope Bay Project since 1995. Figures 2.2-2 to 2.2-6 show the specific locations in the 2019 AEMP study lakes where historical physical limnology (Figure 2.2-2), water quality (Figure 2.2-3), sediment quality (Figure 2.2-4), phytoplankton biomass (Figure 2.2-5), and benthic invertebrate data (Figure 2.2-6) were collected. Historical samples have been collected from a variety of locations and depths within the AEMP study lakes. The frequency and seasonal timing of sampling has also varied since 1995, as have sampling methodologies. For these reasons, professional judgment was used in the selection of historical data that could be used in the analysis of effects. Key determining factors for the inclusion of historical data in the evaluation of effects included the proximity of historical sampling sites to AEMP sampling sites and sampling methodology. Full details of the rationale used in the selection of historical data that were included in evaluation of effects are provided in Appendix C.

Historical data used or considered for the effects analyses were from the following reports: Klohn-Crippen Consultants Ltd. (1995), Rescan (1997, 1998, 1999, 2001, 2010, 2011, 2012, 2013), RL&L Environmental Services Ltd. and Golder Associates Ltd. (2003), Golder Associates Ltd. (2005, 2006, 2007, 2008, 2009), ERM Rescan (2014), and ERM (2015, 2016, 2017a, 2017b, 2018, 2019b, 2019c).

Figure 2.2-2
Physical Limnology Sampling Sites in Patch Lake, Doris Lake, Windy Lake, and Reference Lake B, 1995 to 2019

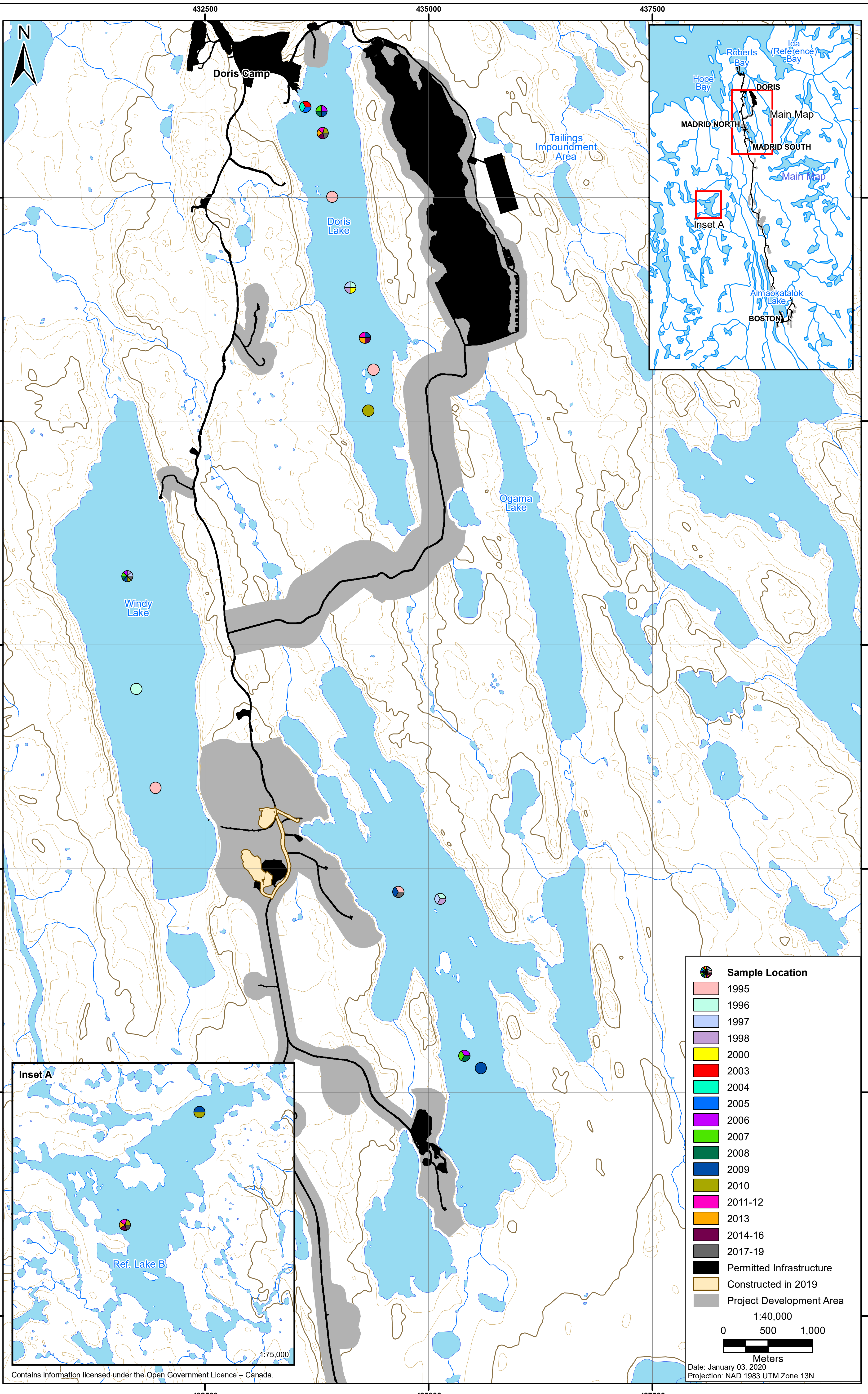


Figure 2.2-3
Water Quality Sampling Sites in Patch Lake, Doris Lake, Windy Lake, and Reference Lake B, 1995 to 2019

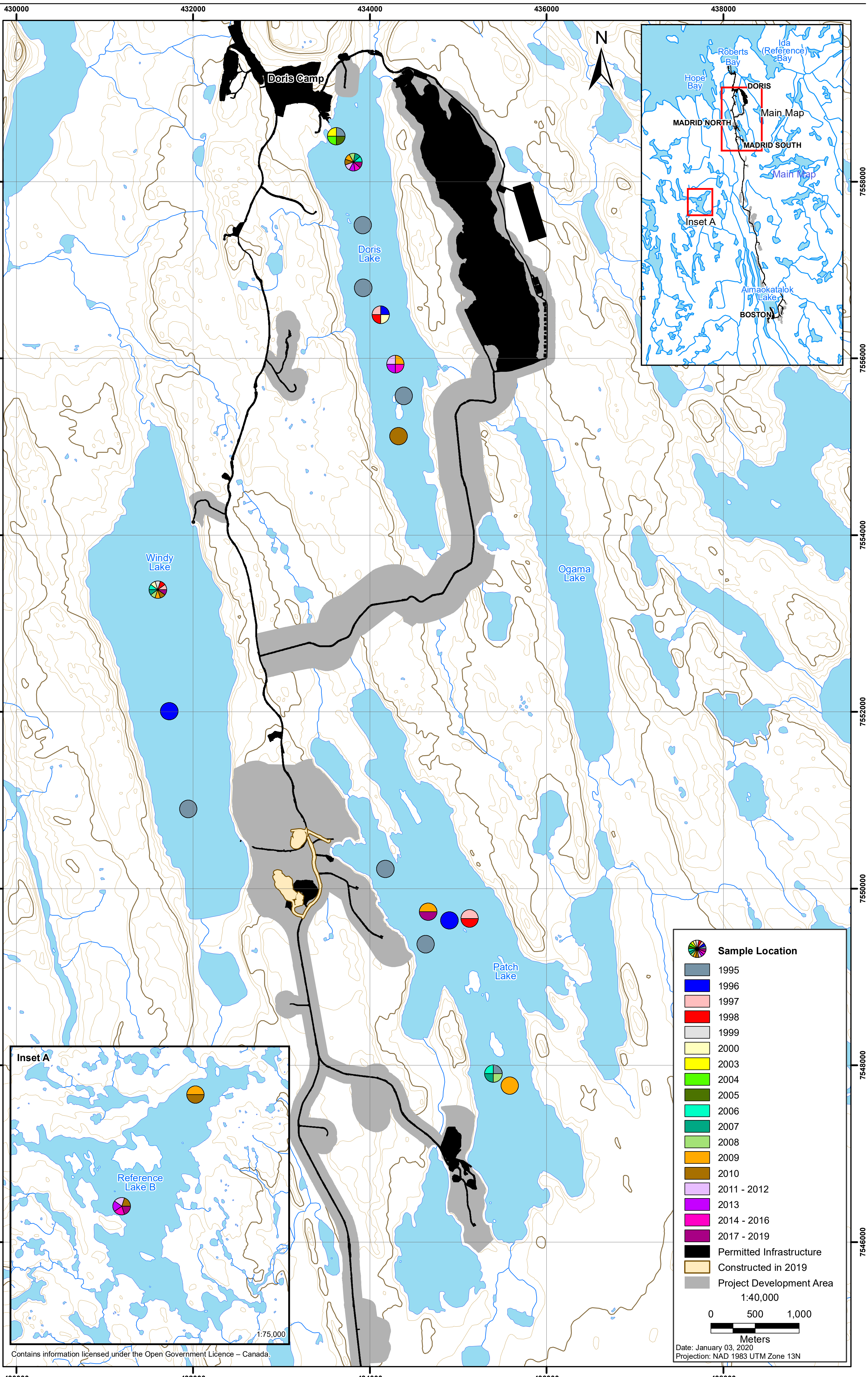


Figure 2.2-4
Sediment Quality Sampling Sites in Patch Lake, Doris Lake, and Reference Lake B, 1996 to 2019

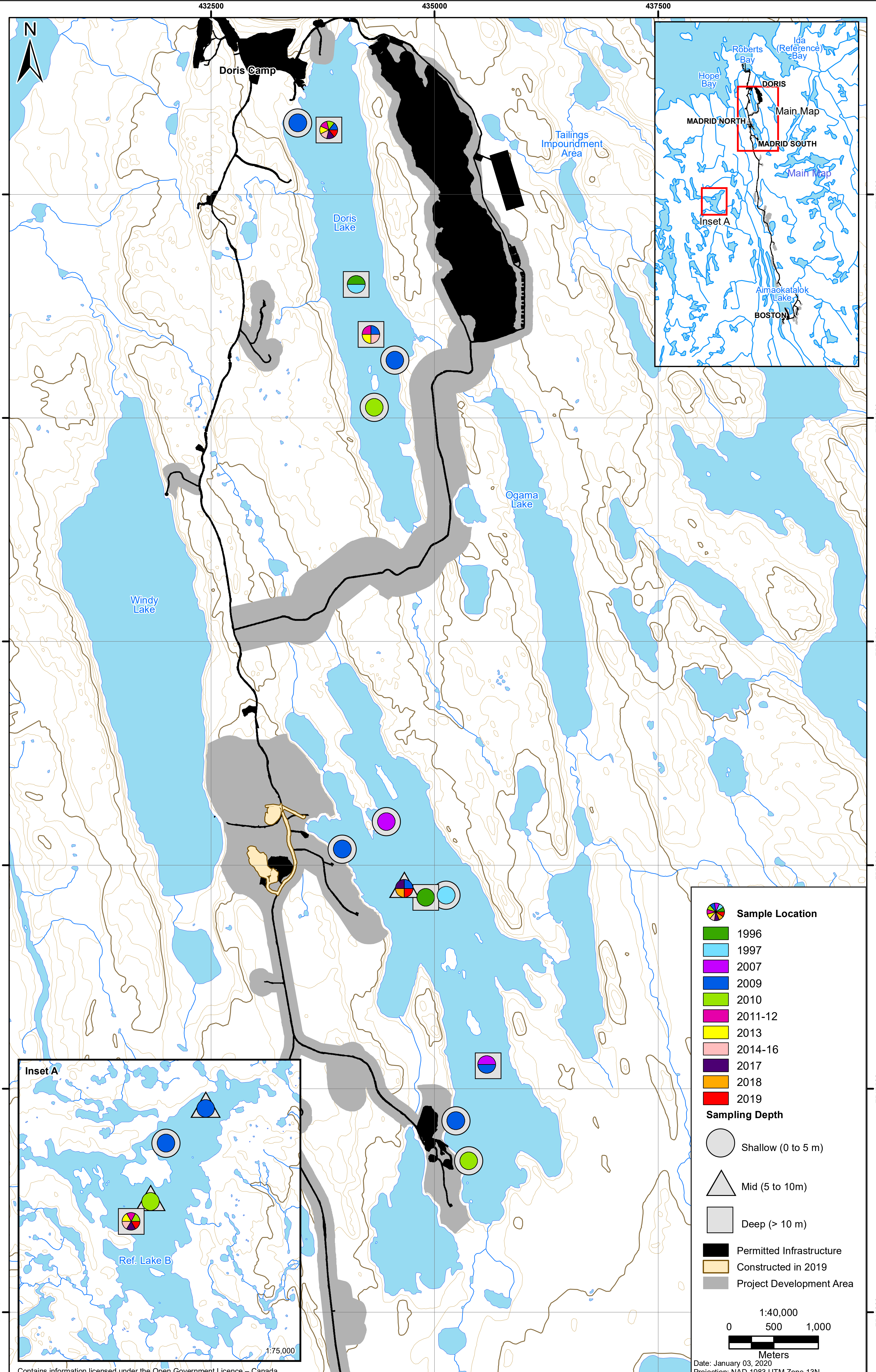


Figure 2.2-5
Phytoplankton Biomass (as Chlorophyll a) Sampling Sites in Patch Lake, Doris Lake, and Reference Lake B, 1997 to 2019

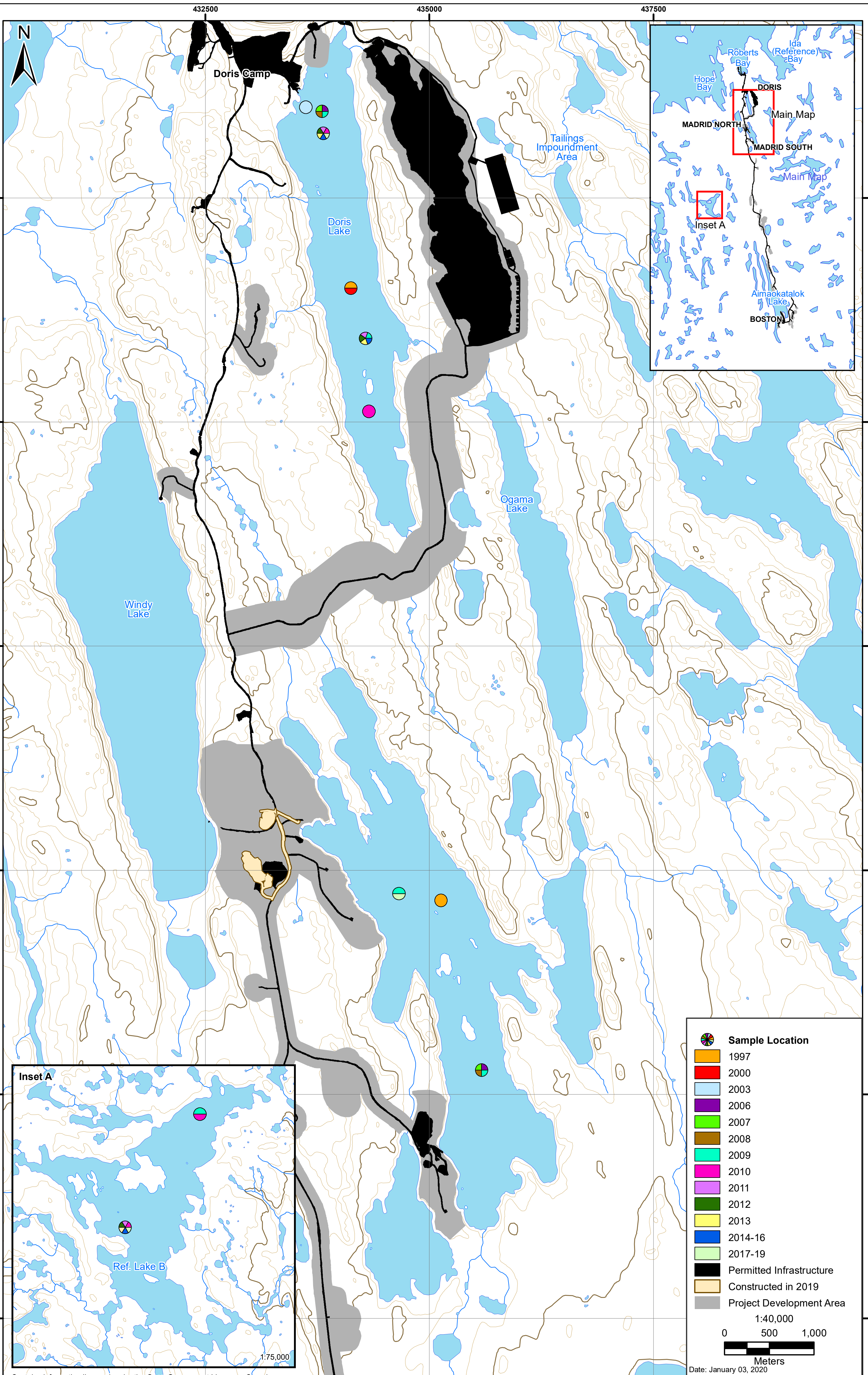
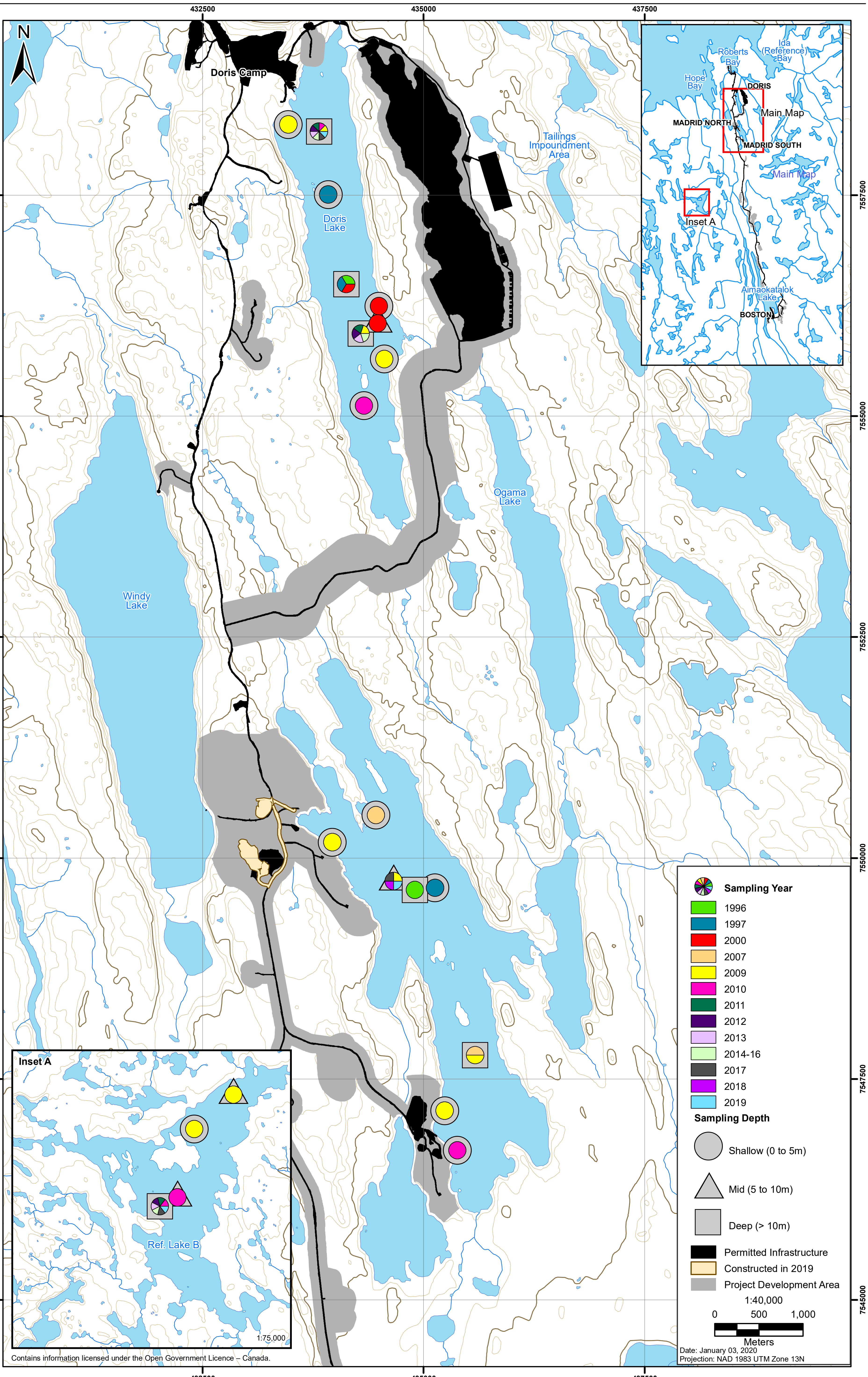


Figure 2.2-6
Benthic Invertebrate Sampling Sites in Patch Lake, Doris Lake, and Reference Lake B, 1996 to 2019



3. EVALUATION OF EFFECTS

In 2019, data were collected from several exposure lakes potentially affected by Project activities and one reference lake (Reference Lake B) to evaluate the potential for Project-related effects to the following components of the freshwater environment:

- water level and ice thickness;
- physical limnology (dissolved oxygen and water temperature);
- water quality;
- sediment quality;
- phytoplankton biomass; and
- benthic invertebrates.

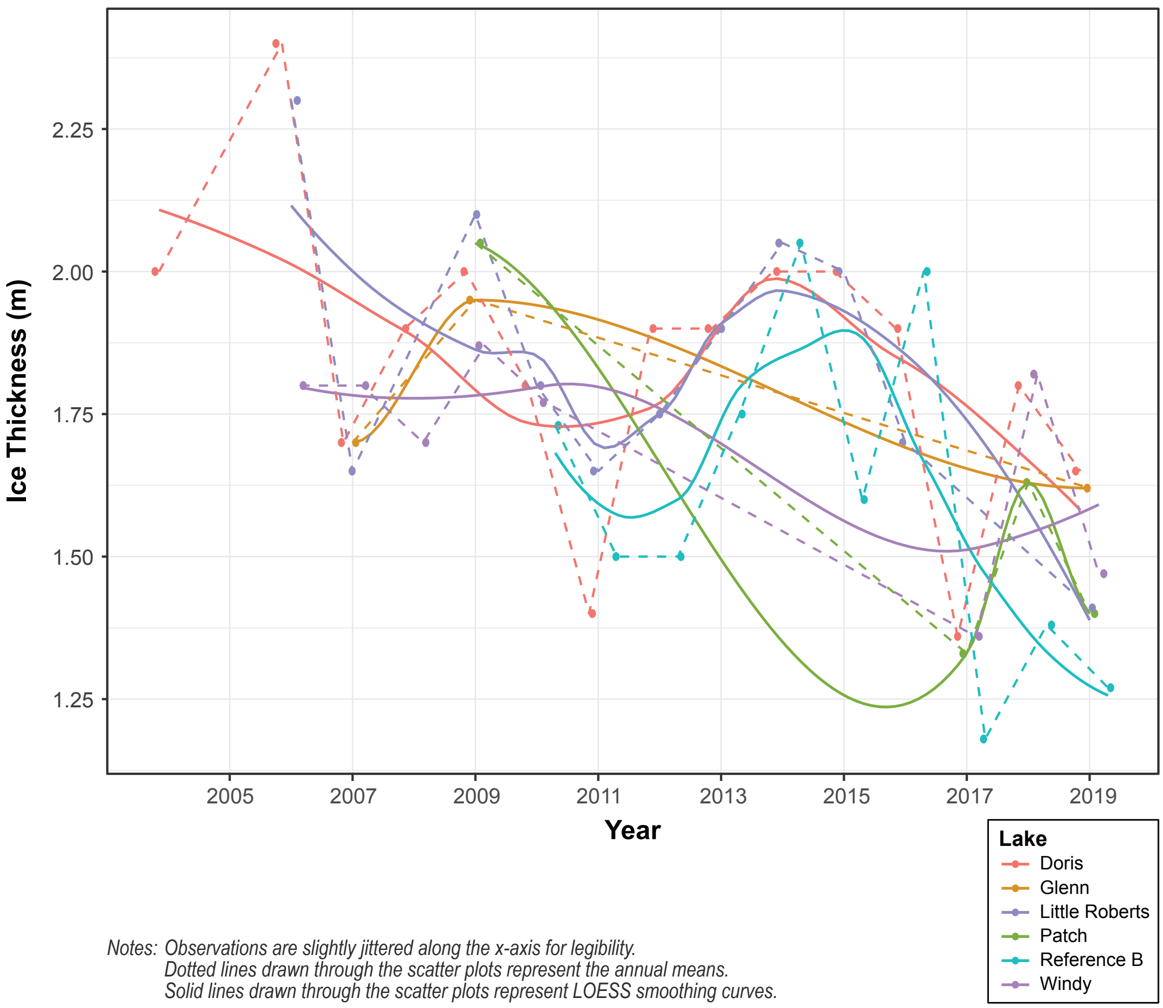
Physical, chemical, and biological data from 2019 (the third year of Doris operations and the first year of Madrid North construction/operations) were evaluated against historical data. The evaluation of effects was based on graphical and statistical analyses of trends over time within each exposure lake and between exposure and reference lakes, comparisons to baseline conditions, and professional judgement. If the evaluation of effects concluded that there may be a Project-related effect on a component of the freshwater environment, and that the Project-related effect met the conditions for triggering a low action level response, further actions would be taken as described in the Response Framework within the Plan (TMAC 2018).

Details of the 2019 AEMP sampling program (including methodology and results) are provided in Appendix A, water level and streamflow monitoring results and conclusions are provided in Appendix B, and details of the statistical analyses (including rationale for inclusion/exclusion of historical data, methodology, and results) are provided in Appendix C.

3.1 Water Level and Ice Thickness

Project-related water use, water withdrawal, and underground mining could cause a reduction in lake level and streamflow, which could adversely affect fish habitat. Water withdrawal from lakes may cause a decrease in the availability and/or suitability of overwintering or spawning habitat under the thick winter ice cover or potentially expose overwintering eggs to air, resulting in mortality (Cott 2007; TMAC 2017b). A reduction in discharge at lake outflow streams may result in reduced availability and/or suitability of fish habitat for migration, rearing, and spawning (TMAC 2017b). If habitat loss does occur as a consequence of Project activities, fisheries offsetting under applicable Fisheries Authorizations may be implemented to compensate for the loss of fish habitat.

In the Madrid-Boston FEIS (TMAC 2017b), maximum baseline variation in open-water lake surface elevation and maximum baseline ice thickness were summed to derive a maximum naturally occurring reduction in under-ice lake surface elevation. Overwintering fish populations could be at risk if the volume of water under the ice is reduced compared to the baseline range. Project activities are predicted to potentially affect the water level and discharge from some exposure lakes, but are not predicted to affect lake ice thickness (TMAC 2017b). However, the thickness of lake ice affects the availability of under-ice habitat available to fish, as there may be less overwintering habitat available to fish if the ice cover is thicker than the normal baseline range. In 2019, the April ice thickness measured in each evaluated lake was consistently lower than the maximum baseline thickness reported in the FEIS (Figure 3.1-1), and the statistical analysis found no evidence of a significant change in ice thickness over time in Doris Lake ($p = 0.254$) or Little Roberts Lake ($p = 0.0633$), nor of a change in mean ice thickness from historical years to 2019 in Windy ($p = 0.204$), Glenn ($p = 0.517$), or Patch lakes ($p = 0584$; Appendix C). Therefore, 2019 under-ice habitat availability was not diminished by unusually thick ice cover.



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.1-1: Ice Thickness in AEMP Monitored Lakes, Hope Bay Project, 2004 to 2019

The April 2019 ice-thickness represents the ice cover for the winter of 2018-2019, and is relevant to a discussion of overwintering fish habitat during the ice-covered period from approximately October 2018 to June 2019. Both the 2018 annual lake level fluctuation in Doris Lake and the 2018 open-water season lake level fluctuation in Windy Lake were within the baseline ranges for these lakes (ERM 2019a). As well, there was no reduction in annual runoff measured at Doris Creek compared to the historical average (ERM 2019a). Taken together, the 2018 water levels and streamflow measurements and the April 2019 ice thickness data suggest that there was no reduction in overwintering fish habitat. Table 3.1-1 presents a summary of the evaluation of effects on overwintering fish habitat (water level and ice thickness).

Data from 2019 show that there was as yet no evidence for a Project-related reduction in lake water levels and streamflow in 2019 following the onset of Madrid North construction and operation (see Appendix B for lake level and streamflow analysis and conclusions). April 2020 ice thickness data will be interpreted together with the 2019 water level results in the 2020 AEMP to determine whether there is any indication of Project effects on the overwintering fish habitat in exposure lakes over the October 2019 to June 2020 ice-covered season.

Table 3.1-1: Summary of Evaluation of Effects to Water Level and Ice Thickness, Hope Bay Project, 2018 to 2019

Exposure Lake	Evidence of Increase in 2019 April Ice Thickness Relative to Baseline?[a]	Evidence of Project-related Change in Lake Level in 2018? (ERM 2019a)	Evidence of Project-related Change in Lake Level in 2019? (Appendix B)
Windy Lake	No	No	No
Glenn Lake	No	No	No
Patch Lake	No	No	No
Doris Lake	No	No	No
Little Roberts Lake	No	No	No

Notes:
[a] Conclusion based on statistical analysis and comparison to baseline conditions.

3.2 Physical Limnology

Dissolved oxygen and temperature profiles were collected in Windy Lake, Patch Lake, Doris Lake, and Reference Lake B in April and August of 2019. Potential Project-related effects to dissolved oxygen concentrations and water temperature are discussed in the following sections.

3.2.1 Dissolved Oxygen

Potential Project-related effects on dissolved oxygen concentrations were evaluated using under-ice dissolved oxygen profiles since concentrations are typically lowest during the ice-covered period, and this season therefore represents the ‘worst case scenario’ for dissolved oxygen levels. The potential for effects to under-ice dissolved oxygen concentration was assessed by graphical analysis. To conclude that the Project had an effect on under-ice dissolved oxygen concentrations, dissolved oxygen profiles from 2019 had to be noticeably different from all available baseline years. Profiles and inter-annual trends at the reference site were also considered to aid in the assessment of whether deviations from baseline conditions are likely naturally occurring or Project related. An adverse Project effect on under-ice season dissolved oxygen concentrations would be manifested as a decrease in dissolved oxygen concentration, since inputs of nutrients or organic carbon to a lake can fuel productivity and oxygen consumption through the microbial respiration of organic matter. If dissolved oxygen concentrations drop below the

CCME guidelines for the protection of cold water aquatic life of 9.5 mg/L for early life stages or 6.5 mg/L for other life stages (CCME 2019c), this could negatively affect fish populations.

In all three exposure lakes, 2019 under-ice dissolved oxygen concentrations were within range or slightly higher than historical concentrations, including concentrations from the 1990s and 2000s before the start of any construction or operation activities in the Project area (Figure 3.2-1).

Dissolved oxygen concentrations measured in April 2019 remained above the CCME guidelines of 6.5 and 9.5 mg/L throughout the water columns of Windy and Patch lakes (Figure 3.2-1). In Doris Lake, dissolved oxygen concentrations remained above CCME guidelines in the upper 10 m of the water column, and dropped to slightly below the 9.5 mg/L guideline level at depth (Figure 3.2-1). Dissolved oxygen concentrations were most variable at Reference Lake B, where the highest (17.7 mg/L) and lowest (1.4 mg/L) dissolved oxygen concentrations were recorded. Concentrations dropped to below both the 9.5 mg/L and the 6.5 mg/L CCME guidelines in Reference Lake B (Figure 3.2-1). A decrease in under-ice dissolved oxygen concentrations at depth is a common and naturally occurring phenomenon in seasonally stratified lakes, and has been observed nearly every year at Doris Lake and Reference Lake B (Figure 3.2-1).

Overall, there was no evidence of an adverse effect of Project activities on under-ice dissolved oxygen concentrations in Windy, Patch, and Doris lakes compared to concentrations recorded during baseline years and concentrations in Reference Lake B.

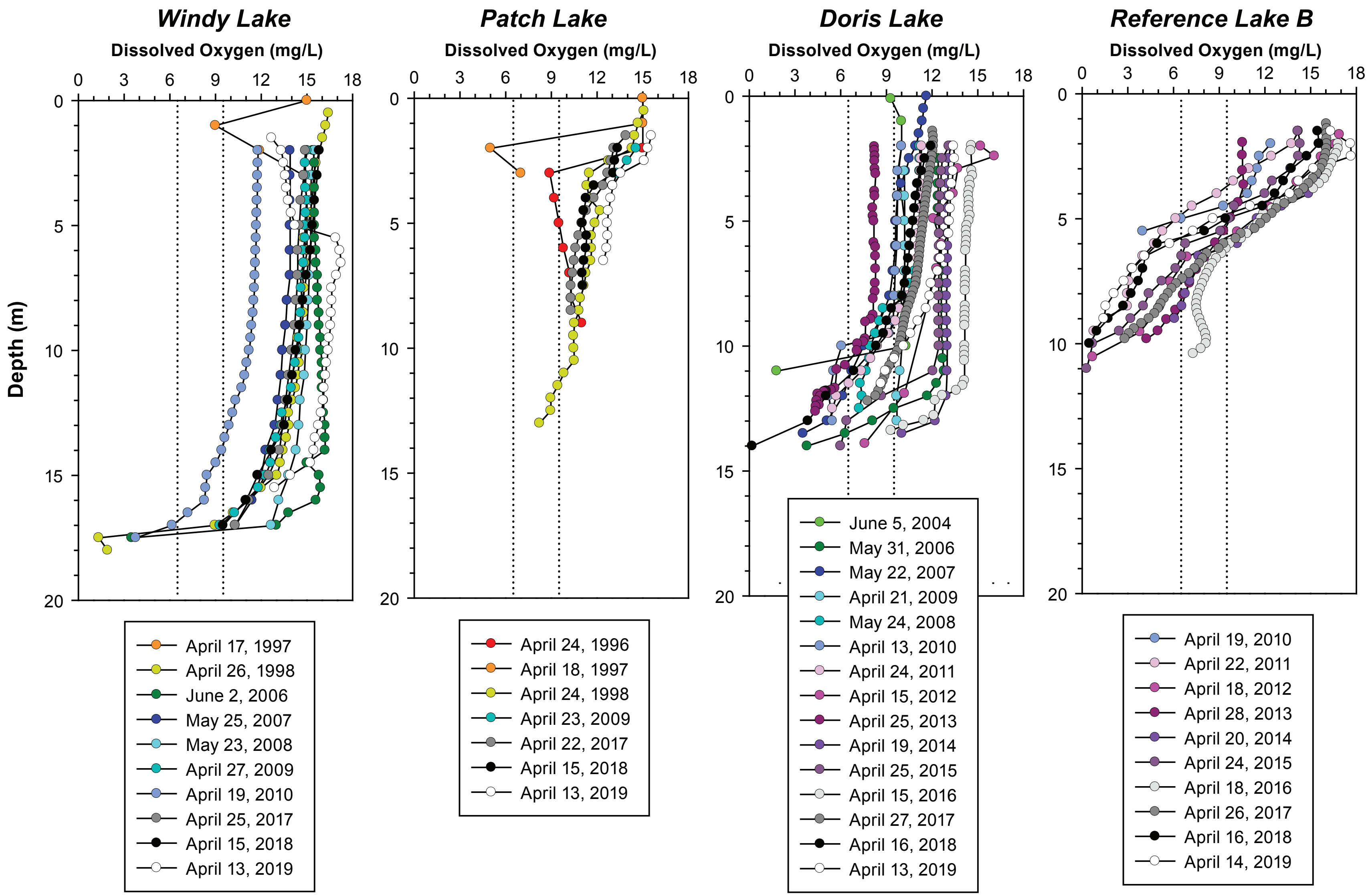
3.2.2 Temperature

The Project is not anticipated to have any effect on the water temperature, thermal stratification regime, or turnover dates of exposure lakes, as there are no plans to release heated effluent to the freshwater environment. However, temperature is included in the evaluation of effects because there is a CCME guideline for temperature, and temperature is included in the Plan as a variable that will be evaluated.

Temperature profiles in exposure lakes have historically been collected during the ice-covered season (typically in April, but sometimes in May or early June) and open-water seasons (July, August, and/or September). For the purposes of the evaluation, historical under-ice profiles from April, May, and June were included in the plots for comparisons to April 2019 profiles; however, as water temperatures can be highly variable over the open-water season, only historical profiles collected in August were included for comparisons to August 2019 profiles. The warmest water temperatures typically occur in August; therefore, assessing under-ice and August (open-water) temperature profiles should cover the entire range of water temperatures in the exposure lakes. The potential for effects on water temperature was assessed by graphical analysis. To conclude that the Project had an effect on under-ice or August water temperature, 2019 temperature profiles had to be noticeably different from all available baseline years. Temperature profiles and inter-annual trends at the reference site were also considered.

Throughout the majority of the lake water columns, under-ice water temperatures in 2019 were generally similar to historical temperatures (Figure 3.2-2); however, at some near-surface depths in both exposure and reference lakes, temperatures of 0 to 0.1°C were among the coolest temperatures recorded. As this trend was evident at both exposure and reference lakes, there is no indication that the Project had any effect on under-ice water temperatures.

Historical and 2019 August profiles show that water columns in the exposure and reference lakes were generally well mixed during the open-water season, with little vertical heterogeneity in temperature (Figure 3.2-3). In each study lake, August temperatures were within the range of baseline temperatures, and there was no evidence of a Project-related change in water temperature.



Note: Vertical dotted lines represent CCME freshwater dissolved oxygen guidelines for the protection of cold water aquatic life: 9.5 mg/L for early life stages; 6.5 mg/L for other life stages.

Figure 3.2-1: Under-ice Dissolved Oxygen Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1996 to 2019

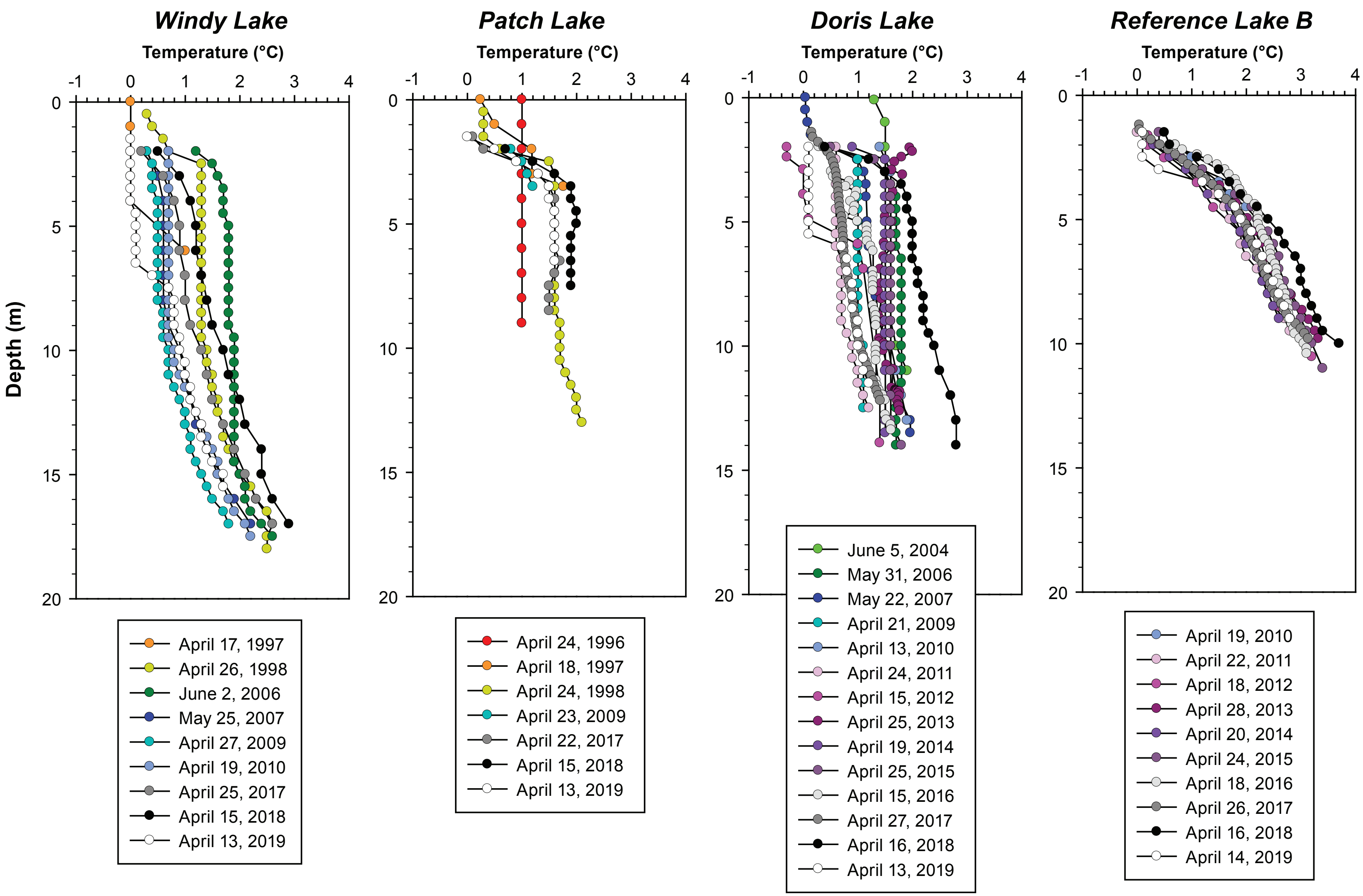


Figure 3.2-2: Under-ice Temperature Profiles in AEMP Monitored Lakes, Hope Bay Project, 1996 to 2019

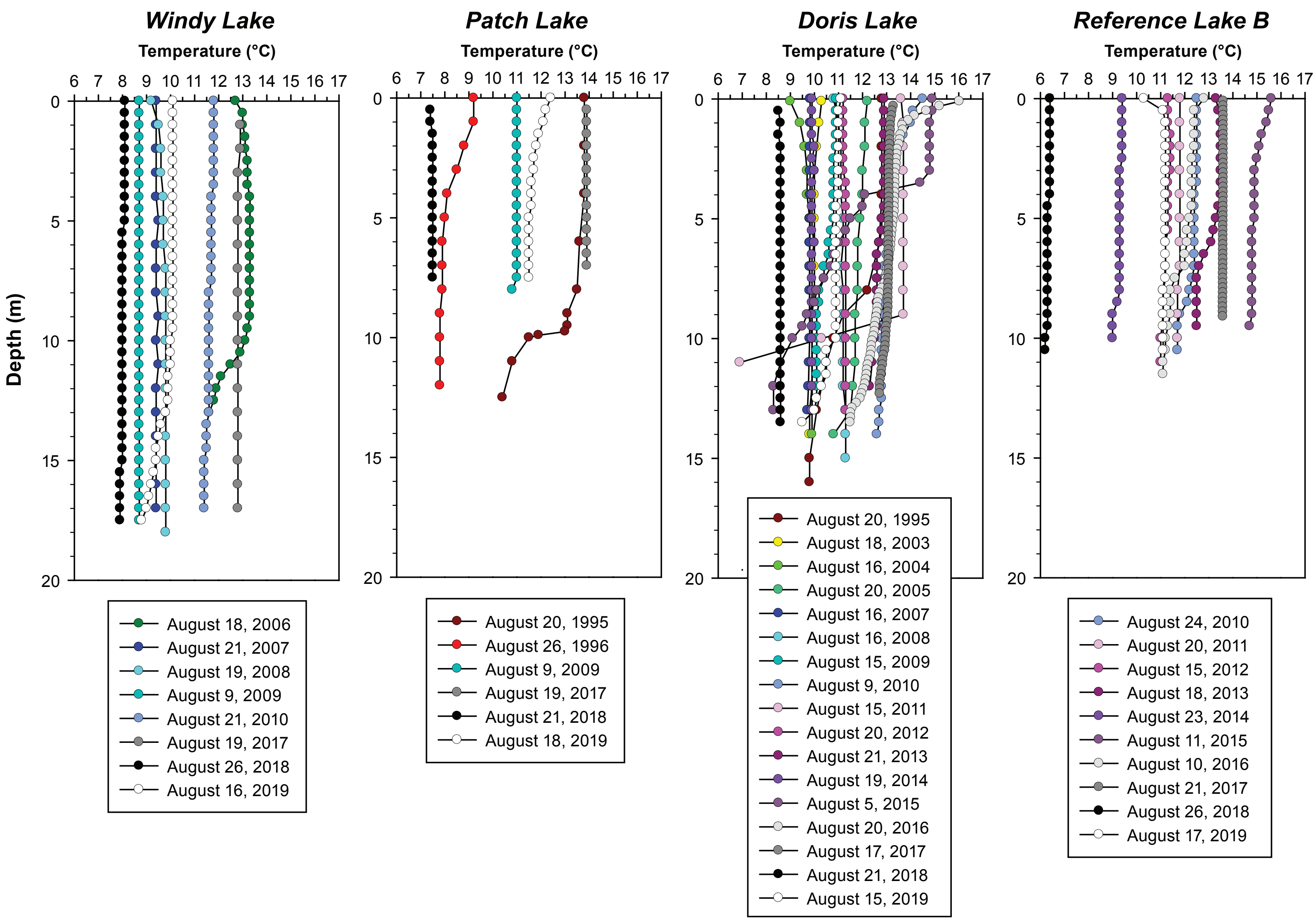


Figure 3.2-3: Open-water (August) Temperature Profiles in AEMP Monitored Lakes, Hope Bay Project, 1996 to 2019

3.2.3 Physical Limnology Summary

Overall, there was no evidence of a Project-related change in either under-ice dissolved oxygen concentrations or water temperatures in exposure lakes. A low action level response was not triggered for temperature or dissolved oxygen concentrations because there were no apparent adverse changes to these variables, and 2019 values were generally within the normal range based on baseline concentrations or followed trends observed at the reference site when values fell outside of the range of baseline levels. Table 3.2-1 presents a summary of the evaluation of effects for these physical components.

Table 3.2-1: Summary of Evaluation of Physical Limnology Effects for Hope Bay Project, 2019

Variable	Evidence of an Adverse[a] Change?		Conclusion of Effect [b]		Low Action Level Triggered?	
	Under-ice	Open-water	Under-ice	Open-water	Under-ice	Open-water
Dissolved Oxygen	No	-	No effect	-	No	-
Temperature	No	No	No effect	No effect	No	No

Notes:

[a] *For water temperature, a change in any direction is considered to be an adverse effect. For under-ice dissolved oxygen concentration, only a decrease is considered to be an adverse effect.*

[b] *Conclusion of effect is based on graphical analysis and professional judgment.*

3.3 Water Quality

Water quality samples were collected from three exposure lakes (Doris, Patch, and Windy lakes) and one reference lake (Reference Lake B) in 2019. A subset of water quality variables (see Table 2.2-1) was evaluated to determine whether Project activities resulted in adverse changes to water quality. Statistical and graphical analyses were used to determine if there are apparent changes in water quality variables in the Project area over time. The statistical analyses consisted of a trend analysis for Doris Lake and a before-after or BACI analysis for Patch and Windy Lakes (see Section 2.2-2 for an overview of the assessment methodology). For Patch and Windy lakes, water quality data collected in the years up to and including 2018 are considered to represent baseline conditions prior to the start to Madrid North construction activities in 2019. For Doris Lake, water quality data collected in the years up to and including 2009 are considered to represent baseline conditions prior to the start of Doris construction activities in 2010.

Trends in the exposure lakes were directly compared to trends in Reference Lake B to establish whether changes in water quality are likely naturally occurring or Project-related. Water quality trends over the open-water and ice-covered seasons were assessed separately since seasonal changes could confound the identification of inter-annual trends.

Water quality variable concentrations were compared to CCME water quality guidelines for the protection of aquatic life (CCME 2019c) to assess whether existing concentrations could adversely affect freshwater biota. CCME guidelines were also applied as water quality benchmarks as per the Response Framework, and 2019 data were screened against 75% of the benchmark as well as baseline and reference conditions as described in Section 2.2.3.1 to determine whether a low action level response was triggered.

The following sections present the evaluation of effects for water quality variables. Water quality data for 2019 are presented in Appendix A, and all statistical analysis results are presented in Appendix C.

3.3.1 pH

pH levels in all three exposure lakes were relatively constant over the last decade, and 2019 pH levels were within the CCME guideline range of 6.5 to 9.0 (Figure 3.3-1). In both Windy and Patch lakes, the before (pre-2019) mean pH was not significantly different from the after (2019) mean for both the under-ice ($p = 0.489$ for Windy Lake; $p = 0.473$ for Patch Lake) and open-water seasons ($p = 0.423$ for Windy Lake; $p = 0.488$ for Patch lake).

In Doris Lake, there was a significant non-zero slope for pH in both the under-ice ($p = 0.0013$) and open-water seasons ($p = 0.0002$), likely driven by the lower and more variable pH levels recorded between 1995 and 2008 compared to the relatively consistent pH from 2009 to 2019 (Figure 3.3-1). However, there was no significant difference in trends between Doris Lake and Reference Lake B for either the under-ice ($p = 0.957$) or open-water seasons ($p = 0.814$), suggesting that any change in pH over time in Doris Lake was unrelated to the Project.

There was no evidence for a Project-related change in pH in Windy, Patch, or Doris lakes, and a low action level response was not triggered for pH.

3.3.2 Total Suspended Solids

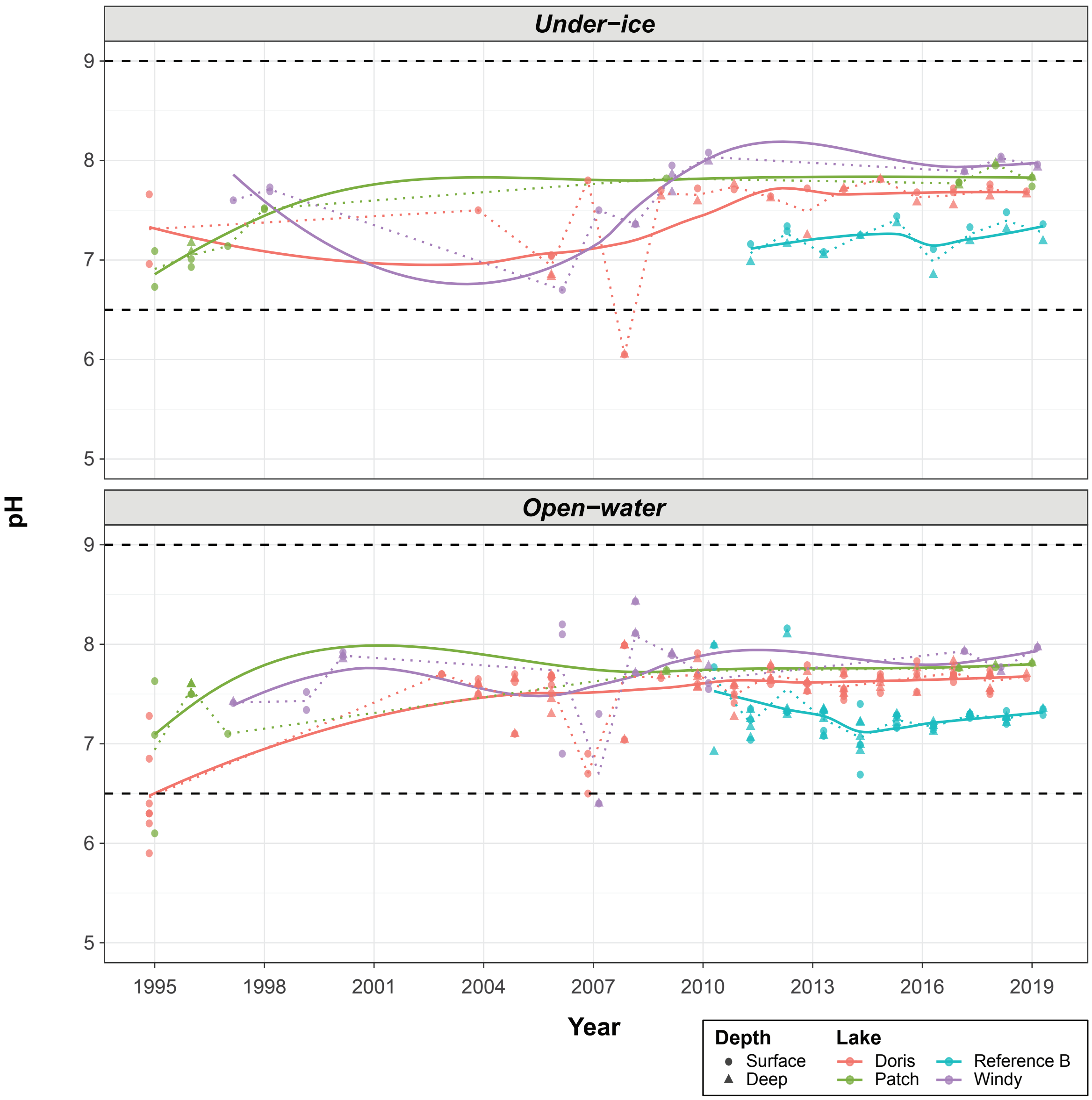
During the 2019 ice-covered season, concentrations of TSS in Windy and Patch lakes were below the detection limit (<1.0 mg/L), and there was concluded to be no Project effect on under-ice TSS concentrations in these lakes. In Doris Lake, under-ice TSS concentrations were inter-annually variable (Figure 3.3-2), and there was a statistically significant non-zero trend over time ($p = 0.0042$). Although it was not possible to compare this trend to the trend in Reference Lake B because of the high proportion of TSS concentrations that were below detection limits in the reference lake dataset, the trend in Doris Lake did not show an overall increase over time and 2019 concentrations were within the range of pre-2010 baseline concentrations (Figure 3.3-2). Therefore, there was no indication of an adverse change in under-ice TSS levels in Doris Lake.

During the open-water season, TSS concentrations in Doris Lake were consistent over time and the TSS trend did not differ from a slope of zero ($p = 0.774$). Similarly, there was no change in the mean TSS concentration between before (pre-2019) and after (2019) periods in Patch Lake ($p = 0.552$). This indicates that the release of water containing high concentrations of suspended sediments to the shoreline of Patch Lake in June 2019 (see Section 1.4) did not result in any residual change in TSS concentrations by the time AEMP open-water sampling was undertaken in August 2019. Open-water TSS concentrations in Windy Lake in 2019 remained below the detection limit (<1.0 mg/L).

Overall, there was no evidence for a Project-related adverse change in TSS concentrations in Windy, Patch, or Doris lakes, and a low action level response was not triggered. 2019 TSS concentrations in the evaluated exposure lakes remained within baseline ranges and CCME guidelines, which are based on background levels.

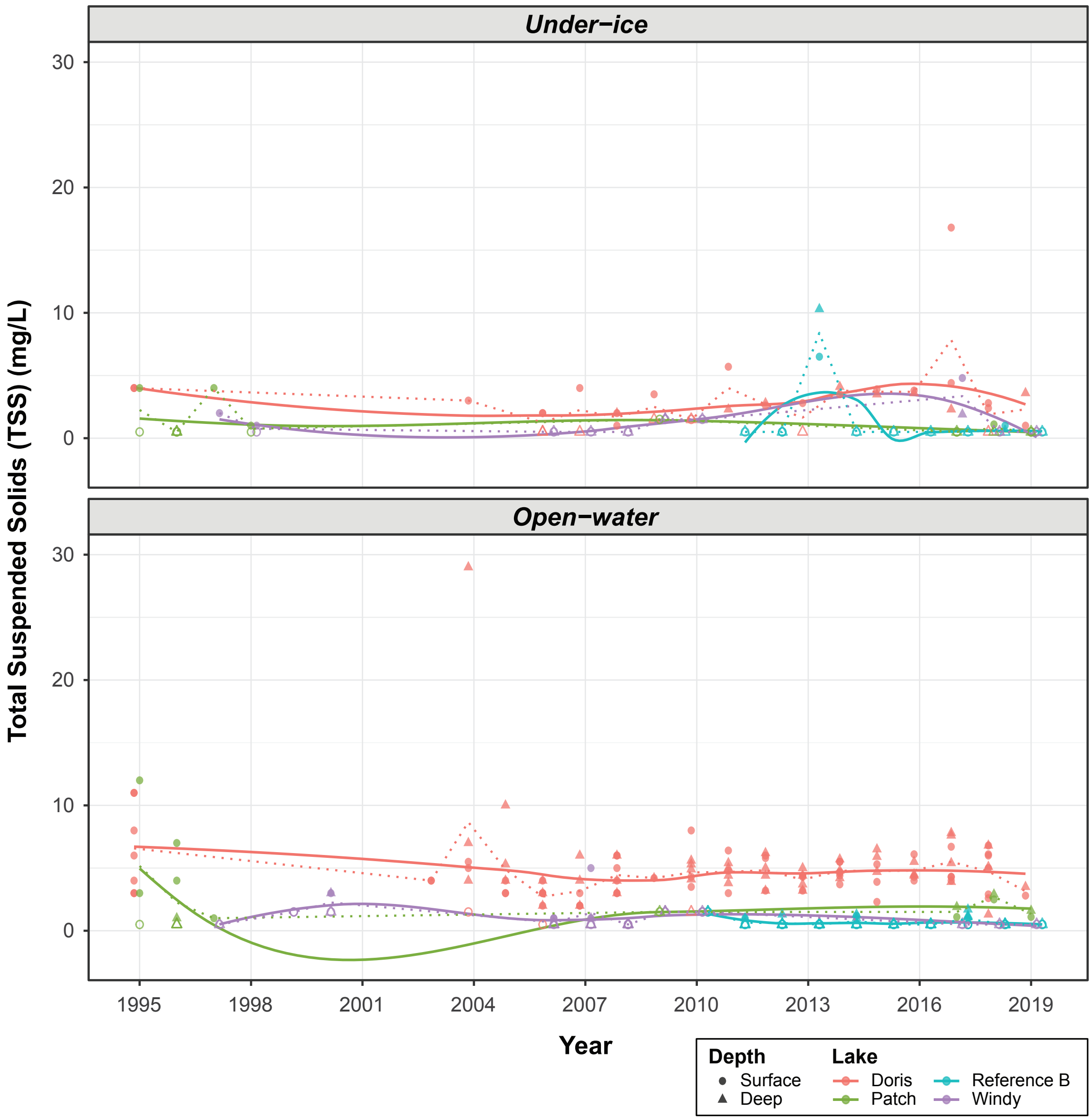
3.3.3 Turbidity

2019 turbidity levels in Windy and Patch lakes were similar to or slightly lower than historical levels (Figure 3.3-3). In Windy Lake (under-ice) and Patch Lake (under ice and open water), the statistical analyses confirmed that there were no significant differences in means between before and after periods (Windy Lake: 0.223 for under ice; Patch Lake: $p = 0.453$ for under ice, $p = 0.324$ for open water). There was a significant change from before to after periods in Windy Lake over the open-water season ($p = 0.0014$), and this change was significantly different from the trend in Reference Lake B ($p = 0.0039$); however, the change in turbidity from historical years to 2019 was a decrease, which does not represent an adverse effect.



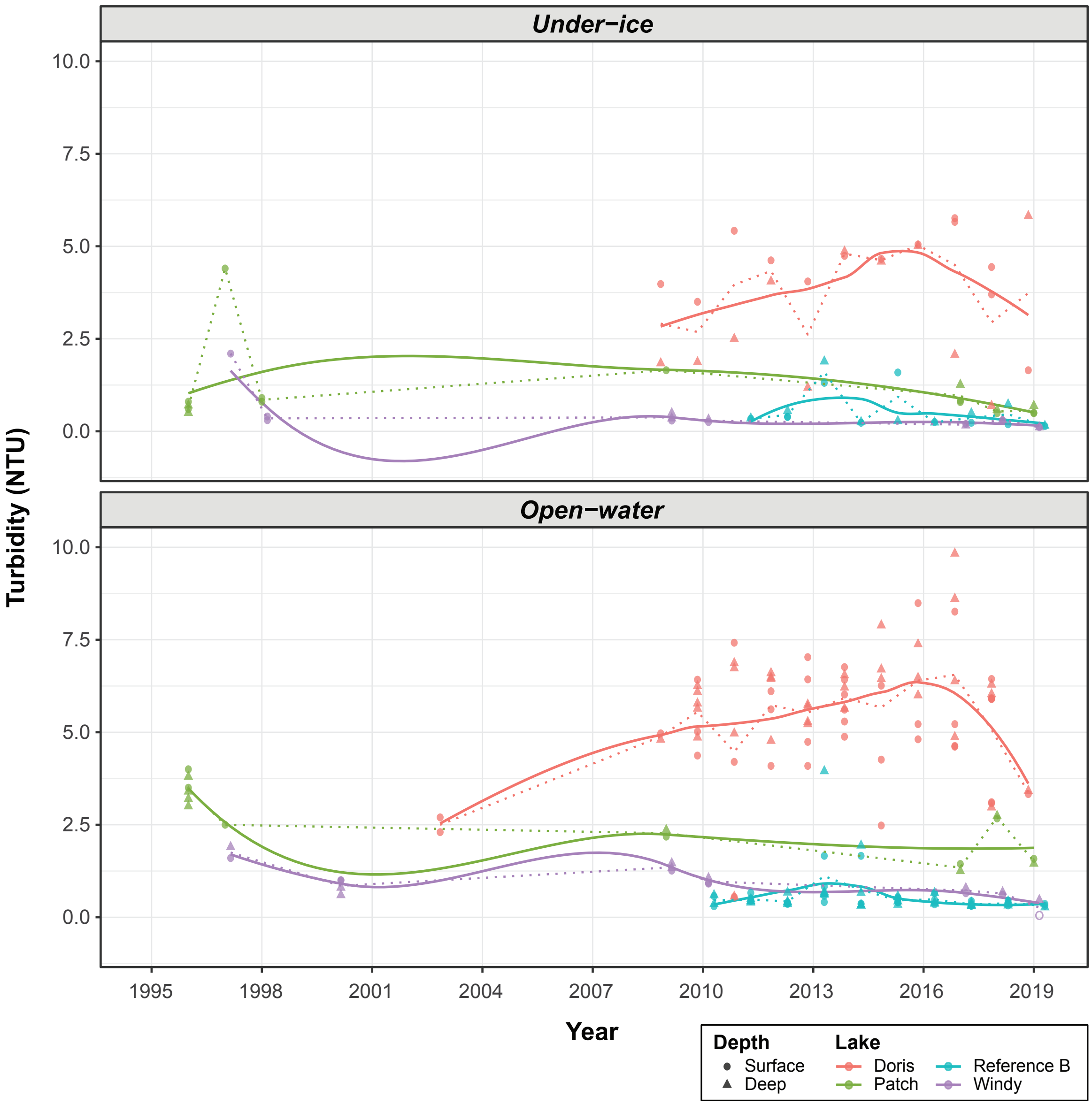
Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline pH range (6.5 to 9.0).

Figure 3.3-1: pH in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.3-2: Total Suspended Solids Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.3-3: Turbidity in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

Trends in both under-ice and open-water turbidity in Doris Lake, as indicated by the local regression (LOESS) smoothing curves, increased slightly over time between baseline years and 2016, followed by a decrease between 2016 and 2019 (Figure 3.3-3). However, turbidity levels were inter- and intra-annually variable, and these apparent trends were not statistically significant (i.e., trends not significantly different from slope of zero; $p = 0.344$ for under ice and $p = 0.156$ for open water).

There was no evidence for a Project-related increase in turbidity in any of the exposure lakes, and the low action level was not triggered. 2019 turbidity levels in the evaluated lakes remained within CCME guidelines, which are based on background levels.

3.3.4 Chloride

In both Windy and Patch lakes, 2019 chloride concentrations were within the range of baseline concentrations (Figure 3.3-4), and the before-after analyses confirmed that 2019 means were not significantly different from historical means (Windy Lake: $p = 0.632$ for under ice, $p = 0.725$ for open water; Patch Lake: $p = 0.953$ for under ice, $p = 0.961$ for open water). Thus there was no evidence of a Project-related change in chloride concentrations in these lakes.

For Doris Lake, the statistical analyses showed that the under-ice and open-water chloride trends were significantly different from a slope of zero ($p < 0.0001$ for both under ice and open water) and from the corresponding trends in Reference Lake B ($p < 0.0001$ for both under ice and open water). However, graphical analysis suggests that under-ice and open-water chloride concentrations in Doris Lake have not increased relative to baseline levels, and concentrations have been decreasing in recent years (Figure 3.3-4). Therefore, there was no evidence of a Project-related adverse change in chloride concentrations in Doris Lake over time.

All 2019 chloride concentrations in the monitored lakes remained below the CCME guideline of 120 mg/L. Although some or all 2019 chloride concentrations in Windy and Patch lake were higher than 90 mg/L (i.e., 75% of the water quality benchmark), the low action level was not triggered because there was no apparent increase in chloride concentrations relative to baseline conditions.

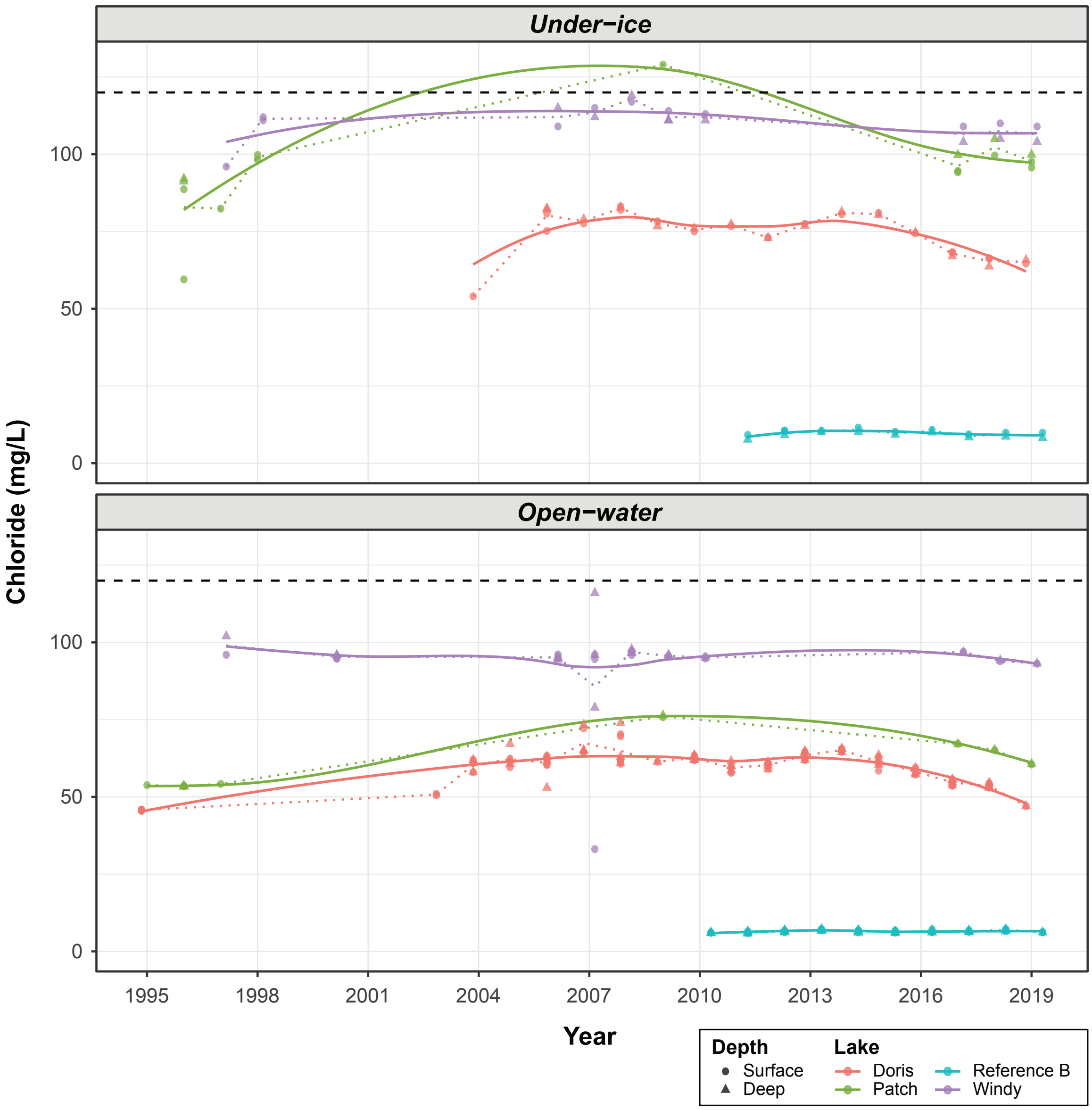
3.3.5 Fluoride

Fluoride concentrations remained relatively unchanged over the last decade in each of the exposure lakes (Figure 3.3-5). The statistical analyses confirmed this consistency over time, as the mean pre-2019 fluoride concentrations in Windy and Patch Lake were not significantly different from 2019 means (Windy Lake: $p = 0.933$ for under ice, $p = 0.911$ for open water; Patch Lake: $p = 0.880$ for under-ice, $p = 0.776$ for open-water), and the fluoride trends in Doris Lake were not significantly different from a slope of zero ($p = 0.874$ for under ice, $p = 0.741$ for open water). Therefore, there was no evidence of a Project-related effect on fluoride concentrations in exposure lakes.

All 2019 fluoride concentrations were below the CCME guideline of 0.12 mg/L and 75% of the water quality benchmark (0.09 mg/L), and a low action level was not triggered.

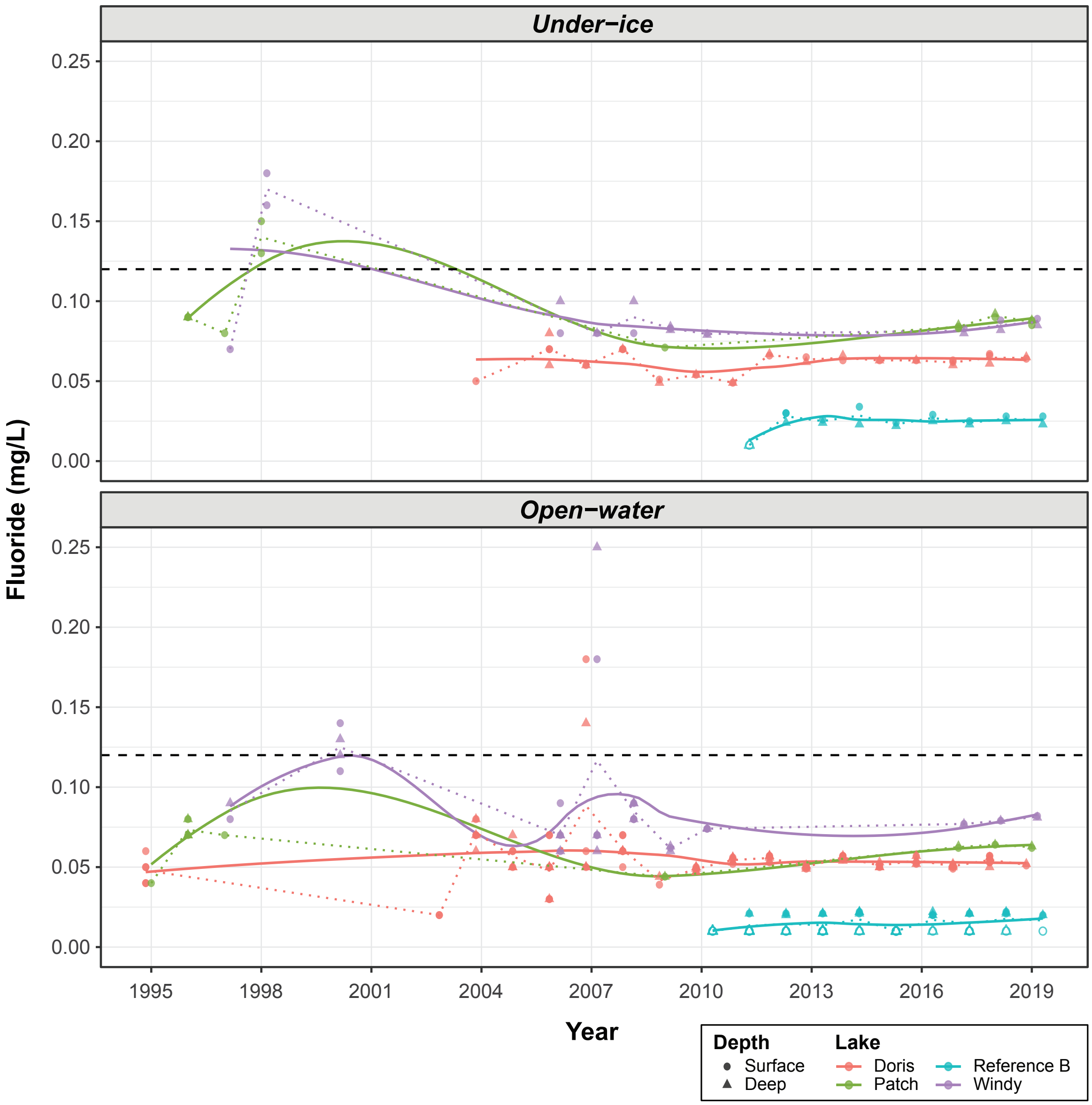
3.3.6 Total Ammonia

Concentrations of total ammonia in Windy and Patch lakes changed little over time (Figure 3.3-6), and the statistical analyses confirmed that pre-2019 mean concentrations did not differ significantly from 2019 means (Windy Lake: $p = 0.224$ for under ice, $p = 0.755$ for open water; Patch Lake: $p = 0.858$ for under ice, open-water analysis not performed because of the high proportion of censored data).



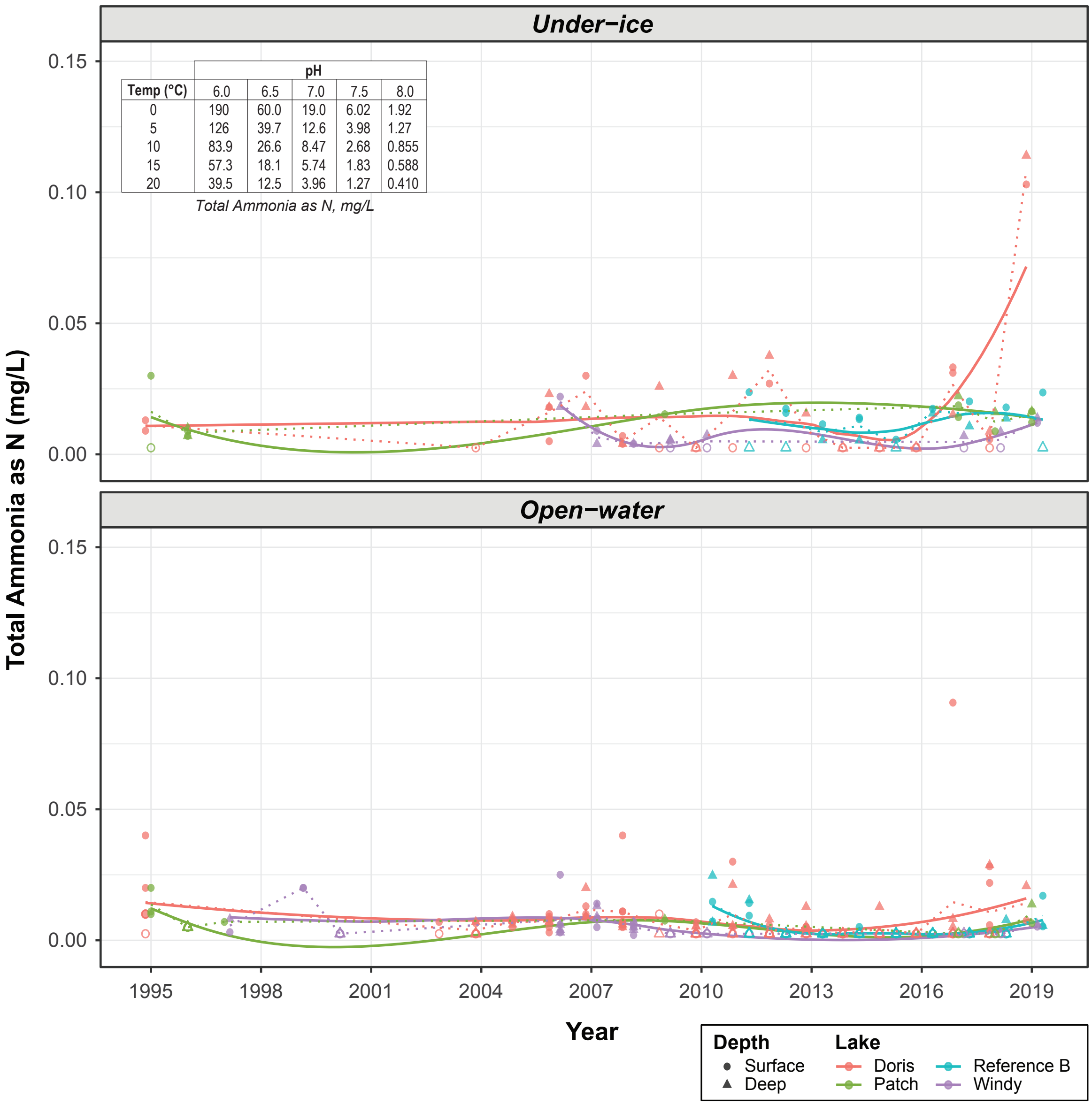
Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME long-term guideline for chloride (120 mg/L).

Figure 3.3-4: Chloride Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME interim guideline for fluoride (0.12 mg/L).

Figure 3.3-5: Fluoride Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



	pH				
Temp (°C)	6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Inset table shows the pH- and temperature-dependent CCME guideline for total ammonia as N.

Figure 3.3-6: Total Ammonia Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

In Doris Lake, the 2019 under-ice total ammonia concentrations of 0.103 mg ammonia-N/L (surface) and 0.114 mg ammonia-N/L (deep) were higher than previous years, as under-ice concentrations from 1995 to 2018 ranged from < 0.005 mg/L to 0.0376 mg/L (Figure 3.3-6). The trend analysis showed that there was a significant non-zero trend in ammonia concentrations in Doris Lake ($p = 0.0017$), which differed from the trend in Reference Lake B ($p = 0.0469$). This increase in ammonia was observed only during the ice-covered season; there was no observed change in concentrations over time during the open-water season (Figure 3.3-6; statistical analysis not performed because of the high proportion of censored data).

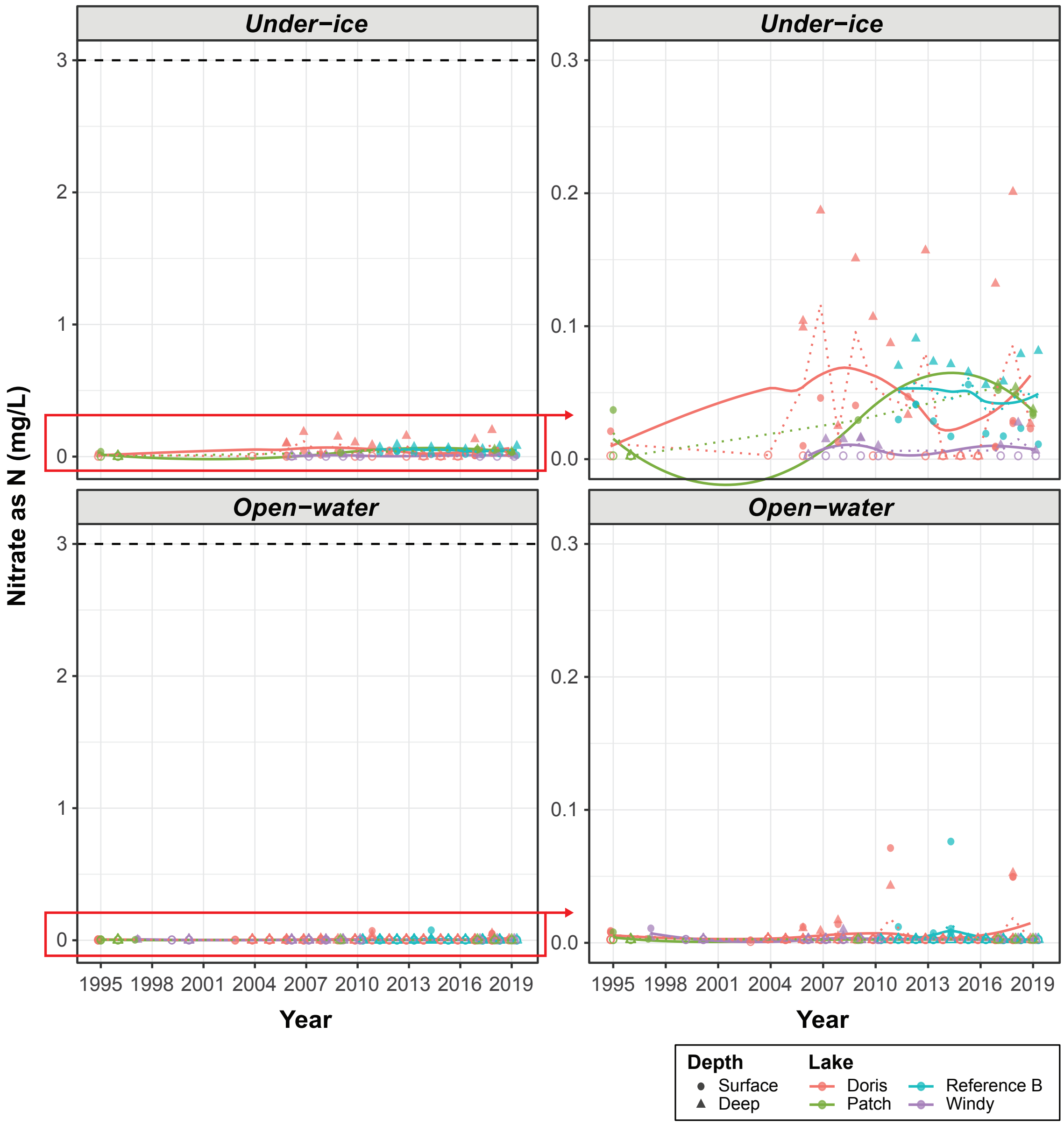
The QA/QC results indicated potential ammonia contamination during the 2019 field season (Section A.4.1 of Appendix A). Concentrations of total ammonia were above the analytical detection limit in the April equipment blank (0.0139 mg ammonia-N/L) and the August field blank (0.0694 mg ammonia-N/L). Contamination may have partially contributed to the high under-ice concentrations; however, it is unlikely that the April concentrations in Doris Lake would be entirely attributable to contamination as concentrations in the Doris Lake samples were approximately an order of magnitude higher than concentrations in the April equipment blank, and the concentrations in the two samples collected from Doris Lake were similar to each other and higher than all other April samples collected from the other lakes (if sample contamination were the cause of elevated measurements, it is unlikely that both Doris Lake samples would have been equally contaminated given that the samples were collected in separate Niskin casts).

It is possible that the increase in under-ice ammonia concentrations in Doris Lake could be related to the Project. An increase in ammonia concentrations relative to baseline levels was predicted in the FEIS for waterbodies in the Doris Watershed downstream of Doris Lake (Doris Creek and Little Roberts) during Project construction and operation phases (TMAC 2017b). Ammonium nitrate fuel oil (ANFO) is commonly used as an explosive in the mining industry, and ammonia could enter waterbodies through surface water runoff or air emissions. High ammonia concentrations would not be expected to persist in a lake once the ice cover melts and primary productivity increases, because ammonia tends to be rapidly taken up by primary producers. Indeed, by the time open-water season water quality samples were collected in August 2019, ammonia concentrations had dropped to more typical levels seen in Doris Lake (Figure 3.3-6). Elevated under-ice ammonia concentrations could have fueled higher phytoplankton biomass levels in Doris Lake early in the open-water season; however, the chlorophyll *a* concentrations measured in August 2019 were within the range of historical levels (Section 3.5). Thus, the elevated ammonia concentrations were short term in duration and did not have an apparent residual effect on phytoplankton biomass.

The CCME guideline for total ammonia is temperature- and pH- dependent. In Doris Lake, the CCME ammonia guideline for the mean under-ice pH of 7.5 (Figure 3.3-1) and temperature range of 0 to 2°C (Figure 3.2-2) ranges from 3.98 to 6.02 mg ammonia-N/L, which is at least 35 times greater than the April 2019 concentrations measured in Doris Lake. Although a Project-related effect on under-ice total ammonia was concluded, a low action level response was not triggered because April 2019 concentrations in Doris Lake remained well below 75% of the water quality benchmark.

3.3.7 Nitrate

In Windy and Patch lakes, April 2019 nitrate concentrations were within the range of baseline concentrations, and there was no apparent increase in under-ice nitrate levels over time (Figure 3.3-7). Statistical analysis was not completed for Windy Lake nitrate because of the high proportion of censored data. For Patch Lake, the before-after analysis confirmed that there was no significant difference between pre-2019 and 2019 mean under-ice nitrate concentrations ($p = 0.728$). During August 2019, all nitrate concentrations in Windy and Patch lakes were below the detection limit (< 0.005 mg nitrate-N/L; Figure 3.3-7). Therefore, there was no evidence of a Project-related effect on under-ice or open-water season nitrate concentrations in these lakes.



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME long-term guideline for nitrate as N (3.0 mg/L).
Graphs on the left show the same data as graphs on the right but at different y-axis scales to show the data relative to the CCME guideline.

Figure 3.3-7: Nitrate Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

Nitrate concentrations were more variable over time in Doris Lake compared to the other monitored lakes (Figure 3.3-7). Under-ice maximum concentrations of 0.1 to 0.2 mg/L were occasionally observed in Doris Lake between 1995 and 2019, while concentrations remained consistently below 0.1 mg/L in the other monitored lakes (Figure 3.3-7). Doris Lake is considered more productive (high nutrient, high chlorophyll) than the other monitored lakes, so it is expected that nutrient concentrations would show greater fluctuation in Doris Lake. High nitrate and phosphate concentrations in Doris Lake in winter/spring stimulate high productivity early in the open-water season as these nutrients are taken up by phytoplankton. Thus nitrate concentrations are low (below the detection limit) in August when phytoplankton biomass (as chlorophyll *a)* levels are high (see Section 3.5). During the ice-covered season, nutrients are remineralized by microbial decomposition and grazers, leading to a return of organic nitrogen to the inorganic pool (e.g., nitrate), and driving up concentrations of nitrate. There is less nitrate/phosphate in the other monitored lakes, which results in chlorophyll a concentrations remaining low, and smaller fluctuations in nutrients.

April 2019 nitrate concentrations in Doris Lake were lower than April 2018 concentrations, within the range of baseline concentrations, and have not increased over time (Figure 3.3-7). However, the trend analysis indicated that there was a significant non-zero temporal trend in under-ice nitrate concentrations in Doris Lake ($p = 0.0006$). The comparison of trends between Doris Lake and Reference Lake B showed that the under-ice nitrate trends were not significantly different between these lakes ($p = 0.0689$), suggesting that there was no Project-related change in under-ice nitrate concentrations in Doris Lake. During the open-water season in August 2019, nitrate concentrations in Doris Lake were below the detection limit (< 0.005 mg nitrate-N/L; Figure 3.3-7). Therefore, there was no evidence of a Project-related effect on under-ice or open-water season nitrate concentrations in Doris Lake.

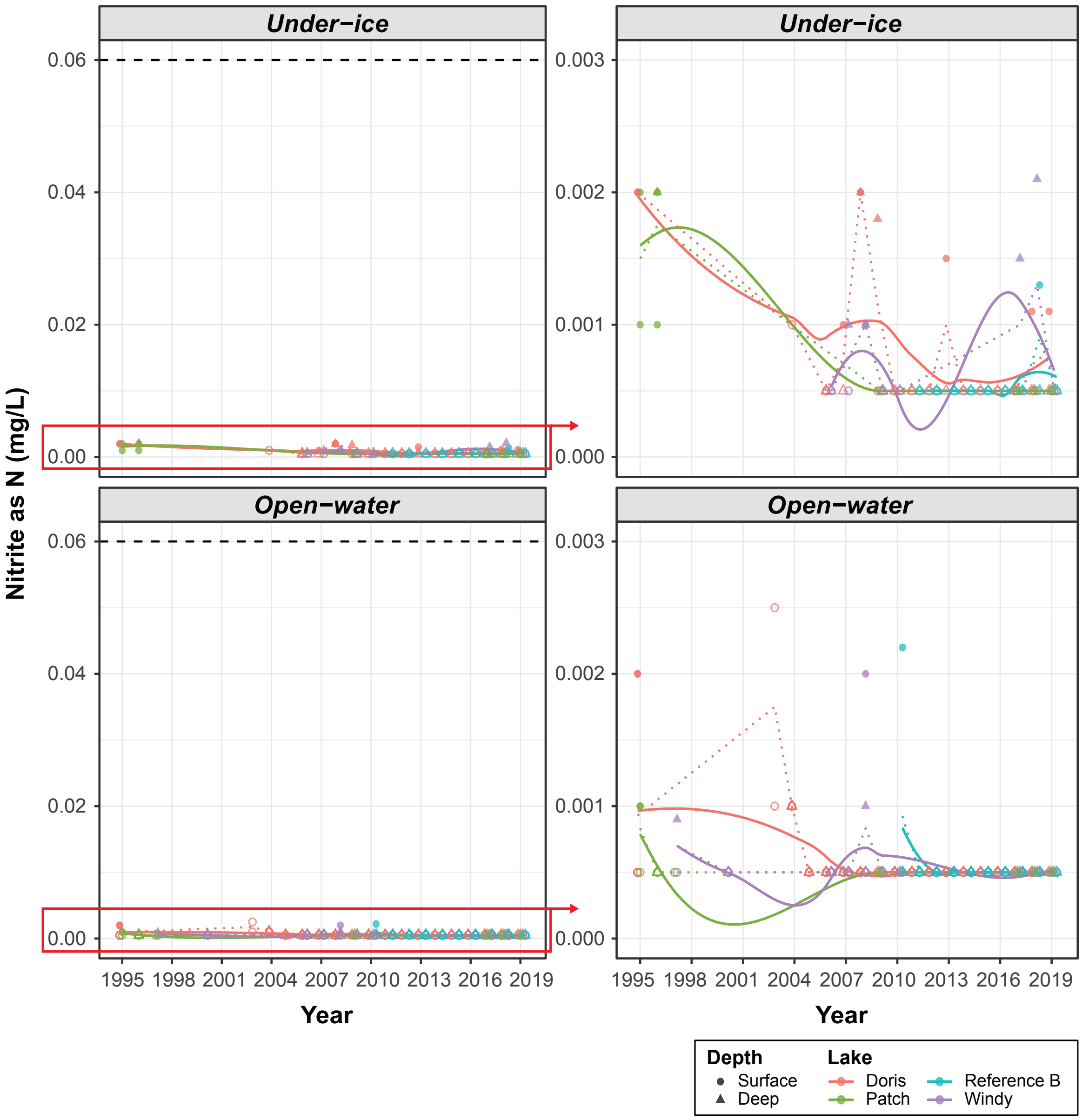
Under-ice and open-water nitrate concentrations in all three exposure lakes remained below the long-term CCME guideline of 3.0 mg nitrate-N/L and a low action level response was not triggered.

3.3.8 Nitrite

In 2019, concentrations of nitrite in all monitored lakes were below the detection limit (< 0.001 mg nitrite-N/L), with the exception of one sample collected in Doris Lake in April, which had a nitrite concentration of 0.0011 mg nitrite-N/L (just over the detection limit). All concentrations were well below the CCME guideline of 0.06 mg nitrite-N/L, and 75% of the water quality benchmark (0.045 mg nitrite-N/L; Figure 3.3-8). Statistical analyses were not completed because of the high proportion of censored data. Trends over time showed no indication of increasing nitrite concentrations; therefore, there was no evidence of an adverse Project effect on nitrite concentrations in Windy, Patch, or Doris lakes, and a low action level response for nitrite was not triggered.

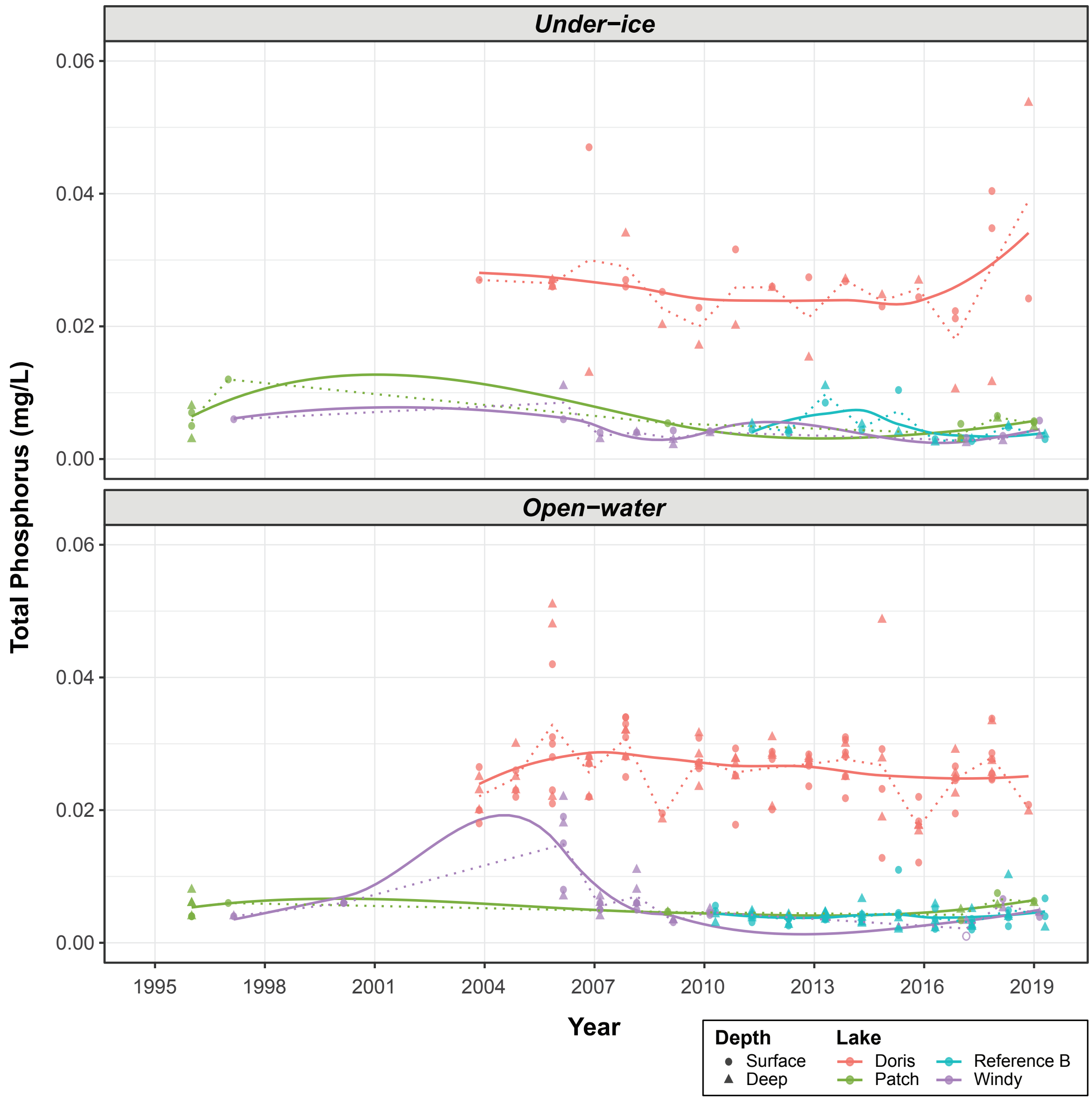
3.3.9 Total Phosphorus

Total phosphorus concentrations over the last two decades ranged from < 0.002 to 0.022 mg/L in Windy Lake and from 0.003 to 0.012 mg/L in Patch Lake (Figure 3.3-9). The average total phosphorus concentration in both lakes was 0.006 mg/L, which is characteristic of an oligotrophic lake (CCME 2019c). Total phosphorus concentrations in Doris North ranged from 0.011 to 0.054 mg/L and averaged 0.026 mg/L, characteristic of a meso-eutrophic lake (CCME 2019c).



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline for nitrite as N (0.06 mg/L).
Graphs on the left show the same data as graphs on the right but at different y-axis scales to show the data relative to the CCME guideline.

Figure 3.3-8: Nitrite Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Total phosphorus trigger ranges from CCME guidance framework: <0.004 mg/L = ultra-oligotrophic; 0.004 to 0.010 mg/L = oligotrophic; 0.01 to 0.02 mg/L = mesotrophic; 0.02 to 0.035 mg/L = meso-eutrophic; 0.035 to 0.1 mg/L = eutrophic; >0.1 mg/L = hyper-eutrophic.

Figure 3.3-9: Total Phosphorus Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

Although the total phosphorus concentration of 0.0537 mg/L measured in April in Doris Lake was slightly higher than the baseline maximum of 0.0470 mg/L, total phosphorus concentrations in all exposure lakes during both the ice-covered and open-water seasons were generally stable over time (Figure 3.3-9). The before-after analyses for Windy and Patch lakes showed that there was no statistically significant difference in mean concentrations from pre-2019 years to 2019 (Windy: $p = 0.756$ for under ice, $p = 0.761$ for open water; Patch: $p = 0.793$ for under ice, $p = 0.442$ for open water). The trend analysis showed that the total phosphorus trend over time in Doris Lake did not differ significantly from a slope of zero for both the ice-covered ($p = 0.443$) and open-water ($p = 0.843$) seasons. Overall, there was no evidence of an adverse change in total phosphorus concentrations in any exposure lake due to Project activities, and the low action level for total phosphorus was not exceeded.

3.3.10 Total Aluminum

Under-ice and open-water season total aluminum concentrations changed little over time in the three exposure lakes (Figure 3.3-10). This was confirmed by the statistical analyses, which indicated that there were no significant differences between pre-2019 and 2019 mean total aluminum concentrations in Windy Lake ($p = 0.0640$ for under ice, $p = 0.985$ for open water) and in Patch Lake ($p = 0.652$ for under ice, $p = 0.786$ for open water), and that the temporal trends in total aluminum concentrations in Doris Lake were not significantly different from a slope of zero ($p = 0.272$ for under ice, $p = 0.888$ for open water).

The total aluminum concentration of 0.112 mg/L measured in Doris Lake in August was slightly higher than the CCME guideline of 0.1 mg/L, and some open-water season total aluminum concentrations in both Doris and Patch lakes exceeded 0.075 mg/L (75% of the total aluminum benchmark; Figure 3.3-10). However, the low action level was not triggered because there was no indication that total aluminum concentrations increased in 2019 relative to baseline levels (which were also occasionally elevated above the CCME guideline and 75% threshold).

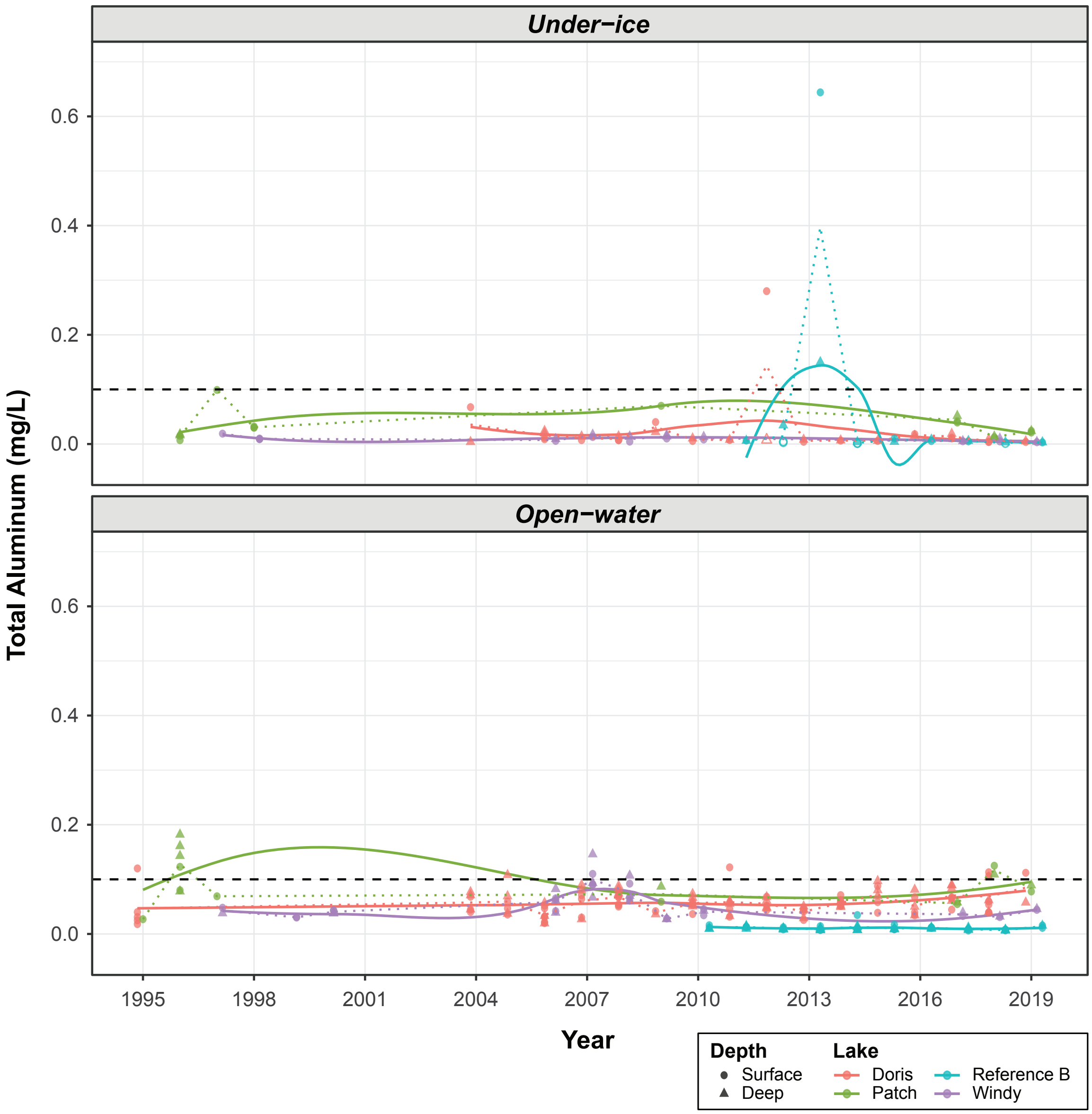
3.3.11 Total Arsenic

In all three exposure lakes, under-ice and open-water season total arsenic concentrations measured in 2019 were at the lower end of the range of historical concentrations (Figure 3.3-11). For both Windy and Patch lakes, pre-2019 mean concentrations were not significantly different from 2019 mean concentrations (Windy Lake: $p = 0.372$ for under ice, $p = 0.476$ for open water; Patch Lake: $p = 0.422$ for under ice, $p = 0.652$ for open water). Total arsenic concentrations in Doris Lake showed a declining trend over time, driven by relatively high total arsenic concentrations measured between 2005 and 2009 (Figure 3.3-11). The trend analysis confirmed that there was a significant non-zero slope in both under-ice and open-water arsenic concentrations ($p < 0.0001$ for both seasons), but that the Doris Lake trends were not significantly different from the Reference Lake B trends ($p = 0.210$ for under ice, $p = 0.895$ for open water). The similarity in trends between Doris Lake and Reference Lake B suggests that observed changes in arsenic over time were naturally occurring and unrelated to the Project.

Total arsenic concentrations measured in Windy, Patch, and Doris lakes in 2019 remained below the CCME guideline of 0.005 mg/L and there was no apparent adverse effect of the Project on arsenic concentrations in the exposure lakes. A low action level response for total arsenic was not triggered.

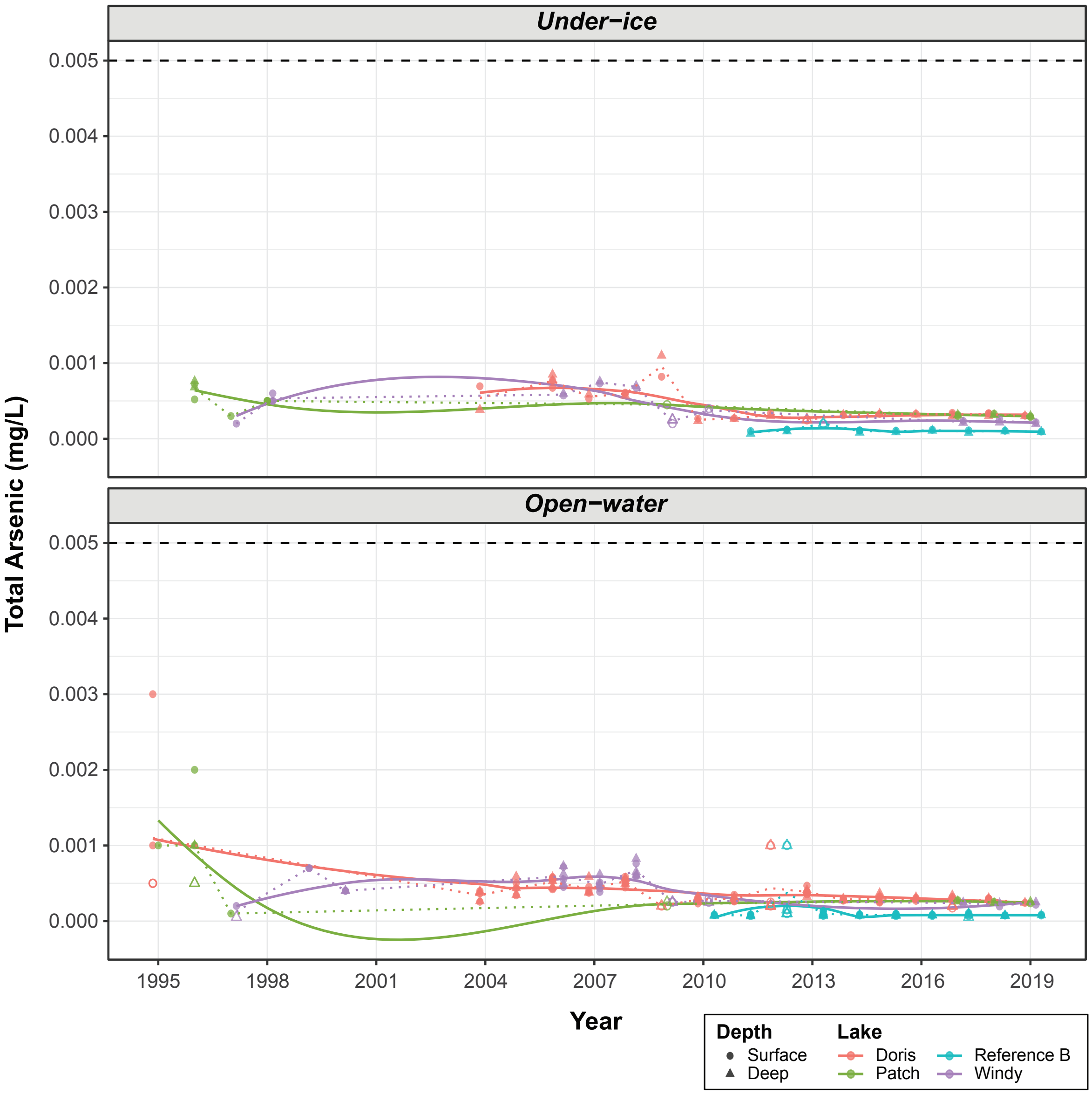
3.3.12 Total Boron

In Windy and Patch lakes, 2019 under-ice and open-water season total boron concentrations were within the range of baseline concentrations (Figure 3.3-12), and the before-after analysis confirmed that there were no significant differences between pre-2019 and 2019 mean concentrations (Windy Lake: $p = 0.693$ for under ice, $p = 0.704$ for open water; Patch Lake: $p = 0.314$ for under ice, $p = 0.701$ for open water).



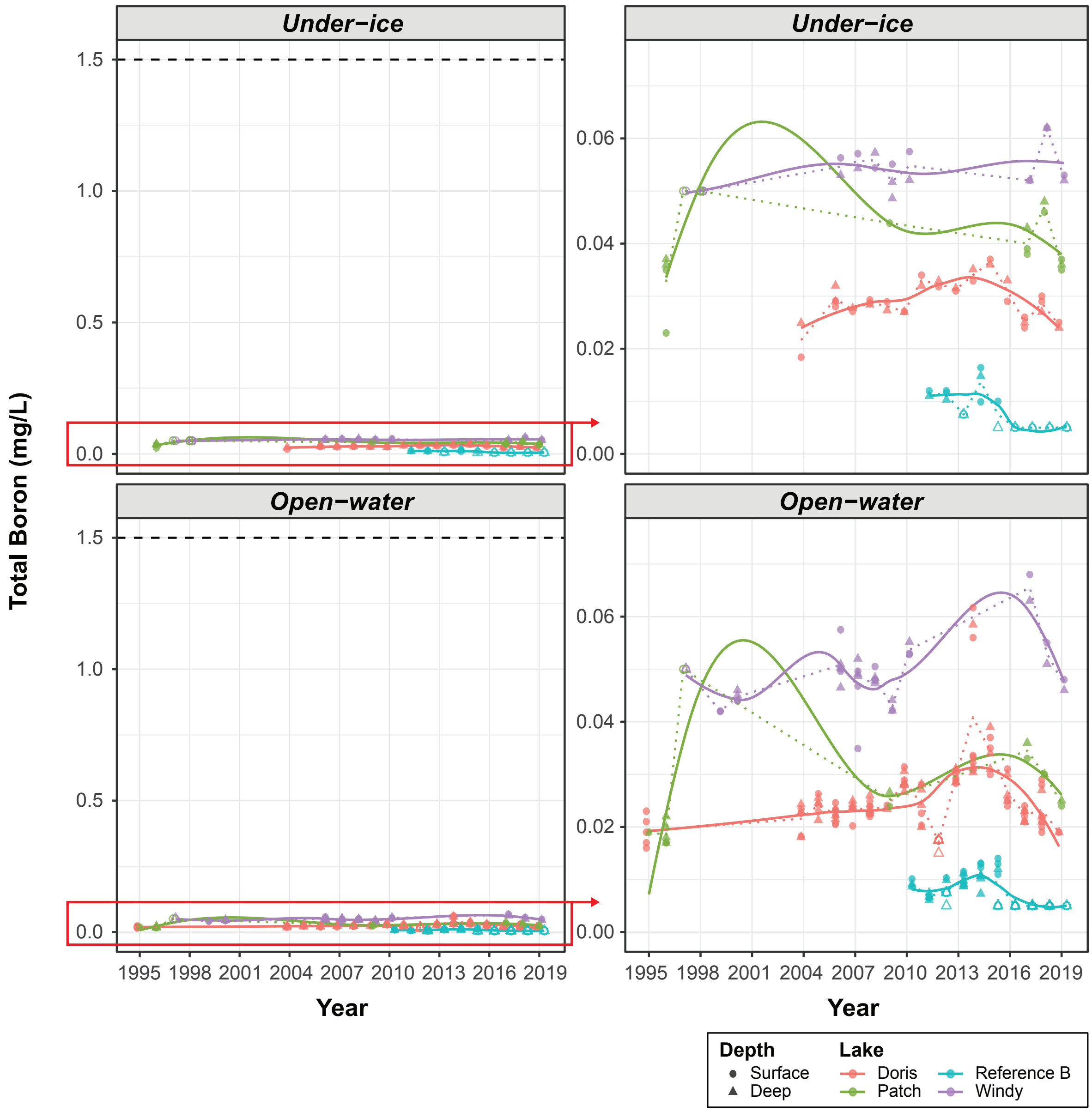
Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the pH-dependent CCME guideline for aluminum
(0.1 mg/L at pH ≥ 6.5; 0.05 mg/L at pH < 6.5); pH was greater than 6.5 in all lake samples in 2019.

Figure 3.3-10: Total Aluminum Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline for arsenic (0.005 mg/L).

Figure 3.3-11: Total Arsenic Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME long-term guideline for boron (1.5 mg/L).
Graphs on the left show the same data as graphs on the right but at different y-axis scales to show the data relative to the CCME guideline.

Figure 3.3-12: Total Boron Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

In Doris Lake, both under-ice and open-water season total boron concentrations increased slightly from the earliest baseline years to 2015, and decreased back to baseline levels between 2015 and 2019 (Figure 3.3-12). These trends were significantly different from a slope of zero ($p < 0.0001$ for both under ice and open water). Although the trends in Reference Lake B could not be evaluated statistically due to the high proportion of concentrations that were below the detection limit, the reference data showed a similar pattern, with concentrations relatively elevated from 2010 to 2015 compared to concentrations from 2016 to 2019, which were consistently below the detection limit (Figure 3.3-12). Although there are significant trends in the Doris Lake total boron data, concentrations from the last five years show a decreasing trend over time, with 2019 concentrations within the baseline range.

Total boron concentrations in all the exposure lakes remained below the CCME long-term guideline of 1.5 mg/L. There was no evidence of a Project effect on boron concentrations in the exposure lakes, and a low action level response was not triggered.

3.3.13 Total Cadmium

All 2019 total cadmium concentrations measured in exposure lakes were below the analytical detection limit (<0.000005 mg/L), and there was no apparent change in total cadmium concentrations over time (Figure 3.3-13). Therefore, there is no evidence of an adverse effect of Project activities on total cadmium concentrations in Windy, Patch, or Doris lakes. All total cadmium concentrations remained below the hardness-dependent CCME guideline and a low action level response was not triggered.

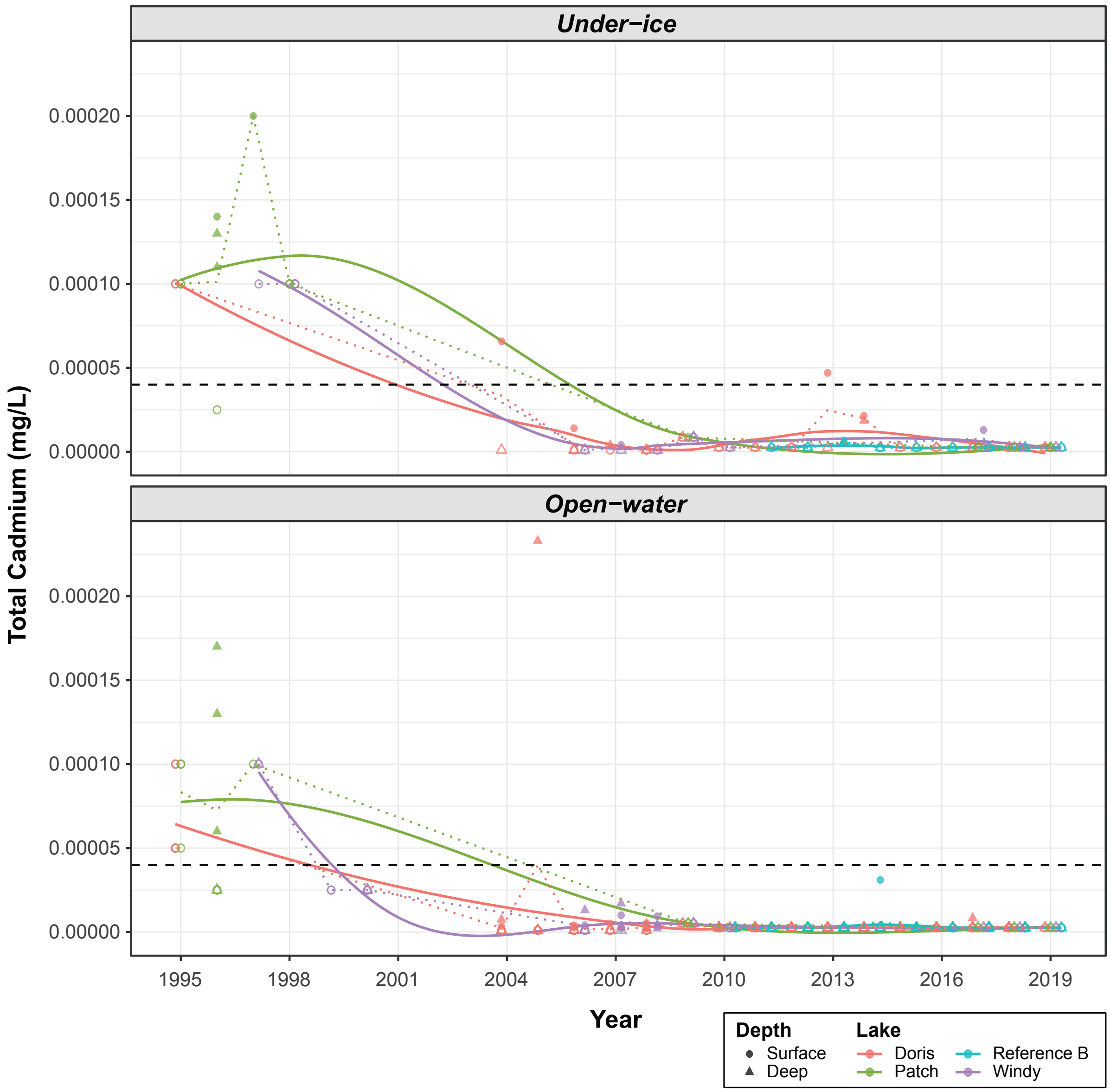
3.3.14 Total Chromium

All concentrations of total chromium in the exposure lakes were below the detection limit (< 0.0005 mg/L) in 2019, with the exception of one sample collected in Doris Lake in August, which had a total chromium concentration of 0.00052 mg/L (slightly over the detection limit; Figure 3.3-14). All 2019 concentrations were below the CCME guideline of 0.001 mg/L for hexavalent chromium, and the CCME guideline of 0.0089 mg/L for trivalent chromium (Figure 3.3-14). Statistical analyses were not completed because of the high proportion of censored data. Trends over time showed no indication of increasing chromium concentrations; therefore, there was no evidence of a Project effect on chromium concentrations in Windy, Patch, or Doris lakes, and a low action level response for total chromium was not triggered.

3.3.15 Total Copper

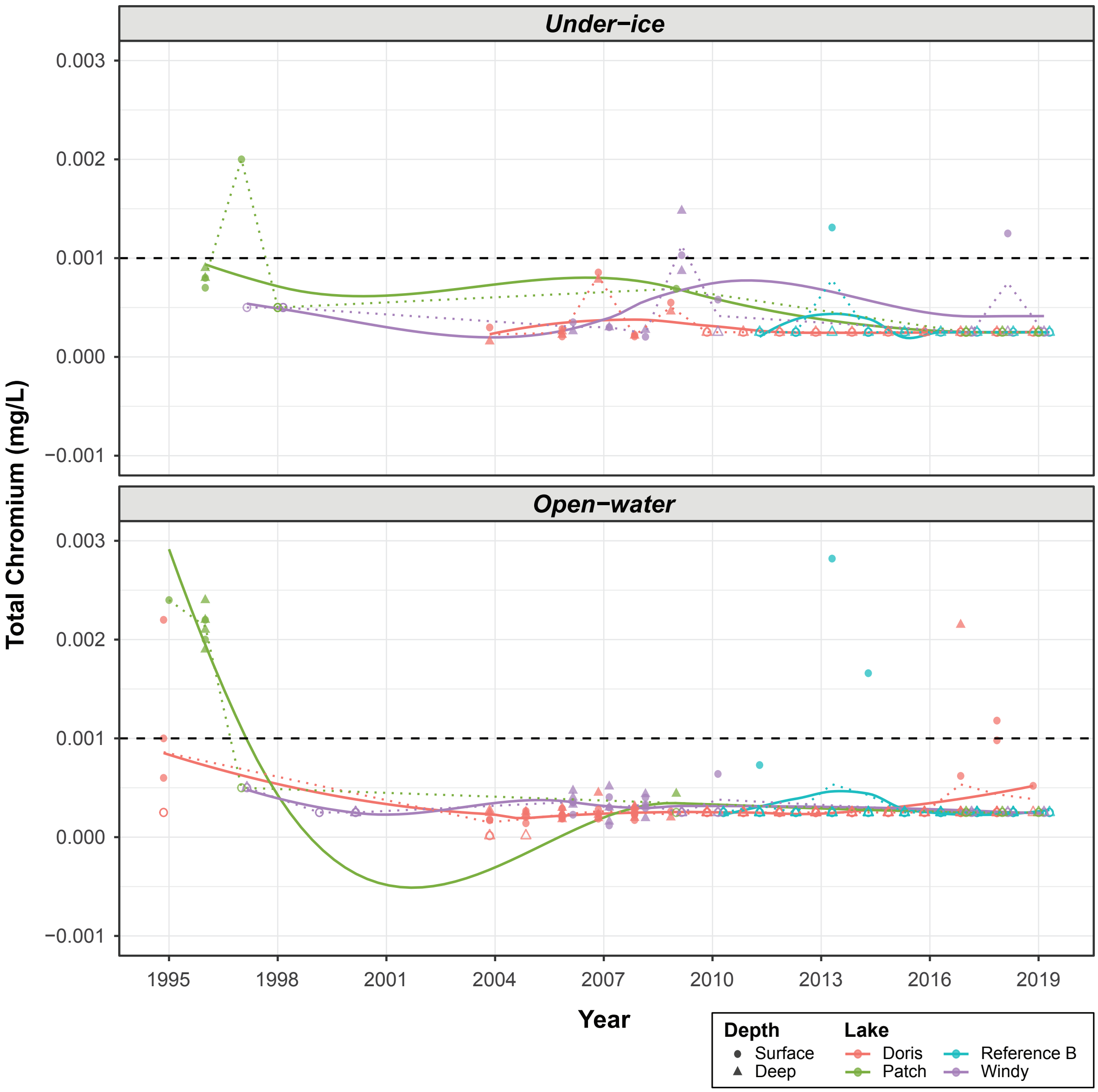
Under-ice and open-water total copper concentrations in Windy, Patch, and Doris lakes changed little over time (Figure 3.3-15). This was confirmed by the statistical analyses, which showed that there were no significant differences between pre-2019 and 2019 mean total copper concentrations in Windy Lake ($p = 0.795$ for under ice, $p = 0.438$ for open water) and Patch Lake ($p = 0.399$ for under ice, $p = 0.762$ for open water), and the temporal trends in total copper concentrations in Doris Lake were not significantly different from a slope of zero ($p = 0.0954$ for under ice, $p = 0.979$ for open water). Thus, there was no indication that the Project adversely affected total copper concentrations in the exposure lakes.

The total copper concentration of 0.00226 mg/L measured in Doris Lake in April 2019 slightly exceeded the hardness-dependent CCME guideline for copper, and both samples collected in Doris Lake in April exceeded the low action level condition of 75% of the benchmark. However, 2019 copper concentrations did not trigger the low action level because concentrations have not changed from baseline levels.



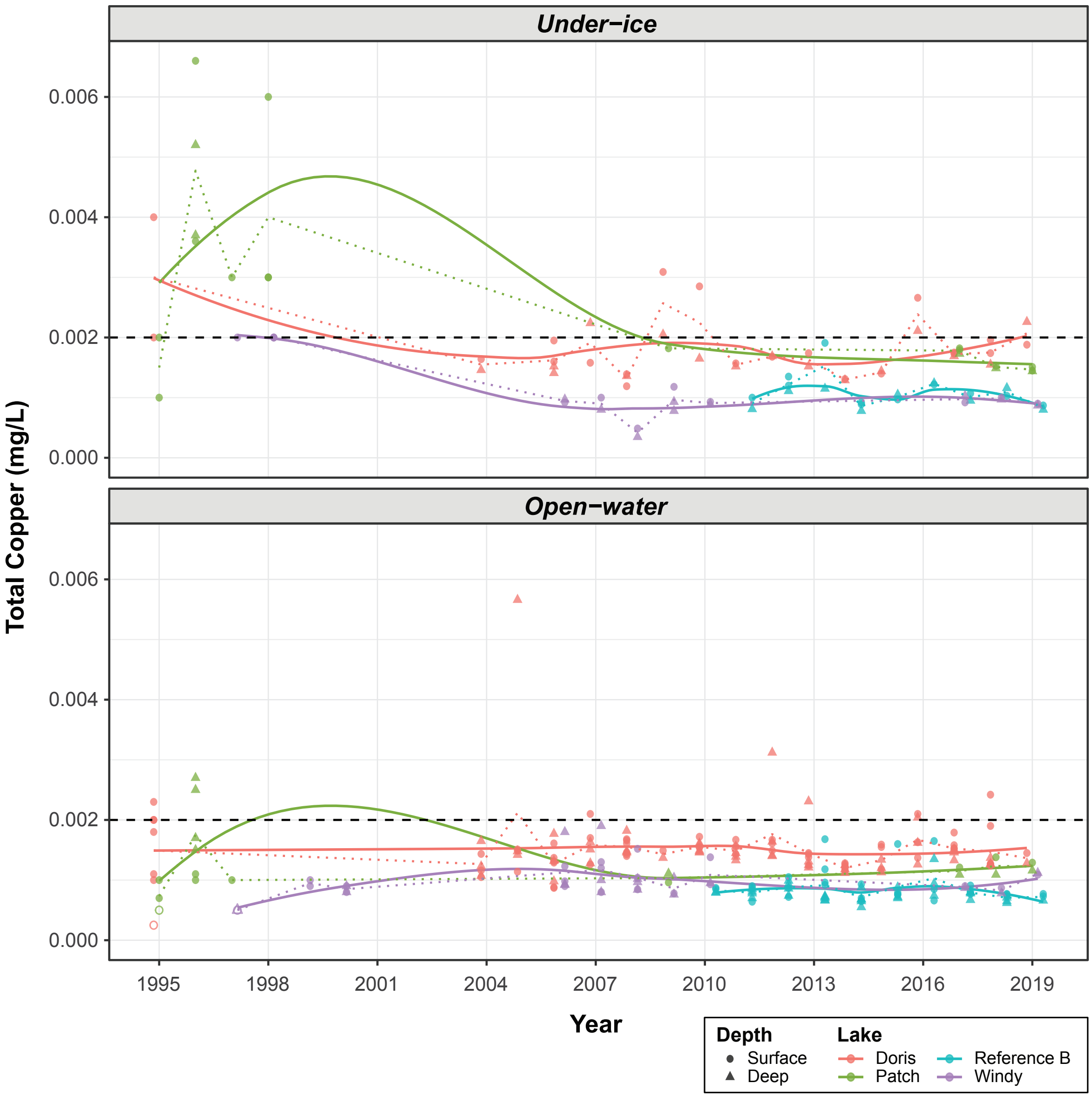
Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the minimum hardness-dependent CCME long-term guideline for cadmium of 0.00004 mg/L (for hardness as $CaCO_3$ of < 17 mg/L); the CCME guideline increases with increasing hardness.

Figure 3.3-13: Total Cadmium Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline for hexavalent chromium (0.001 mg/L);
the CCME interim guideline for trivalent chromium (0.0089 mg/L) is not shown.

Figure 3.3-14: Total Chromium Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the minimum hardness-dependent CCME guideline for copper of 0.002 mg/L (for hardness as $CaCO_3$ of < 82 mg/L); the CCME guideline increases with increasing hardness.

Figure 3.3-15: Total Copper Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

3.3.16 Total Iron

In 2019, under-ice concentrations of total iron were below the detection limit in Doris and Windy lakes (< 0.03 mg/L), and ranged from 0.032 to 0.063 mg/L in Patch Lake (Figure 3.3-16). The 2019 Patch Lake concentrations were within range of baseline under-ice concentrations, and the pre-2019 mean was not significantly different from the 2019 mean ($p = 0.582$).

During the 2019 open-water season, total iron concentrations in Windy and Patch Lakes were similar to historical concentrations (Figure 3.3-16), and the before-after analysis confirmed that pre-2019 means were not significantly different from 2019 means (Windy Lake: $p = 0.598$; Patch Lake: $p = 0.582$). In Doris Lake, although August 2019 concentrations were within range of baseline concentrations, the trend analysis showed that there was a significant non-zero trend in total iron concentrations ($p < 0.0001$). It was not possible to compare trends between Doris Lake and Reference Lake B because of the high proportion of concentrations that were below detection limits in the reference lake dataset. Given that mean 2019 open-water iron concentrations in Doris Lake were lower than mean 2017 and 2018 concentrations and within the range of pre-construction (pre-2010) baseline levels, there was no apparent adverse change in total iron concentrations in Doris Lake (Figure 3.3-16).

All 2019 total iron concentrations in the exposure lakes were below the CCME guideline of 0.3 mg/L and a low action level response for total iron was not triggered.

3.3.17 Total Lead

All concentrations of total lead in the exposure lakes were below the detection limit (< 0.00005 mg/L) in 2019, with the exception of one sample collected in Doris Lake in August, which had a total lead concentration of 0.000054 mg/L (slightly over the detection limit; Figure 3.3-17). The total lead method blank tested as part of the laboratory QA/QC program exceeded the data quality objective (DQO) for total lead (Section A.4.1 of Appendix A); as a result of this exceedance, total lead concentrations within five times the detection limit (such as the detectable concentration of 0.000054 mg/L in Doris Lake) should be considered unreliable. Nevertheless, this single unreliable concentration was within the range of baseline concentrations, and the trend analysis for open-water season total lead concentrations in Doris Lake showed that the trend in lead concentrations was not significantly different from a slope of zero ($p = 0.224$). All total lead concentrations in the exposure lakes were below the hardness-dependent CCME guideline.

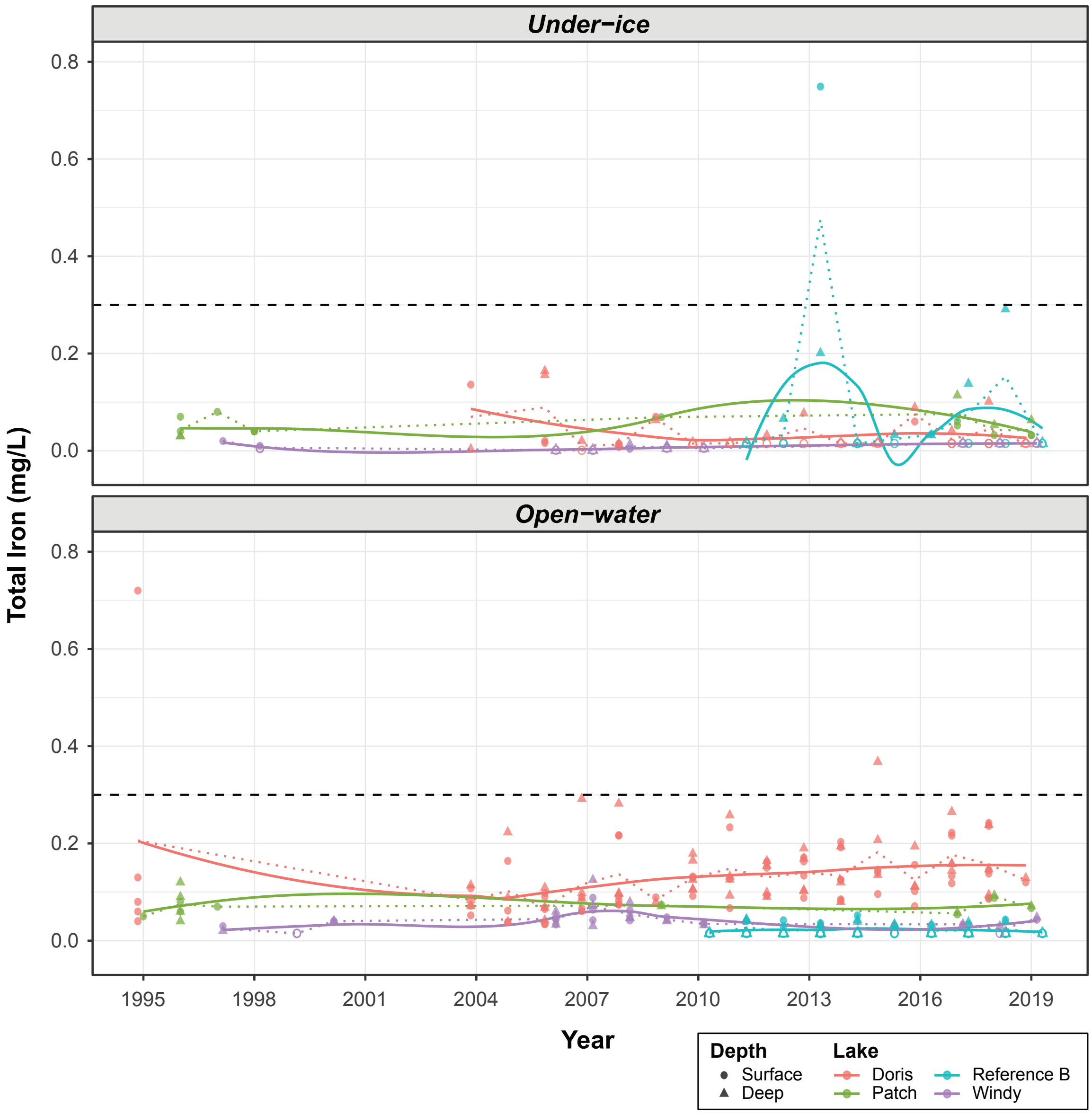
Overall, there was no apparent Project-related increase in total lead concentrations in Windy, Patch, or Doris lakes, and a low action level response for total lead was not triggered.

3.3.18 Total Mercury

In Windy Lake, 2019 under-ice and open-water total mercury concentrations were below the detection limit (< 0.0005 μg/L). In Patch Lake, 2019 under-ice mercury concentrations were below the detection limit and open-water total mercury concentrations were just over the detection limit (mean of 0.00063 μg/L; Figure 3.3-18). Given the high proportion of non-detectable concentrations in the datasets for these lakes, statistical analyses were not completed; however, the trends in total mercury over time show no indication of increases from baseline concentrations (Figure 3.3-18).

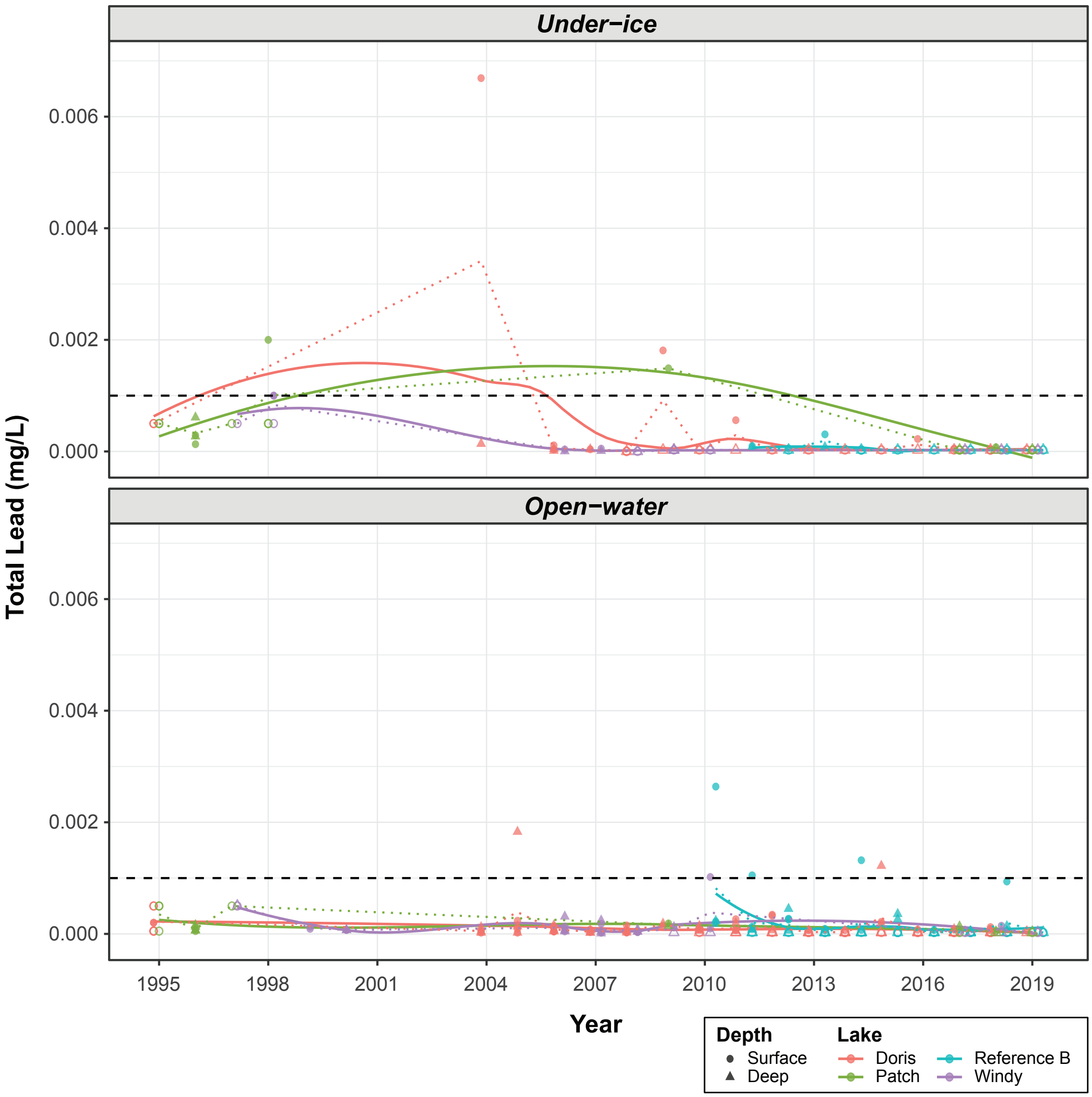
In Doris Lake, 2019 total mercury concentrations were slightly over the detection limit, averaging 0.00058 μg/L in April and 0.00102 μg/L in August (Figure 3.3-18). Under-ice trends were not analyzed statistically due to the high proportion of censored data. The trend analysis for the open-water season showed that the total mercury trend was not significantly different from a slope of zero ($p = 0.735$).

Overall, there was no apparent Project effect on total mercury concentrations in the exposure lakes, and all concentrations were below the CCME guideline of 0.026 μg/L. A low action level response for total mercury was not triggered.



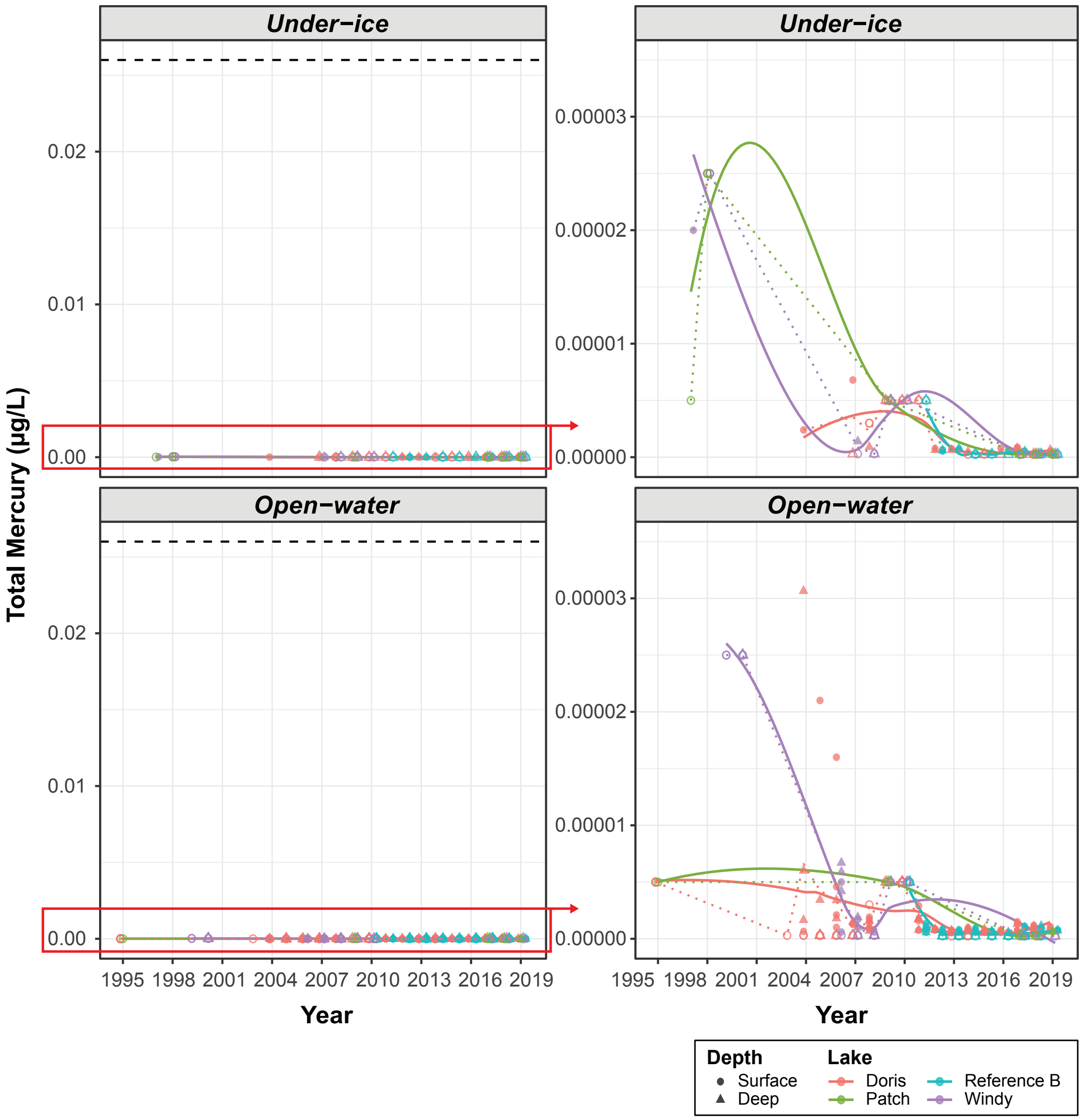
Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline for iron (0.3 mg/L).

Figure 3.3-16: Total Iron Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the minimum hardness-dependent CCME guideline for lead of 0.001 mg/L (for hardness as $CaCO_3$ of ≤ 60 mg/L); the CCME guideline increases with increasing hardness.

Figure 3.3-17: Total Lead Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline for mercury (0.026 µg/L).
Graphs on the left show the same data as graphs on the right but at different y-axis scales to show the data relative to the CCME guideline.

Figure 3.3-18: Total Mercury Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

3.3.19 Total Molybdenum

There were clear spatial differences in total molybdenum concentrations among the monitored lakes, with the highest concentrations in Windy Lake, lowest concentrations in Reference Lake B, and intermediate concentrations in Doris and Patch lakes (Figure 3.3-19). All 2019 total molybdenum concentrations in the monitored lakes remained below the CCME guideline of 0.073 mg/L.

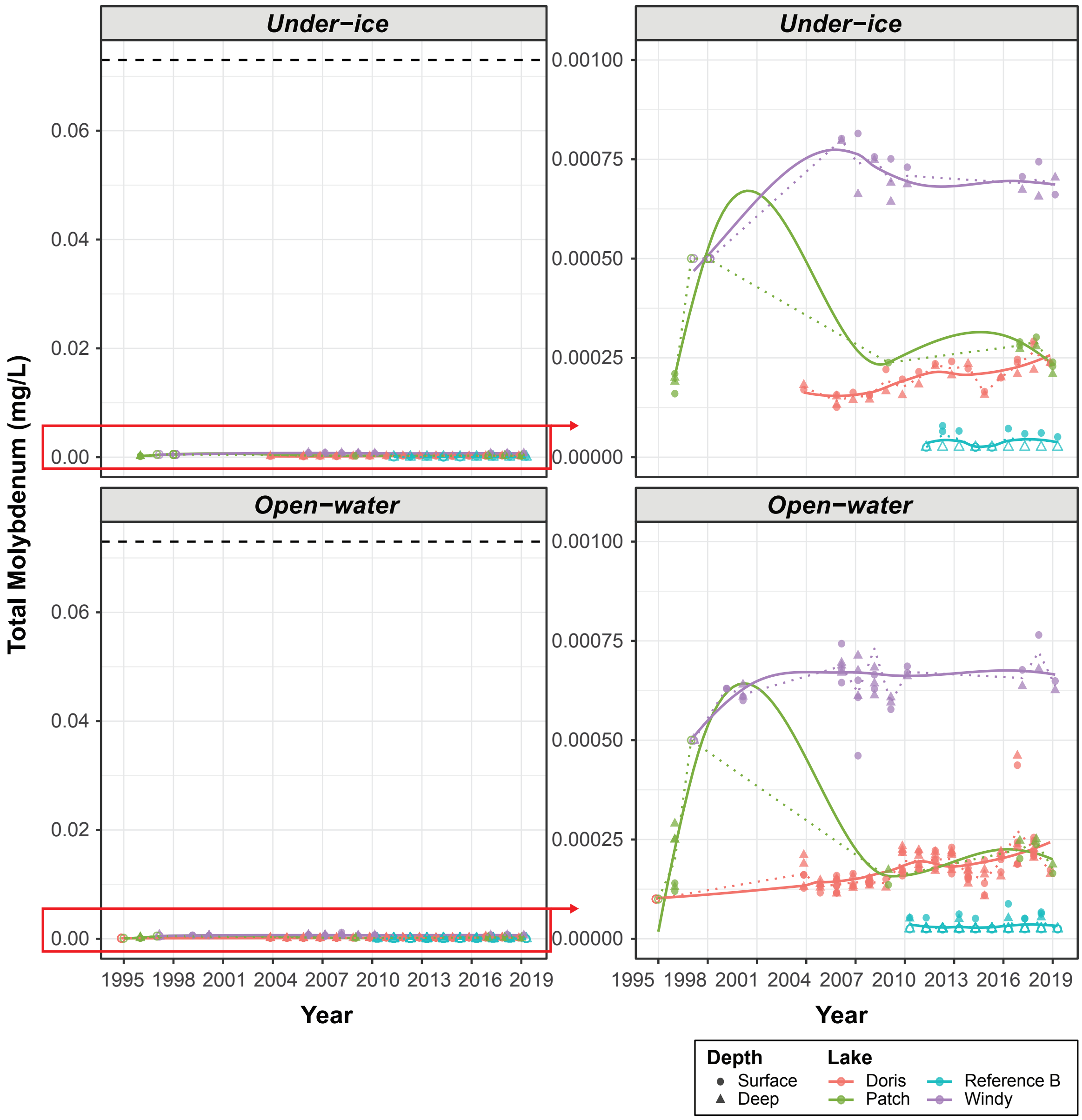
In Windy and Patch lakes, both under-ice and open-water total molybdenum concentrations were relatively consistent over time (Figure 3.3-19), and the before-after analysis showed that pre-2019 mean concentrations were not significantly different from 2019 means (Windy Lake: $p = 0.959$ for under ice, $p = 0.958$ for open water; Patch Lake: $p = 0.449$ for under ice, $p = 0.694$ for open water).

In Doris Lake, under-ice concentrations of total molybdenum increased slightly over time (Figure 3.3-19), and although 2019 concentrations (mean: 0.00024 mg/L) were lower than 2018 concentrations (mean: 0.00026 mg/L), they remained slightly elevated compared to the pre-2010 baseline range (0.00013 to 0.00022 mg/L). Open-water concentrations also increased slightly over time (Figure 3.3-19); however, the 2019 mean concentration (0.00017 mg/L) was lower than mean concentrations in recent years (2018 mean: 0.00023 mg/L, 2017 mean: 0.00027 mg/L, 2016 mean: 0.00020 mg/L), and was within the pre-2010 baseline range (0.00011 to 0.00021 mg/L). The trend analysis showed that there was a statistically significant non-zero trend in both under-ice ($p < 0.0001$) and open-water ($p < 0.0001$) total molybdenum concentrations in Doris Lake, though these trends could not be compared to the Reference Lake B trend because of the high proportion of concentrations that were below the detection limit in the reference lake dataset. Although under-ice molybdenum concentrations in Doris Lake have increased over time relative to baseline levels, such a slight increase is unlikely to be ecologically significant as 2019 concentrations were approximately 300 times lower than the CCME guideline for the protection of aquatic life. Molybdenum concentrations observed in Doris Lake in 2019 were also less than 50% of concentrations observed in Windy Lake and remained within the range of naturally occurring concentrations in Project area lakes (Figure 3.3-19).

Of all the lake/season combinations that were evaluated for effects, a potential Project effect was identified for Doris Lake under-ice molybdenum concentrations due to the increasing trend and the slightly elevated concentrations compared to baseline conditions; however, a low action level response for molybdenum was not triggered since concentrations remained far below the low action level condition of 75% of the benchmark. An increase in total molybdenum concentrations relative to baseline levels was predicted in the FEIS for waterbodies in the Doris Watershed downstream of Doris Lake (Doris Creek and Little Roberts Lake; TMAC 2017b). This increase from baseline levels was predicted to occur during all Project phases for Doris Creek, and during operations and post-closure phases for Little Roberts Lake (TMAC 2017b). The FEIS further predicted that molybdenum concentrations would not exceed the CCME guideline in waterbodies within the Doris Watershed (TMAC 2017b). In addition, seepage from roads and infrastructure is monitored as part of the annual geochemical monitoring program (SRK 2020).

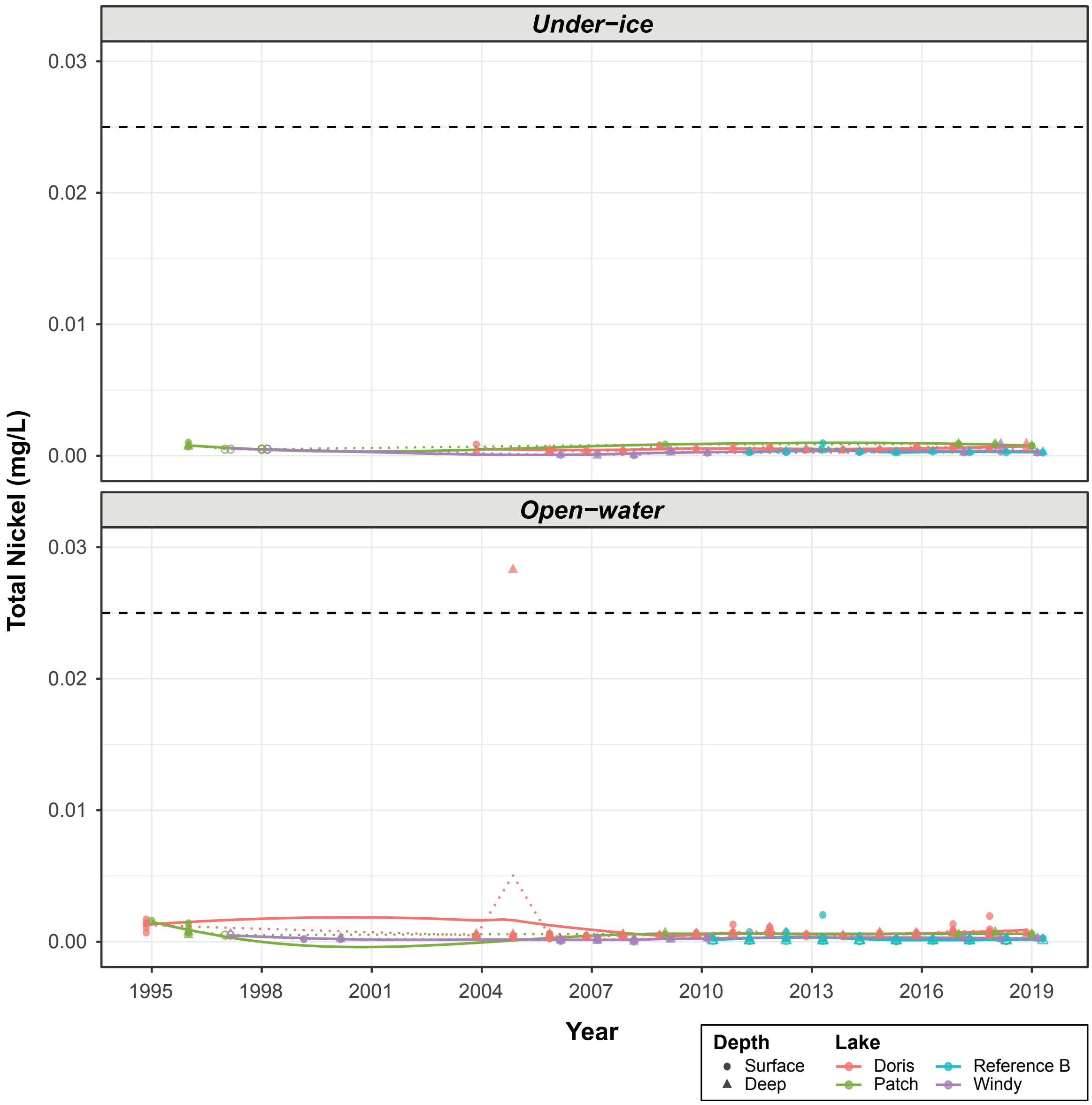
3.3.20 Total Nickel

Under-ice and open-water total nickel concentrations in Windy, Patch, and Doris lakes have changed little over time (Figure 3.3-20). This was confirmed by the statistical analyses, which showed that there were no significant differences between pre-2019 and 2019 mean total nickel concentrations in Windy Lake ($p = 0.850$ for under ice, $p = 0.718$ for open water) and Patch Lake ($p = 0.876$ for under ice, $p = 0.614$ for open water), and the temporal trends in total nickel concentrations in Doris Lake were not significantly different from a slope of zero ($p = 0.462$ for under ice, $p = 0.260$ for open water). Thus, there was no indication that the Project adversely affected total nickel concentrations in the exposure lakes in 2019. All 2019 total nickel concentrations remained below the minimum hardness-dependent CCME guideline of 0.025 mg/Land a low action level response for total nickel was not triggered.



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME interim guideline for molybdenum (0.073 mg/L).
Graphs on the left show the same data as graphs on the right but at different y-axis scales to show the data relative to the CCME guideline.

Figure 3.3-19: Total Molybdenum Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the minimum hardness-dependent CCME guideline for nickel of 0.025 mg/L (for hardness as $CaCO_3$ of ≤ 60 mg/L); the CCME guideline increases with increasing hardness.

Figure 3.3-20: Total Nickel Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

3.3.21 Total Selenium

All 2019 total selenium concentrations in Windy, Patch, and Doris lakes were below the analytical detection limit (< 0.00020 mg/L) and the CCME guideline of 0.001 mg/L (Figure 3.3-21). Statistical analysis of total selenium trends was not conducted; however, graphical analysis suggests that there was no increase in concentrations over time (Figure 3.3-21), and no evidence of a Project effect on total selenium concentrations in the exposure lakes. A low action level response for total selenium was not triggered.

3.3.22 Total Silver

All 2019 total silver concentrations in Windy, Patch, and Doris lakes were below the analytical detection limit (< 0.000005 mg/L), the CCME guideline of 0.00025 mg/L (Figure 3.3-22). Statistical analysis of total silver trends was not conducted; however, graphical analysis suggests that there was no increase in concentrations over time (Figure 3.3-22), and no evidence of a Project effect on total silver concentrations in the exposure lakes. A low action level response for total silver was not triggered.

3.3.23 Total Thallium

All 2019 total thallium concentrations in Windy, Patch, and Doris lakes were below the analytical detection limit (< 0.000005 mg/L), the CCME guideline of 0.0008 mg/L (Figure 3.3-23). Statistical analysis of total thallium trends was not conducted; however, graphical analysis suggests that there was no increase in concentrations over time (Figure 3.3-23), and no evidence of a Project effect on total thallium concentrations in the exposure lakes. A low action level response for total thallium was not triggered.

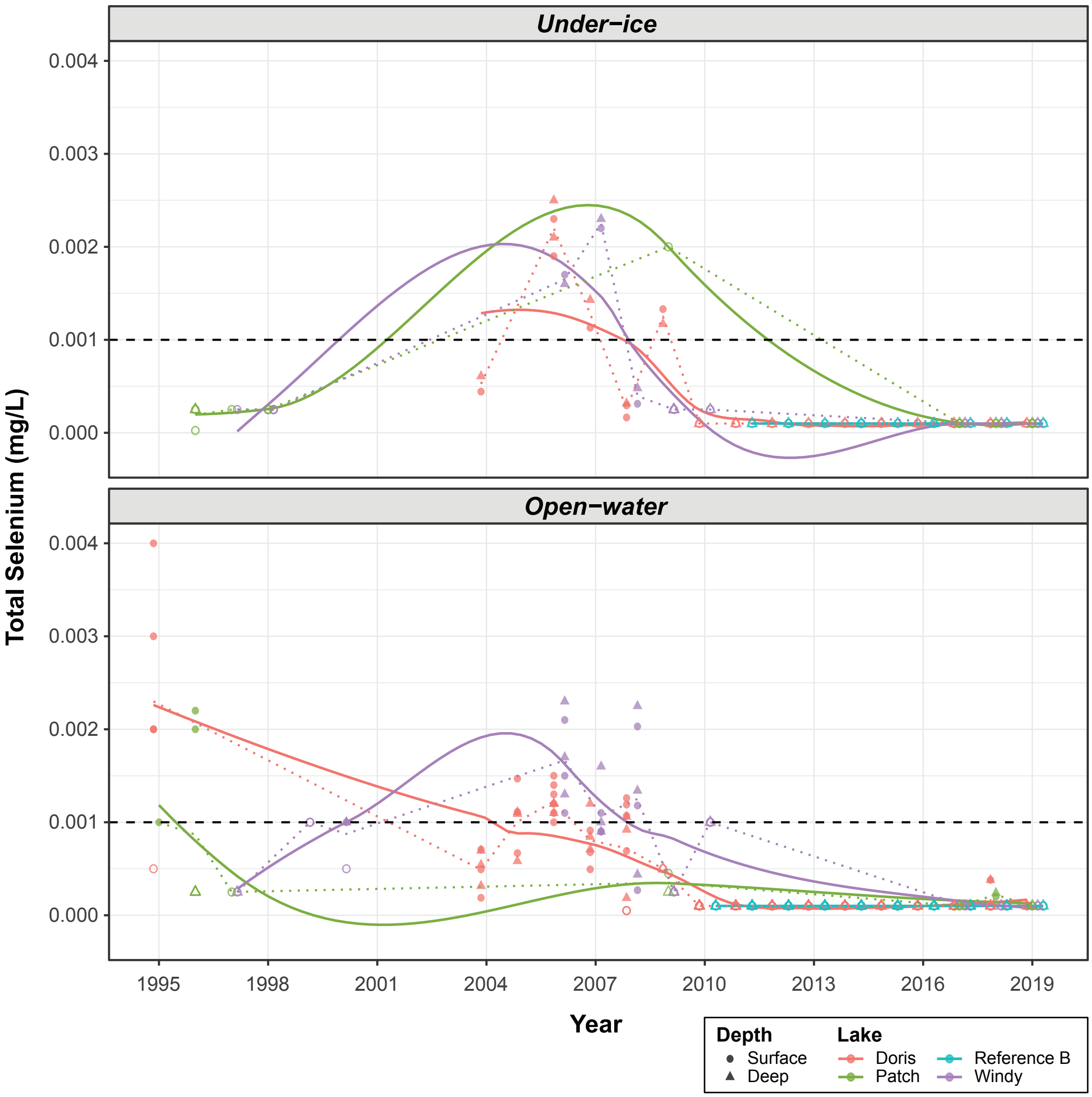
3.3.24 Total Uranium

In Windy and Patch lakes, both under-ice and open-water total uranium concentrations were relatively consistent over time (Figure 3.3-24), and the before-after analysis showed that pre-2019 mean concentrations were not significantly different from 2019 means (Windy Lake: $p = 0.580$ for under ice, $p = 0.349$ for open water; Patch Lake: $p = 0.924$ for under ice, $p = 0.976$ for open water).

In Doris Lake, under-ice concentrations of total uranium increased slightly over time (Figure 3.3-24), and the trend analysis showed that there was a statistically significant non-zero trend in total uranium concentrations ($p < 0.0001$), which differed from the trend in Reference Lake B ($p = 0.0054$). However, 2019 concentrations (mean: 0.000042 mg/L) were lower than mean concentrations in recent years (2018 mean: 0.000051 mg/L, 2017 mean: 0.000054), and within the range of pre-2010 baseline concentrations (0.000020 to 0.000045 mg/L). Therefore, there was no apparent adverse change in under-ice total uranium concentrations in Doris Lake in 2019.

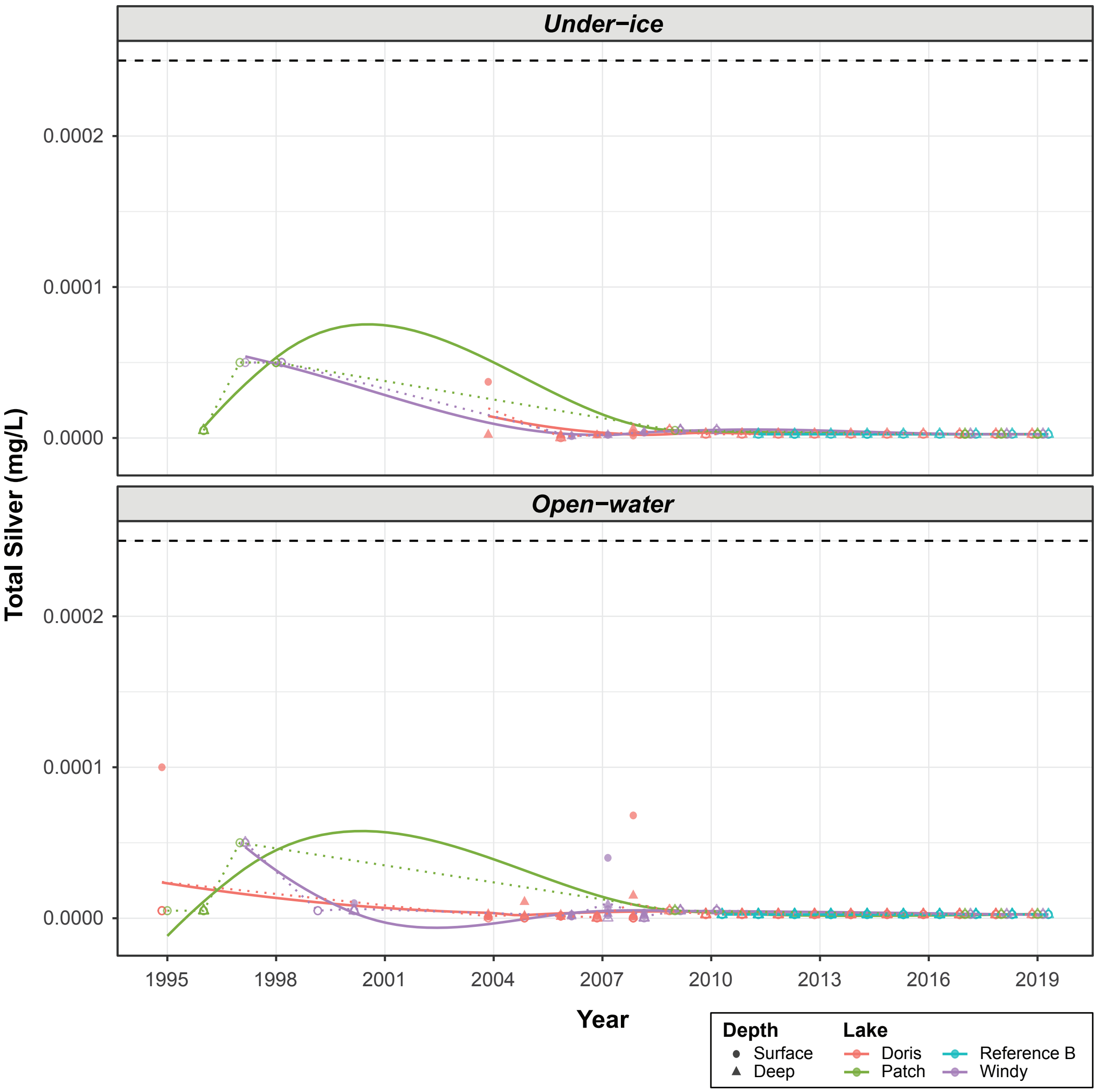
Similar to under-ice concentrations, open-water total uranium concentrations in Doris Lake also increased slightly over time (Figure 3.3-24) and there was a significant non-zero trend ($p = 0.0134$). However, the open-water uranium trends between Doris Lake and Reference Lake B were not significantly different ($p = 0.605$), suggesting that the open-water change in total uranium concentrations over time was naturally occurring and not Project-related. 2019 open-water uranium concentrations were also within the range of baseline concentrations (Figure 3.3-24).

All 2019 total uranium concentrations in Windy, Patch, and Doris lakes were below the CCME long-term guideline of 0.015 mg/L. Total uranium concentrations in the exposure lakes did not trigger a low action level response.



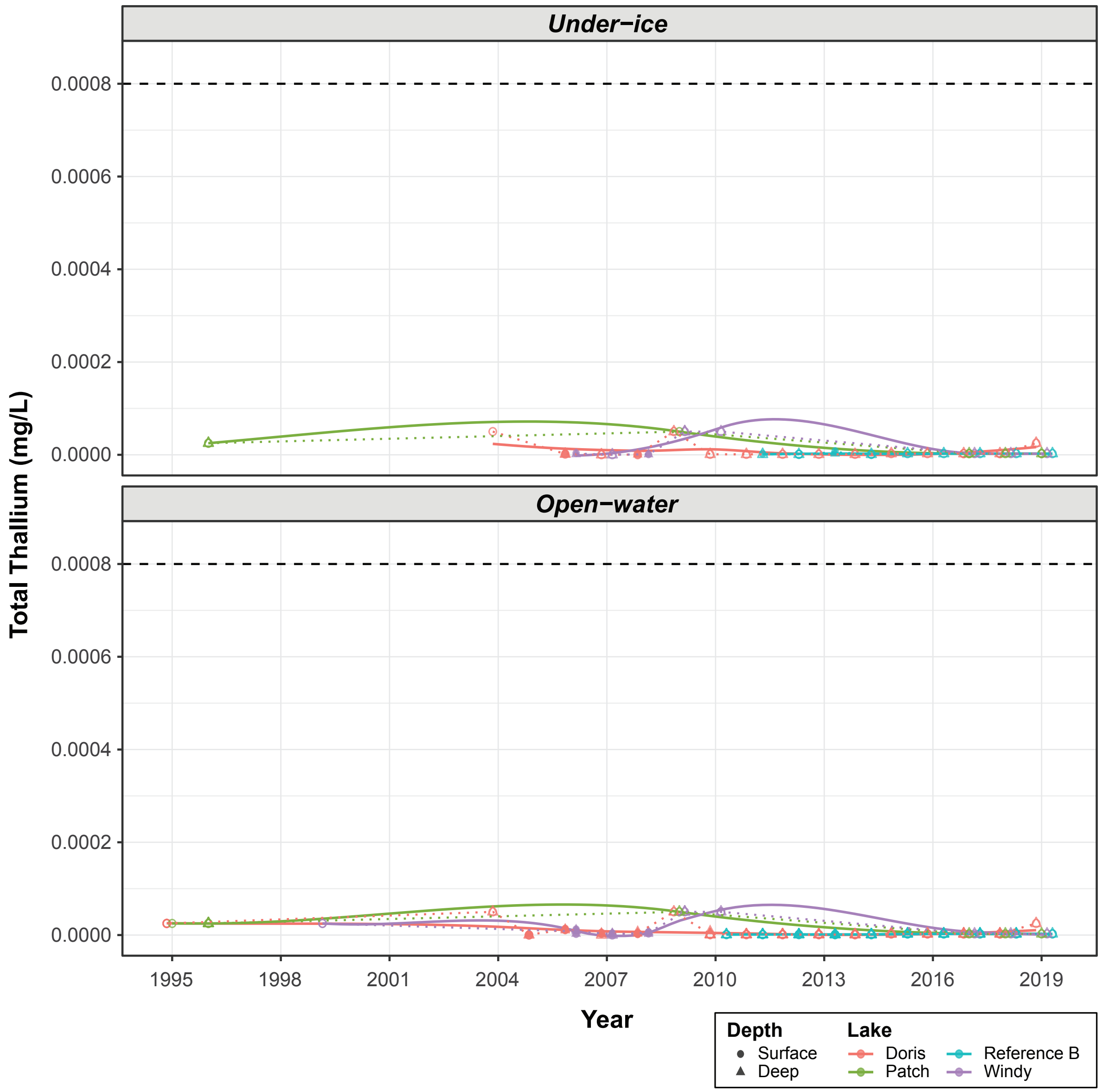
Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline for selenium (0.001 mg/L).

Figure 3.3-21: Total Selenium Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



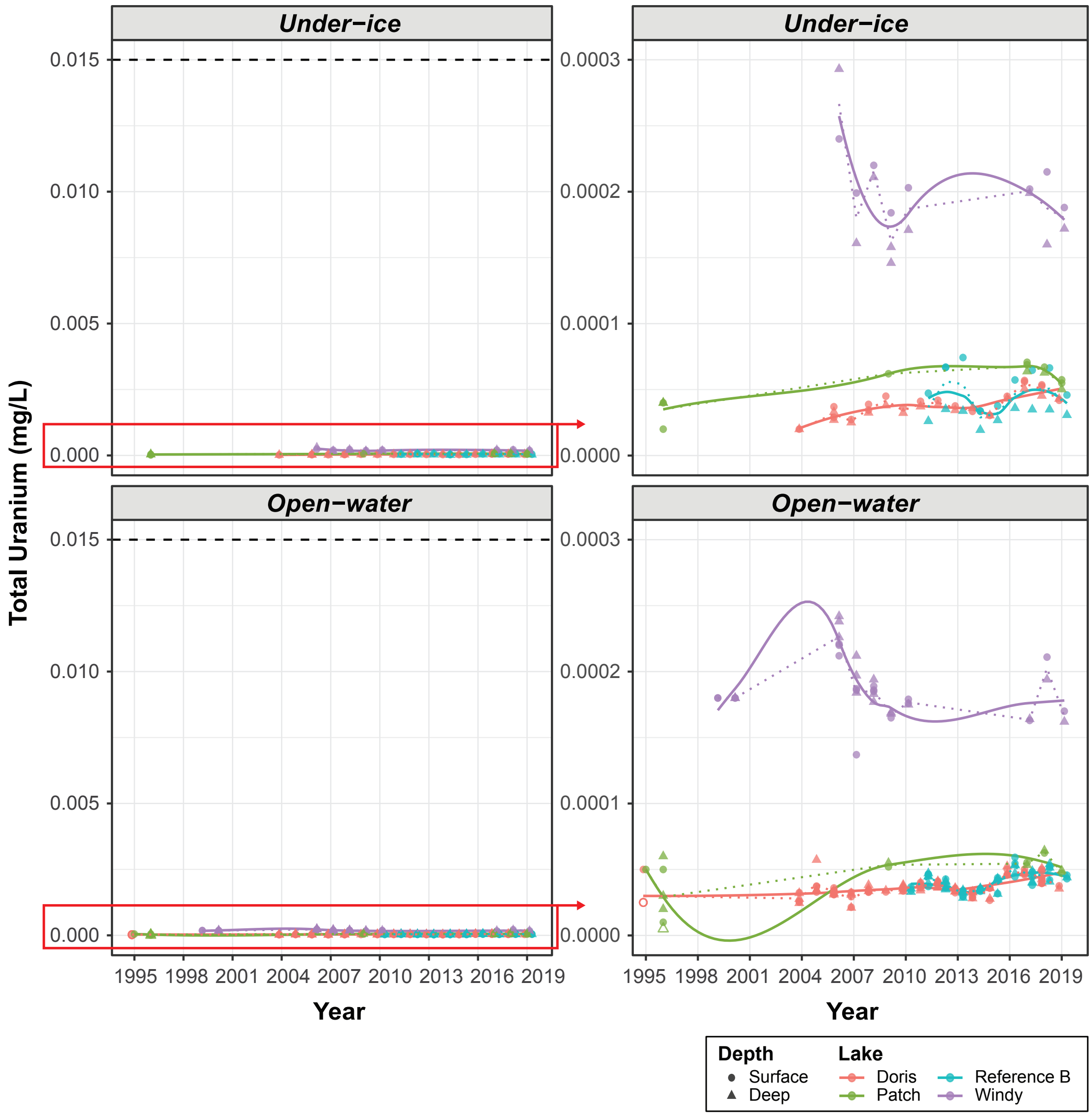
Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME long-term guideline for silver (0.00025 mg/L).

Figure 3.3-22: Total Silver Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME guideline for thallium (0.0008 mg/L).
1997 and 1998 concentrations below the unusually high detection limits of 0.1 and 0.2 were excluded from plots.

Figure 3.3-23: Total Thallium Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME long-term guideline for uranium (0.015 mg/L).
Graphs on the left show the same data as graphs on the right but at different y-axis scales to show the data relative to the CCME guideline.

Figure 3.3-24: Total Uranium Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

3.3.25 Dissolved Zinc

All concentrations of dissolved zinc in the exposure lakes were below the detection limit (< 0.0010 mg/L) in 2019, with the exception of one sample collected in Doris Lake in April, which had a dissolved zinc concentration of 0.0023 mg/L (Figure 3.3-25). This single detectable concentration was within the range of baseline concentrations, and although the trend analysis showed that there was a significant non-zero trend in under-ice dissolved zinc concentrations in Doris Lake ($p < 0.0001$), there was no indication that the trend was an increase (Figure 3.3-25). Statistical analyses were not completed for Windy Lake, Patch Lake, and for open-water Doris Lake concentrations because of the high proportion of censored data.

All dissolved zinc concentrations were below the pH-, hardness- and dissolved organic carbon (DOC)-dependent CCME guideline. Overall, there was no evidence of a Project effect on dissolved zinc concentrations in Windy, Patch, or Doris lakes, and a low action level response for dissolved zinc was not triggered.

3.3.26 Water Quality Summary

Tables 3.3-1 to 3.3-3 provide summaries of the evaluation of effects for water quality for each exposure lake (Windy, Patch, and Doris lakes, respectively). The conclusions of the AEMP evaluation of effects feed into the Response Framework to identify potential Project effects that may require management action to prevent adverse environmental consequences. Table 3.3-4 presents a summary of the screening of the results of the evaluation of effects against the conditions that must be met to trigger a ‘low action level’ response under the Response Framework (as described in Section 2.2.3.1).

The evaluation of effects concluded that there were no Project-related changes in water quality in 2019 in both Windy (Table 3.3-1) and Patch lakes (Table 3.3-2). There were potential Project-related increases identified for both under-ice total ammonia and under-ice total molybdenum concentrations in Doris Lake (Table 3.3-3); however, low action level responses were not triggered for these variables because concentrations remained below the low action level condition of 75% of the benchmark (Table 3.3-4). At least one condition was not met for each evaluated lake/season/variable combination; therefore, no low action level responses were triggered for water quality during the 2019 assessment year (Table 3.3.4).

3.4 Sediment Quality

Sediment quality samples were collected from two exposure lakes (Doris Lake and Patch Lake) and one reference lake (Reference Lake B) in August 2019. A subset of sediment quality variables (see Table 2.2-1) was evaluated using statistical and graphical analyses to determine whether Project activities resulted in adverse changes to sediment quality. For Patch Lake, sediment quality data collected between 2009 and 2018 are considered to represent baseline conditions prior to the start to Madrid North construction activities in 2019. For Doris Lake, sediment quality data collected in 2009 are considered to represent baseline conditions prior to the start of Doris construction activities in 2010. Trends in sediment quality in exposure lakes were also compared to trends in Reference Lake B to determine whether any observed changes in sediment quality over time were likely naturally occurring or Project related.

Sediment quality variable concentrations were compared to CCME sediment quality guidelines for the protection of aquatic life (CCME 2019a) to assess whether existing concentrations could adversely affect freshwater organisms. CCME guidelines for sediments include interim sediment quality guidelines (ISQGs) and probable effects levels (PELs). The more conservative ISQGs are levels below which adverse biological effects are rarely observed. The higher PELs correspond to concentrations above which negative effects would be expected (CCME 2019a). Sediment quality data were also compared against 75% of the ISQG and PEL guidelines as one of the conditions to determine whether a low action level threshold was exceeded (see Section 2.2.3).

Table 3.3-1: Summary of Evaluation of Effects for Windy Lake Water Quality, Hope Bay Project, 2019

Variable	Statistical Analysis: BA or BACI Analysis				Graphical Analysis/Interpretation		Conclusion of Effect [c]	
	Under-ice		Open-water		Evidence of an Adverse [b] Change?			
	Within Lake Before-After Change (BA Analysis)? [a]	Difference in Before-After Trend Relative to Reference Lake (BACI Analysis)? [a]	Within Lake Before-After Change (BA Analysis)? [a]	Difference in Before-After Trend Relative to Reference Lake (BACI Analysis)? [a]	Under-ice	Open-water	Under-ice	Open-water
pH	No	☐	No	☐	No	No	No effect	No effect
Total Suspended Solids	◆	◆	◆	◆	No	No	No effect	No effect
Turbidity	No	☐	Yes	Yes	No	No	No effect	No effect
Chloride	No	☐	No	☐	No	No	No effect	No effect
Fluoride	No	☐	No	☐	No	No	No effect	No effect
Total Ammonia	No	☐	No	☐	No	No	No effect	No effect
Nitrate	◆	◆	◆	◆	No	No	No effect	No effect
Nitrite	◆	◆	◆	◆	No	No	No effect	No effect
Total Phosphorus	No	☐	No	☐	No	No	No effect	No effect
Total Aluminum	No	☐	No	☐	No	No	No effect	No effect
Total Arsenic	No	☐	No	☐	No	No	No effect	No effect
Total Boron	No	☐	No	☐	No	No	No effect	No effect
Total Cadmium	◆	◆	◆	◆	No	No	No effect	No effect
Total Chromium	◆	◆	◆	◆	No	No	No effect	No effect
Total Copper	No	☐	No	☐	No	No	No effect	No effect
Total Iron	◆	◆	No	☐	No	No	No effect	No effect
Total Lead	◆	◆	◆	◆	No	No	No effect	No effect
Total Mercury	◆	◆	◆	◆	No	No	No effect	No effect
Total Molybdenum	No	☐	No	☐	No	No	No effect	No effect
Total Nickel	No	☐	No	☐	No	No	No effect	No effect
Total Selenium	◆	◆	◆	◆	No	No	No effect	No effect
Total Silver	◆	◆	◆	◆	No	No	No effect	No effect
Total Thallium	◆	◆	◆	◆	No	No	No effect	No effect
Total Uranium	No	☐	No	☐	No	No	No effect	No effect
Dissolved Zinc	◆	◆	◆	◆	No	No	No effect	No effect

Notes:
BA = Before-After, BACI = Before-After/Control-Impact
[a] Statistically significant difference at $p < 0.05$
[b] For pH, any deviation from baseline levels is considered to be an adverse effect; for all remaining variables, only an increase from baseline levels is considered to be an adverse effect.
[c] Conclusion of effect is based on statistical analysis, graphical analysis, comparison to normal baseline range, and professional judgment.
Diamond (◆) indicates that statistical analysis was not possible because of the high proportion of censored data.
Square (☐) indicates that the statistical comparison to Reference Lake B is not reported because the first step of the statistical analysis indicated no significant difference between before and after periods.

Table 3.3-2: Summary of Evaluation of Effects for Patch Lake Water Quality, Hope Bay Project, 2019

Variable	Statistical Analysis: BA or BACI Analysis				Graphical Analysis/Interpretation		Conclusion of Effect [c]	
	Under-ice		Open-water		Evidence of an Adverse [b] Change?			
	Within Lake Before-After Change (BA Analysis)? [a]	Difference in Before-After Trend Relative to Reference Lake (BACI Analysis)? [a]	Within Lake Before-After Change (BA Analysis)? [a]	Difference in Before-After Trend Relative to Reference Lake (BACI Analysis)? [a]	Under-ice	Open-water	Under-ice	Open-water
pH	No	☐	No	☐	No	No	No effect	No effect
Total Suspended Solids	◆	◆	No	☐	No	No	No effect	No effect
Turbidity	No	☐	No	☐	No	No	No effect	No effect
Chloride	No	☐	No	☐	No	No	No effect	No effect
Fluoride	No	☐	No	☐	No	No	No effect	No effect
Total Ammonia	No	☐	◆	◆	No	No	No effect	No effect
Nitrate	No	☐	◆	◆	No	No	No effect	No effect
Nitrite	◆	◆	◆	◆	No	No	No effect	No effect
Total Phosphorus	No	☐	No	☐	No	No	No effect	No effect
Total Aluminum	No	☐	No	☐	No	No	No effect	No effect
Total Arsenic	No	☐	No	☐	No	No	No effect	No effect
Total Boron	No	☐	No	☐	No	No	No effect	No effect
Total Cadmium	◆	◆	◆	◆	No	No	No effect	No effect
Total Chromium	◆	◆	◆	◆	No	No	No effect	No effect
Total Copper	No	☐	No	☐	No	No	No effect	No effect
Total Iron	No	☐	No	☐	No	No	No effect	No effect
Total Lead	◆	◆	◆	◆	No	No	No effect	No effect
Total Mercury	◆	◆	◆	◆	No	No	No effect	No effect
Total Molybdenum	No	☐	No	☐	No	No	No effect	No effect
Total Nickel	No	☐	No	☐	No	No	No effect	No effect
Total Selenium	◆	◆	◆	◆	No	No	No effect	No effect
Total Silver	◆	◆	◆	◆	No	No	No effect	No effect
Total Thallium	◆	◆	◆	◆	No	No	No effect	No effect
Total Uranium	No	☐	No	☐	No	No	No effect	No effect
Dissolved Zinc	◆	◆	◆	◆	No	No	No effect	No effect

Notes:
BA = Before-After, BACI = Before-After/Control-Impact
[a] Statistically significant difference at $p < 0.05$
[b] For pH, any deviation from baseline levels is considered to be an adverse effect; for all remaining variables, only an increase from baseline levels is considered to be an adverse effect.
[c] Conclusion of effect is based on statistical analysis, graphical analysis, comparison to normal baseline range, and professional judgment.
Diamond (◆) indicates that statistical analysis was not possible because of the high proportion of censored data.
Square (☐) indicates that the statistical comparison to Reference Lake B is not reported because the first step of the statistical analysis indicated no significant difference between before and after periods.

Table 3.3-3: Summary of Evaluation of Effects for Doris Lake Water Quality, Hope Bay Project, 2019

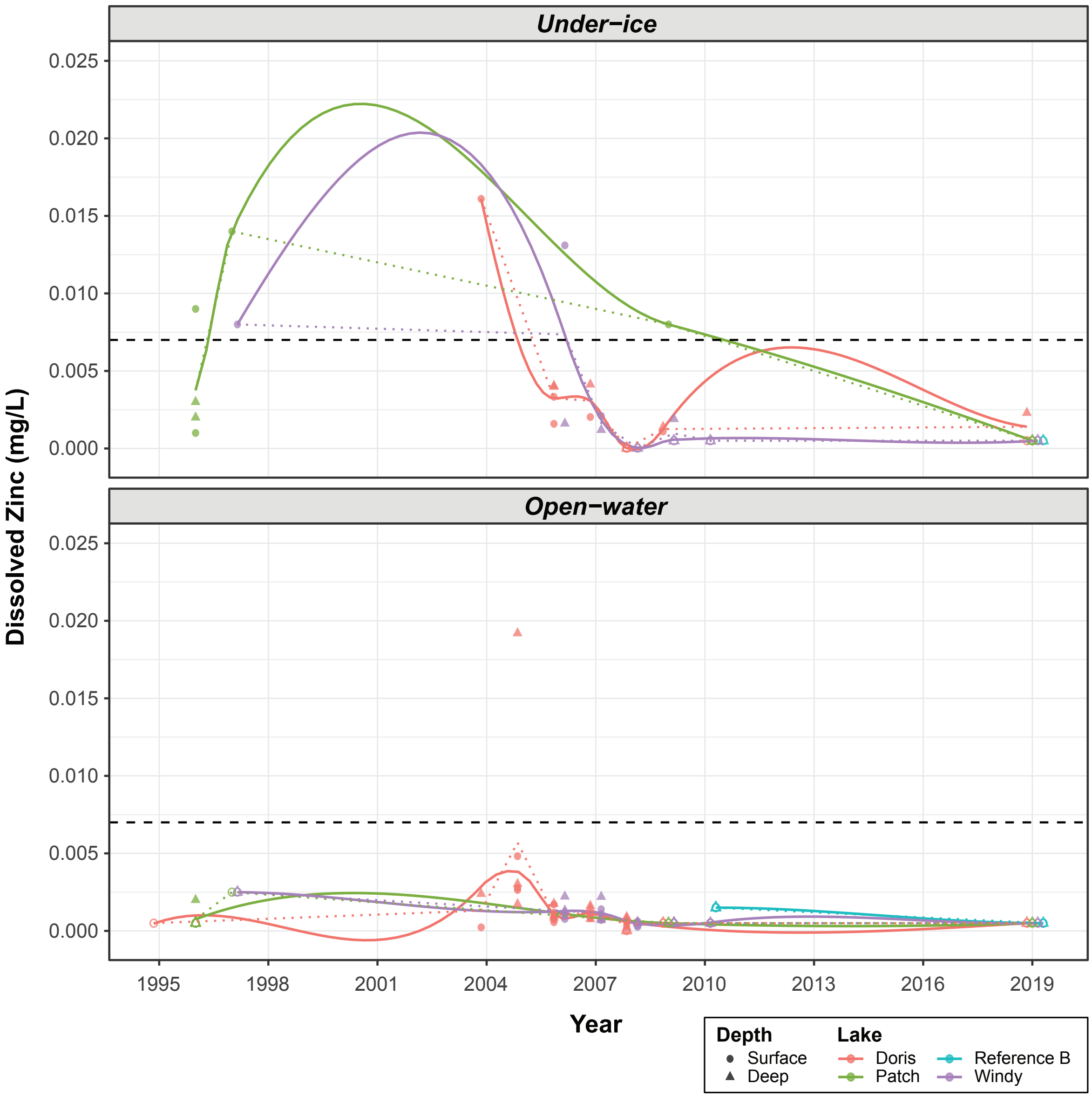
Variable	Statistical Analysis: Linear Mixed Model or Tobit Regression				Graphical Analysis/Interpretation		Conclusion of Effect [c]	
	Under-ice		Open-water		Evidence of an Adverse [b] Change?			
	Different from slope 0? [a]	Different from Reference Lake B slope? [a]	Different from slope 0? [a]	Different from Reference Lake B slope? [a]	Under-ice	Open-water	Under-ice	Open-water
pH	Yes	No	Yes	No	No	No	No effect	No effect
Total Suspended Solids	Yes	◆	No	☐	No	No	No effect	No effect
Turbidity	No	☐	No	☐	No	No	No effect	No effect
Chloride	Yes	Yes	Yes	Yes	No	No	No effect	No effect
Fluoride	No	☐	No	☐	No	No	No effect	No effect
Total Ammonia	Yes	Yes	◆	◆	Yes	No	Possible effect	No effect
Nitrate	Yes	No	◆	◆	No	No	No effect	No effect
Nitrite	◆	◆	◆	◆	No	No	No effect	No effect
Total Phosphorus	No	☐	No	☐	No	No	No effect	No effect
Total Aluminum	No	☐	No	☐	No	No	No effect	No effect
Total Arsenic	Yes	No	Yes	No	No	No	No effect	No effect
Total Boron	Yes	◆	Yes	◆	No	No	No effect	No effect
Total Cadmium	◆	◆	◆	◆	No	No	No effect	No effect
Total Chromium	◆	◆	◆	◆	No	No	No effect	No effect
Total Copper	No	☐	No	☐	No	No	No effect	No effect
Total Iron	◆	◆	Yes	◆	No	No	No effect	No effect
Total Lead	◆	◆	No	☐	No	No	No effect	No effect
Total Mercury	◆	◆	No	☐	No	No	No effect	No effect
Total Molybdenum	Yes	◆	Yes	◆	Yes	No	Possible effect	No effect
Total Nickel	No	☐	No	☐	No	No	No effect	No effect
Total Selenium	◆	◆	◆	◆	No	No	No effect	No effect
Total Silver	◆	◆	◆	◆	No	No	No effect	No effect
Total Thallium	◆	◆	◆	◆	No	No	No effect	No effect
Total Uranium	Yes	Yes	Yes	No	No	No	No effect	No effect
Dissolved Zinc	Yes	◆	◆	◆	No	No	No effect	No effect

Notes:
[a] Statistically significant difference at $p < 0.05$
[b] For pH, any deviation from baseline levels is considered to be an adverse effect; for all remaining variables, only an increase from baseline levels is considered to be an adverse effect.
[c] Conclusion of effect is based on statistical analysis, graphical analysis, comparison to normal baseline range, and professional judgment.
Diamond (◆) indicates that statistical analysis was not possible because of the high proportion of censored data.
Square (☐) indicates that the statistical comparison to Reference Lake B is not reported because the first step of the statistical analysis indicated no significant difference from a slope of zero.

Table 3.3-4: Comparison of Water Quality to Response Framework Conditions for Triggering a Low Action Level Response, Hope Bay Project, 2019

Exposure Lake:	Windy Lake			Windy Lake			Patch Lake			Patch Lake			Doris Lake			Doris Lake			Low Action Level Response Triggered for Any Lake?
Season:	Under-ice			Open-water			Under-ice			Open-water			Under-ice			Open-water			
Conditions for Low Action Level Response:	Conditions Met	Conditions Not Met	Conditions Not Evaluated [a]	Conditions Met	Conditions Not Met	Conditions Not Evaluated [a]	Conditions Met	Conditions Not Met	Conditions Not Evaluated [a]	Conditions Met	Conditions Not Met	Conditions Not Evaluated [a]	Conditions Met	Conditions Not Met	Conditions Not Evaluated [a]	Conditions Met	Conditions Not Met	Conditions Not Evaluated [a]	
Water Quality Variable																			
pH		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	No
Total Suspended Solids		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	No
Turbidity	2 (↓)	1, 3	4	2 (↓)	1, 3	4		1, 2, 3	4		1, 2, 3	4	2 (↑)	1, 3	4		1, 2, 3	4	No
Chloride	3	1, 2	4	3	1, 2	4	3	1, 2	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	No
Fluoride		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	No
Total Ammonia		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		2, 3	1, 4	1, 2 (↑), 4	3			2, 3	1, 4	No
Nitrate		2, 3	1, 4		2, 3	1, 4		1, 2, 3	4		2, 3	1, 4		1, 2, 3	4		2, 3	1, 4	No
Nitrite		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4	No
Total Phosphorus		1, 2	3, 4		1, 2	3, 4		1, 2	3, 4		1, 2	3, 4	2 (↑)	1	3, 4		1, 2	3, 4	No
Total Aluminum	2 (↓)	1, 3	4		1, 2, 3	4		1, 2, 3	4	3	1, 2	4	2 (↓)	1, 3	4	3	1, 2	4	No
Total Arsenic		1, 2, 3	4		1, 2, 3	4	2 (↓)	1, 3	4		1, 2, 3	4	2 (↓)	1, 3	4		1, 2, 3	4	No
Total Boron		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	No
Total Cadmium		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4	No
Total Chromium		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4	No
Total Copper		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	3	1, 2	4		1, 2, 3	4	No
Total Iron		2, 3	1, 4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		2, 3	1, 4		1, 2, 3	4	No
Total Lead		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		1, 2, 3	4	No
Total Mercury		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		1, 2, 3	4	No
Total Molybdenum		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	1, 2 (↑)	3	4		1, 2, 3	4	No
Total Nickel		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	2 (↑)	1, 3	4		1, 2, 3	4	No
Total Selenium		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4	2 (↓)	3	1, 4		2, 3	1, 4	No
Total Silver		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4	No
Total Thallium		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4	No
Total Uranium		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4		1, 2, 3	4	No
Dissolved Zinc		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		2, 3	1, 4		1, 2, 3	4		2, 3	1, 4	No

Notes:
Condition 1: identification of a statistically significant and potentially adverse change from baseline conditions.
Condition 2: the concentration of the water quality variable is outside of the normal range based on baseline concentration.
Condition 3: the concentration of the water quality variable exceeds 75% of a benchmark.
Condition 4: if a potentially adverse change is detected at the exposure site, the absence of a similar change at the reference site.
↑ and ↓ indicate that at least one replicate concentration was higher or lower that the baseline range, respectively. For Windy Lake, baseline data were from 1997 to 2019; for Patch Lake, baseline data were from 1995 to 2018; for Doris Lake, baseline data were from 1995 to 2009.
[a] Condition was not evaluated either because it was not necessary (i.e., at least one other condition was not met), or because there was not enough information for the evaluation (e.g., because of high proportion of censored data or absence of a water quality benchmark).



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
The long-term CCME guideline for dissolved zinc is hardness-, pH-, and dissolved organic carbon (DOC)-dependent; black dashed lines represent the dissolved zinc guideline of 0.007 mg/L for waters with a hardness of 50 mg $CaCO_3$/L, pH of 7.5, and DOC of 0.5 mg/L.

Figure 3.3-25: Dissolved Zinc Concentrations in AEMP Monitored Lakes, Hope Bay Project, 1995 to 2019

The following sections present the evaluation of effects for sediment quality variables. Sediment quality data for 2019 are presented in Appendix A, and all statistical analysis results are presented in Appendix C.

3.4.1 Arsenic

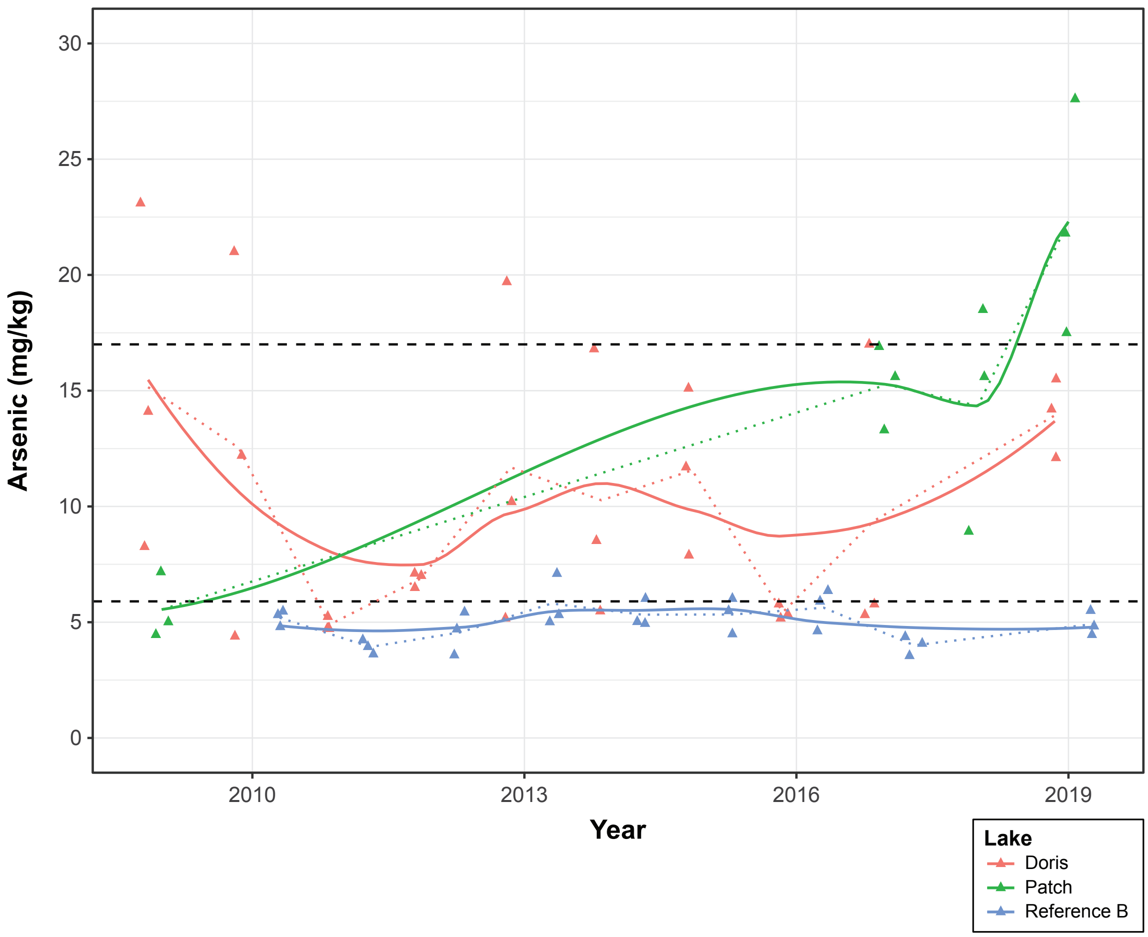
Sediment arsenic concentrations in Patch and Doris lakes were highly variable both inter-annually and among replicates within a given year (Figure 3.4-1). Mean annual arsenic concentrations in both lakes were generally between the ISQG of 5.9 mg/kg and the PEL of 17 mg/kg (Figure 3.4-1). Elevated concentrations of arsenic are naturally occurring as concentrations measured during baseline years were also higher than the ISQG guideline.

In Patch Lake, the mean sediment arsenic concentration in 2019 (22.2 mg/kg) exceeded the PEL of 17 mg/kg and was higher than mean sediment arsenic concentrations measured in previous years, which were just below the PEL (Figure 3.4-1). However, this apparent change in sediment arsenic concentrations was not statistically significant as the before-after analysis indicated that there was no statistically significant difference in means between baseline years (2009 to 2018) and 2019 ($p = 0.230$). There was no apparent Project-related increase in arsenic concentrations in the water column of Patch Lake (Section 3.3-11) thus elevated values cannot be associated with increases in water column. Elevated sediment arsenic concentrations greater than the PEL may also negatively affect benthic invertebrate communities in Patch Lake; however no adverse changes to benthic invertebrate communities were detected (Section 3.6). Arsenic will continue to be closely monitored to determine if there is an increasing trend in the sediments of Patch Lake, or whether concentrations were elevated in 2019 due to natural variability. Although 2019 sediment arsenic concentrations in Patch Lake were outside of the normal range based on baseline concentrations and exceeded 75% of the ISQG and PEL guidelines, the low action level for arsenic in Patch Lake sediments was not exceeded because there was no statistically significant increase in concentrations.

Doris Lake sediment arsenic concentrations in 2019 were within the range of baseline (2009) concentrations (Figure 3.4-1). The trend in arsenic concentrations over time in Doris Lake showed inter-annual variability, but no clear directional change (Figure 3.4-1). The sediment arsenic trend over time in Doris Lake was significantly different from a slope of zero ($p = 0.0305$), but not significantly different from the trend in Reference Lake B ($p = 0.273$). This suggests that there were parallel changes in arsenic over time between Doris Lake and Reference Lake B, and inter-annual variability in sediment arsenic concentrations in Doris Lake was likely naturally occurring and not related to the Project. Although arsenic concentrations in Doris Lake sediments were higher than 75% of the ISQG guideline, a low action level response was not triggered because sediment arsenic concentrations were within the range of baseline concentrations and did not increase over time.

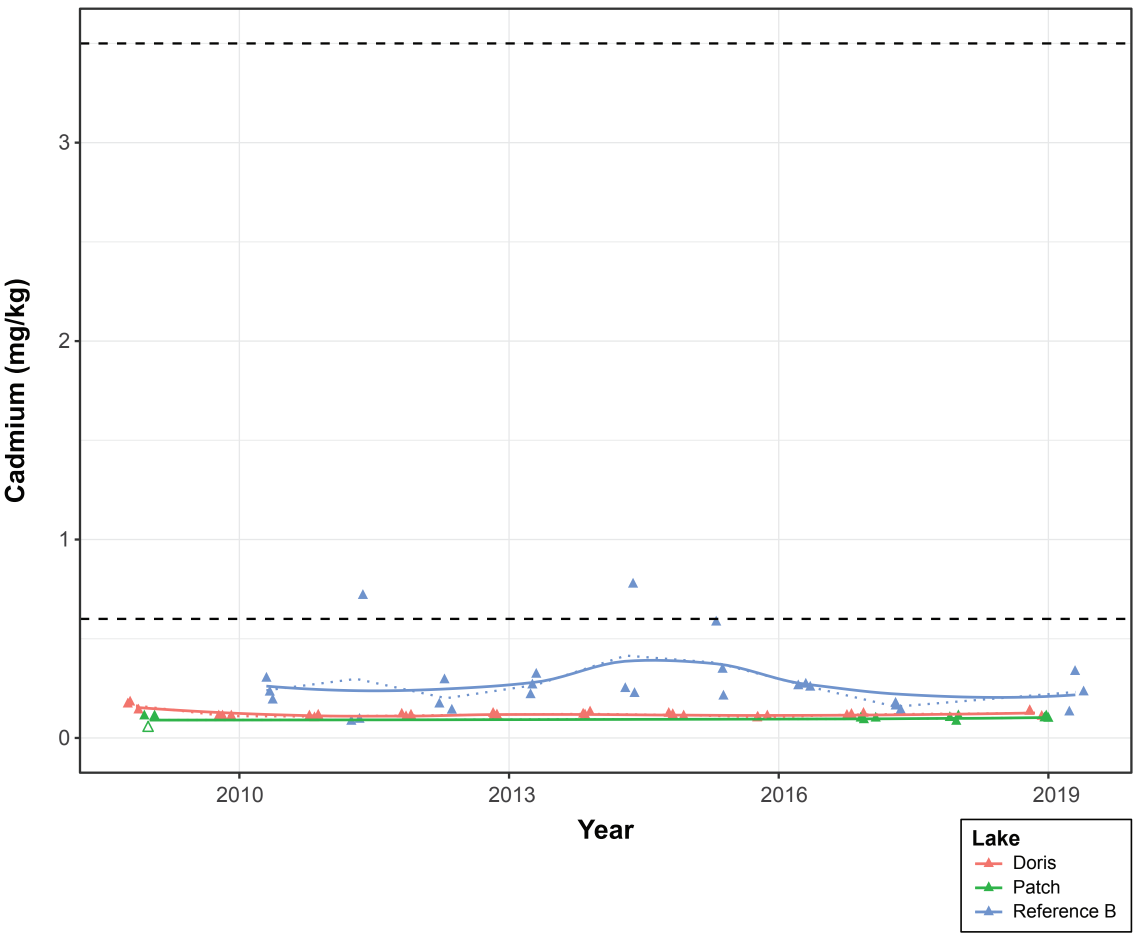
3.4.2 Cadmium

Sediment cadmium concentrations were nearly constant over time in both Patch and Doris lakes, and tended to be lower than cadmium concentrations in Reference Lake B sediments (Figure 3.4-2). The statistical analysis confirmed that the cadmium trend over time in Doris Lake was not significantly different from a slope of zero ($p = 0.902$), and the before-after comparison of cadmium concentrations in Patch Lake showed no significant difference between before (2009 to 2018) and after (2019) periods ($p = 0.277$). Thus, Project activities had no apparent adverse effect on cadmium concentrations in Patch and Doris lake sediments, and a low action level response was not triggered. Sediment cadmium concentrations in both exposure lakes also remained below the CCME ISQG of 0.6 mg/kg and the PEL of 3.5 mg/kg (Figure 3.4-2).



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for arsenic (5.9 mg/kg) and the probable effects level (PEL) for arsenic (17 mg/kg).

Figure 3.4-1: Arsenic Concentrations in AEMP Monitored Lake Sediments, Hope Bay Project, 2009 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for cadmium (0.6 mg/kg) and the probable effects level (PEL) for cadmium (3.5 mg/kg).

Figure 3.4-2: Cadmium Concentrations in AEMP Monitored Lake Sediments, Hope Bay Project, 2009 to 2019

3.4.3 Chromium

Sediment chromium concentrations in Patch and Doris lakes were elevated compared to the reference lake, but remained relatively consistent over time, with mean concentrations always greater than the CCME ISQG of 37.3 mg/kg and slightly below the PEL of 90 mg/kg (Figure 3.4-3). Elevated concentrations of chromium are naturally occurring in the monitored lakes, as concentrations measured during baseline years were also higher than the ISQG guideline. The statistical analysis indicated that that the chromium trend over time in Doris Lake was not significantly different from a slope of zero ($p = 0.253$), and the before-after comparison of chromium concentrations in Patch Lake showed no significant difference between before (2009 to 2018) and after (2019) periods ($p = 0.971$). Although chromium concentrations in both Patch and Doris lakes were consistently higher than the ISQG guideline, a low action level response for chromium was not triggered because there was no evidence of a Project-related increase in chromium concentrations over time in either exposure lake.

3.4.4 Copper

Sediment copper concentrations in both Patch and Doris lakes changed little over time (Figure 3.4-4). The statistical analyses confirmed that the before (2009 to 2018) and after (2019) mean sediment copper concentrations in Patch Lake were not significantly different ($p = 0.590$), and the sediment copper trend over time in Doris Lake was not significantly different from a slope of zero ($p = 0.423$). Mean sediment copper concentrations in Doris Lake from 2009 to 2019 were consistently above the CCME ISQG of 35.7 mg/kg but below the PEL of 197 mg/kg, while concentrations in Patch Lake were at or slightly below the ISQG (Figure 3.4-4). A low action level response for copper was not triggered because there was no apparent Project-related increase in sediment copper concentrations.

3.4.5 Lead

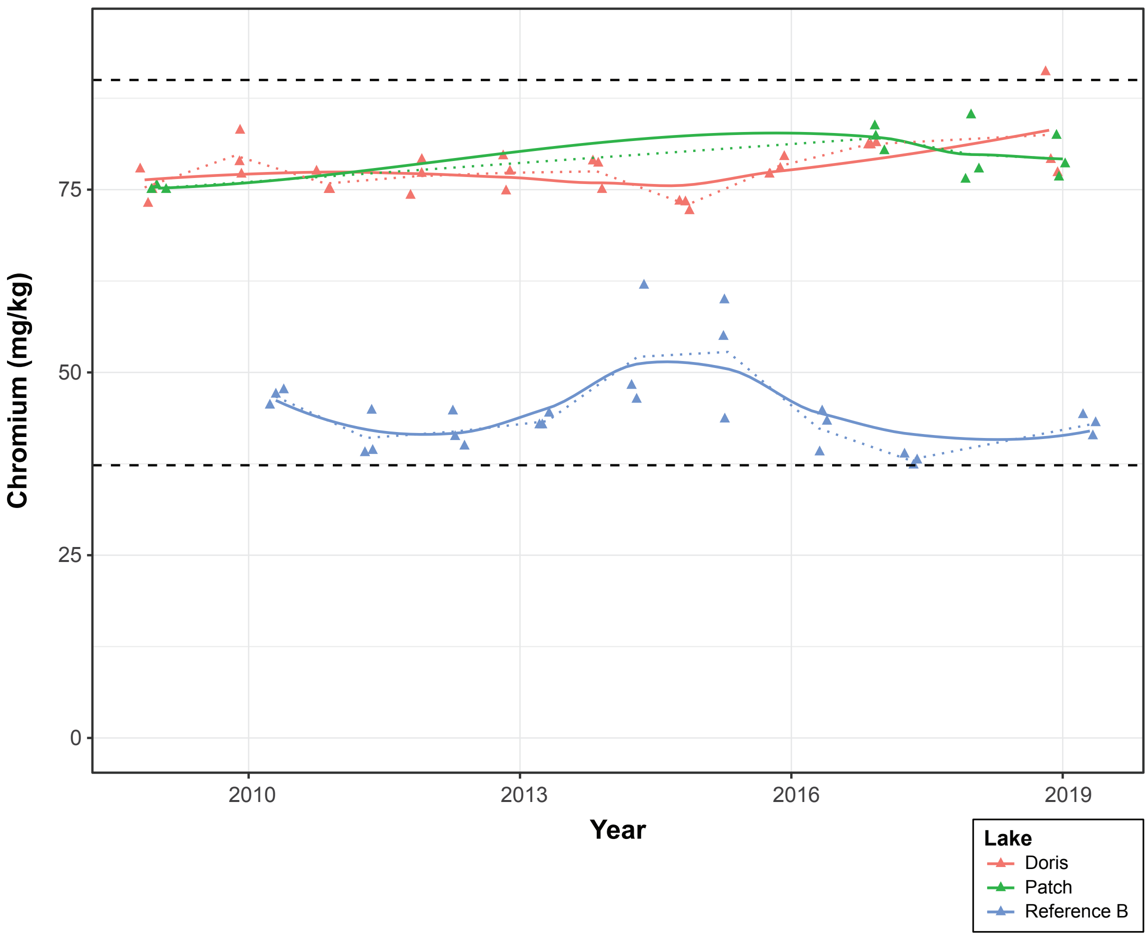
Sediment lead concentrations in Patch Lake were highest in 2009, and were relatively similar between 2017 and 2019 (Figure 3.4-5). The before-after analysis showed that the before (2009 to 2018) mean was not significantly different from the 2019 mean ($p = 0.668$), suggesting that there was no effect of Project activities on sediment lead concentrations in this lake.

In Doris Lake, the highest mean sediment lead concentration of 14.4 mg/kg was measured during the baseline year (2009), and concentrations decreased to 9.96 mg/kg in 2011 followed by a gradual increase to a mean of 12.4 mg/kg in 2019 (Figure 3.4-5). Although there was no evidence of an overall increase in sediment lead concentrations over time, the statistical analysis showed that the trend in sediment lead concentrations in Doris Lake was significantly different from a slope of zero ($p = 0.0127$) and significantly different from the trend in Reference Lake B ($p < 0.0001$). However, because the overall trend in 2009 to 2019 lead concentrations in Doris Lake sediments was not an increase, there is no evidence of an adverse change in lead concentrations over time.

Sediment lead concentrations in both exposure lakes remained well below the CCME ISQG of 35 mg/kg, the PEL of 91.3 mg/kg (Figure 3.4-5), and a low action level response was not triggered for lead.

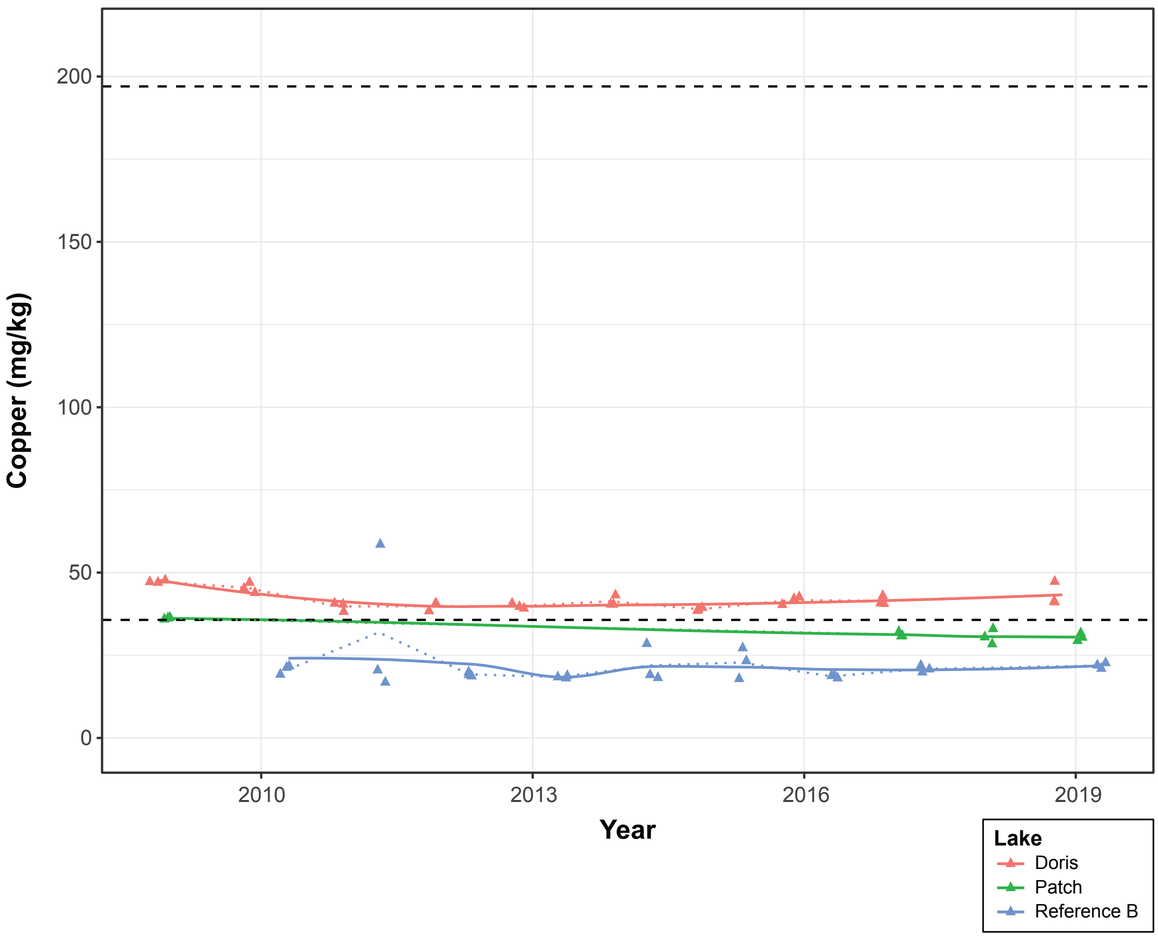
3.4.6 Mercury

Mercury concentrations in the sediments of Patch and Doris lakes were generally consistent over time from 2009 to 2019 (Figure 3.4-6). The statistical analyses confirmed that the before (2009 to 2018) and after (2019) mean sediment mercury concentrations in Patch Lake were not significantly different ($p = 0.255$), and the sediment mercury trend over time in Doris Lake was not significantly different from a slope of zero ($p = 0.0578$). Therefore, there was no apparent Project effect on sediment mercury concentrations in the exposure lakes, and a low action level response was not triggered. All sediment mercury concentrations remained below the CCME ISQG of 0.170 mg/kg and the PEL of 0.486 mg/kg (Figure 3.4-6).



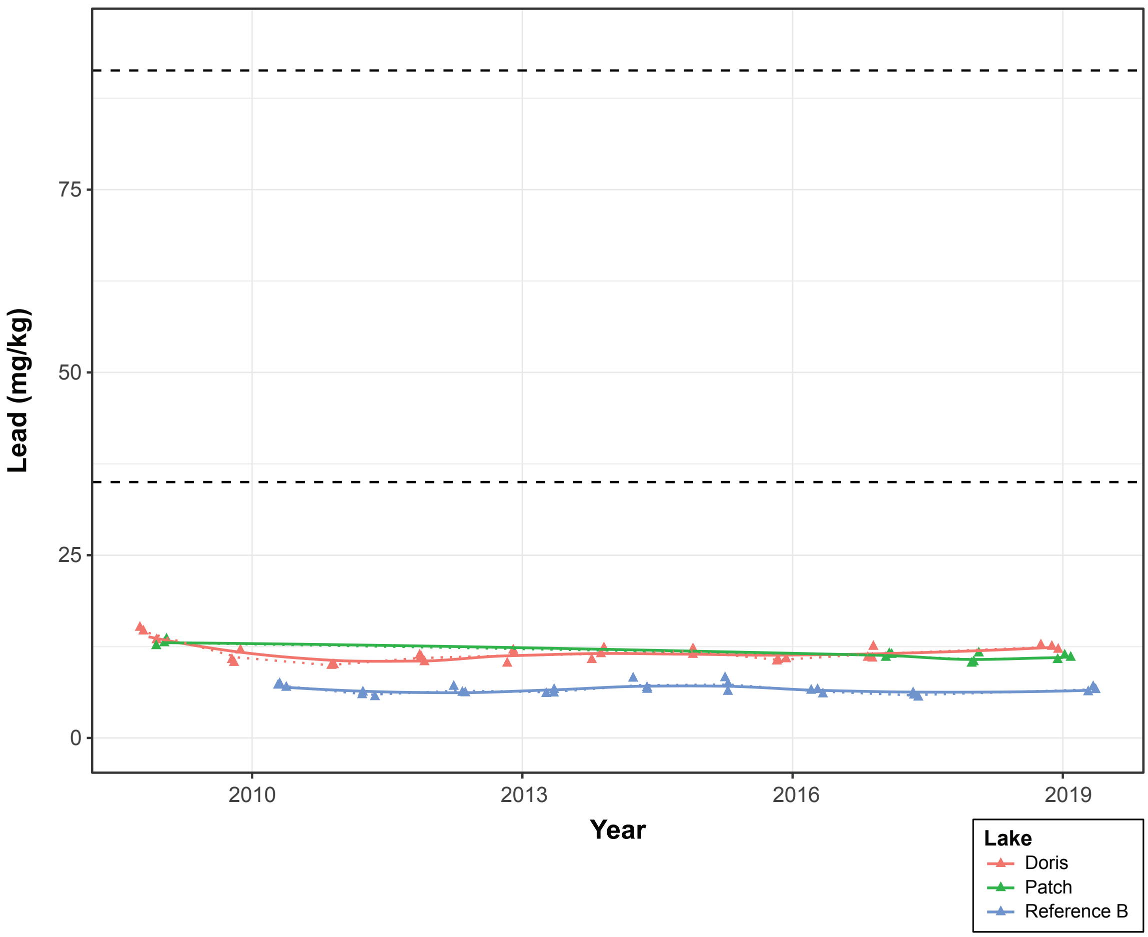
Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for chromium (37.3 mg/kg) and the probable effects level (PEL) for chromium (90 mg/kg).

Figure 3.4-3: Chromium Concentrations in AEMP Monitored Lake Sediments, Hope Bay Project, 2009 to 2019



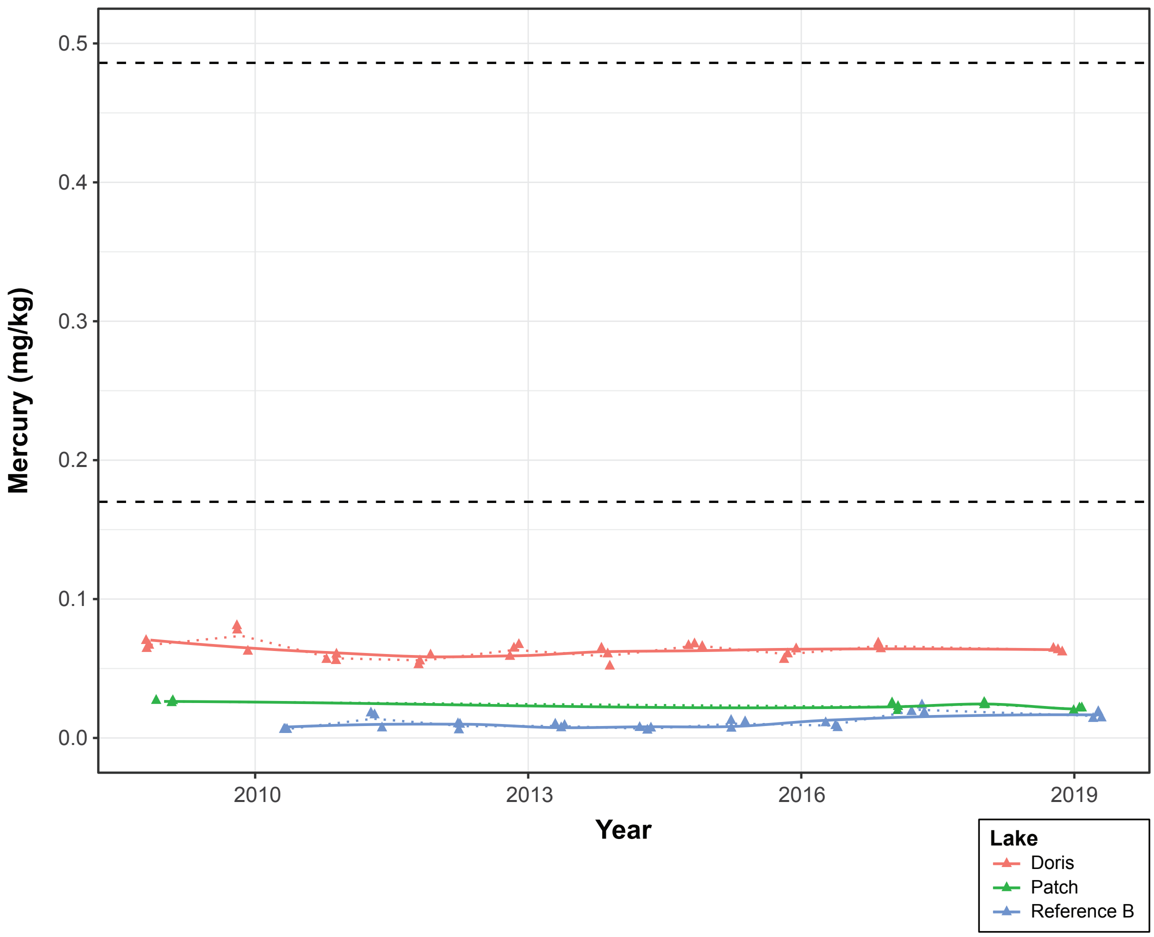
Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for copper (35.7 mg/kg) and the probable effects level (PEL) for copper (197 mg/kg).

Figure 3.4-4: Copper Concentrations in AEMP Monitored Lake Sediments, Hope Bay Project, 2009 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for lead (35 mg/kg) and the probable effects level (PEL) for lead 91.3 mg/kg).

Figure 3.4-5: Lead Concentrations in AEMP Monitored Lake Sediments, Hope Bay Project, 2009 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for mercury (0.17 mg/kg) and the probable effects level (PEL) for mercury (0.486 mg/kg).

Figure 3.4-6: Mercury Concentrations in AEMP Monitored Lake Sediments, Hope Bay Project, 2009 to 2019

3.4.7 Zinc

Sediment zinc concentrations in Patch and Doris lakes changed little over time from 2009 to 2019 (Figure 3.4-7). This consistency over time was confirmed by the statistical analyses, which showed that the before (2009 to 2018) and after (2019) mean sediment zinc concentrations in Patch Lake were not significantly different ($p = 0.353$), and the sediment zinc trend over time in Doris Lake was not significantly different from a slope of zero ($p = 0.750$). Mean sediment zinc concentrations in Doris and Patch lakes in 2019 were below the ISQG of 123 mg/kg and the PEL of 315 mg/kg (Figure 3.4-7). There was no apparent adverse change in sediment zinc concentrations due to Project activities, and a low action level response was not triggered.

3.4.8 Sediment Quality Summary

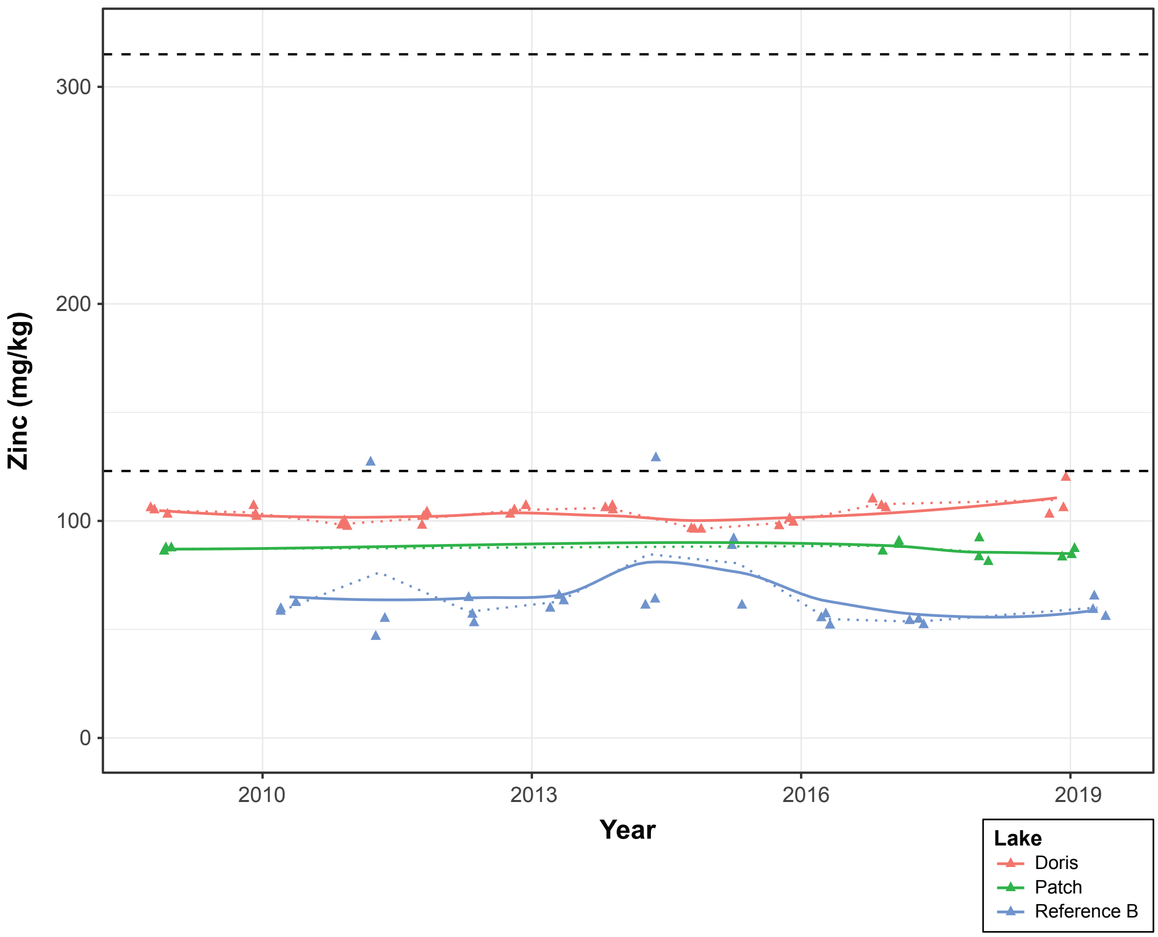
Tables 3.4-1 and 3.4-2 provide summaries of the evaluation of effects for sediment quality in Patch and Doris lakes. The conclusions of the AEMP evaluation of effects feed into the Response Framework to identify potential Project effects that may require management action to prevent adverse environmental consequences. Table 3.4-3 presents a summary of the screening of the results of the evaluation of effects against the conditions that must be met to trigger a ‘low action level’ response under the Response Framework (as described in Section 2.2.3.1).

The evaluation of effects concluded that there were no Project-related changes in sediment quality in 2019 in both Patch and Doris lakes. Sediment arsenic concentrations in Patch Lake were higher in 2019 than in previous years, but the statistical analysis showed that this change was not statistically significant. Concentrations of some sediment metals (i.e., arsenic and chromium in both lakes and copper in Doris Lake) exceeded the ISQG (and occasionally PEL guidelines) in 2019; however, these metals were naturally elevated as these guidelines were also exceeded during baseline years. As shown in Table 3.4-3, at least one condition was not met for each evaluated lake/variable combination; therefore, no low action level responses were triggered for sediment quality during the 2019 assessment year.

Table 3.4-1: Summary of Evaluation of Effects for Patch Lake Sediment Quality, Hope Bay Project, 2019

Variable	Statistical Analysis: BA or BACI Analysis		Graphical Analysis/ Interpretation	
	Within Lake Before-After Change (BA Analysis)? [a]	Difference in Before-After Trend Relative to Reference Lake (BACI Analysis)? [a]	Evidence of an Adverse[b] Change?	Conclusion of Effect [c]
Arsenic	No	☐	Yes	No effect
Cadmium	No	☐	No	No effect
Chromium	No	☐	No	No effect
Copper	No	☐	No	No effect
Lead	No	☐	No	No effect
Mercury	No	☐	No	No effect
Zinc	No	☐	No	No effect

Notes:
BA = Before-After, BACI = Before-After/Control-Impact
[a] Statistically significant difference at $p < 0.05$
[b] Only an increase from baseline levels is considered to be an adverse effect.
[c] Conclusion of effect is based on statistical analysis, graphical analysis, comparison to normal baseline range, and professional judgment.
Square (☐) indicates that the statistical comparison to Reference Lake B is not reported because the first step of the statistical analysis indicated no significant difference between before and after periods.



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.
Black dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for zinc (123 mg/kg) and the probable effects level (PEL) for zinc (315 mg/kg).

Figure 3.4-7: Zinc Concentrations in AEMP Monitored Lake Sediments, Hope Bay Project, 2009 to 2019

Table 3.4-2: Summary of Evaluation of Effects for Doris Lake Sediment Quality, Hope Bay Project, 2019

Variable	Statistical Analysis: Linear Mixed Model or Tobit Regression		Graphical Analysis/Interpretation	Conclusion of Effect [c]
	Different from Slope 0? [a]	Different from Reference Lake B Slope? [a]	Evidence of an Adverse [b] Change?	
Arsenic	Yes	No	No	No effect
Cadmium	No	☐	No	No effect
Chromium	No	☐	No	No effect
Copper	No	☐	No	No effect
Lead	Yes	Yes	No	No effect
Mercury	No	☐	No	No effect
Zinc	No	☐	No	No effect

Notes:
[a] Statistically significant difference at $p < 0.05$
[b] Only an increase from baseline levels is considered to be an adverse effect.
[c] Conclusion of effect is based on statistical analysis, graphical analysis, comparison to normal baseline range, and professional judgment.
Square (☐) indicates that the statistical comparison to Reference Lake B is not reported because the first step of the statistical analysis indicated no significant difference from a slope of zero.

Table 3.4-3: Comparison of Sediment Quality to Response Framework Conditions for Triggering a Low Action Level Response, Hope Bay Project, 2019

Exposure Lake:	Patch Lake			Doris Lake			Low Action Level Response Triggered for Any Lake?
Conditions for Low Action Level Response:	Conditions Met	Conditions Not Met	Conditions Not Evaluated[a]	Conditions Met	Conditions Not Met	Conditions Not Evaluated[a]	
Sediment Quality Variable							
Arsenic	2 (↑), 3	1	4	3	1, 2	4	No
Cadmium		1, 2, 3	4	2 (↓)	1, 3	4	No
Chromium	3	1, 2	4	2 (↑), 3	1	4	No
Copper	3	1, 2	4	2 (↓), 3	1	4	No
Lead		1, 2, 3	4	2 (↓)	1, 3	4	No
Mercury		1, 2, 3	4	2 (↓)	1, 3	4	No
Zinc		1, 2, 3		2 (↑), 3	1	4	No

Notes:
Condition 1: identification of a statistically significant and potentially adverse change from baseline conditions.
Condition 2: the concentration of the sediment quality variable is outside of the normal range based on baseline concentration.
Condition 3: the concentration of the sediment quality variable exceeds 75% of a benchmark.
Condition 4: if a potentially adverse change is detected at the exposure site, the absence of a similar change at the reference site.
↑ and ↓ indicate that at least one replicate concentration was higher or lower that the baseline range, respectively. For Patch Lake, baseline data were from 2009 to 2018; for Doris Lake, baseline data were from 2009.
[a] Condition was not evaluated either because it was not necessary (i.e., at least one other condition was not met), or because there was not enough information for the evaluation (e.g., because of high proportion of censored data).

3.5 Phytoplankton Biomass

Phytoplankton are important primary producers in lakes, and phytoplankton biomass levels are estimated using the main photosynthetic pigment, chlorophyll *a*. Changes in chlorophyll *a* concentrations over time can be used as an indicator of changes in water quality and ecosystem health. The introduction of nutrients (e.g., phosphorus and nitrogen) through site runoff into lakes near Project infrastructure or activities could lead to increased primary production, while increases in certain water quality variables such as TSS, turbidity, or heavy metals could cause a decrease in primary production.

In August 2019, chlorophyll *a* samples were collected from the surface waters of two exposure lake sites (Doris Lake and Patch Lake) and one reference lake site (Reference Lake B) to estimate phytoplankton biomass levels. For Patch Lake, phytoplankton biomass data collected between 2009 and 2018 are considered to represent baseline conditions prior to the start to Madrid North construction activities in 2019. For Doris Lake, phytoplankton biomass data collected in 2009 are considered to represent baseline conditions prior to the start of Doris construction activities in 2010. Statistical and graphical analyses were used to determine if there were changes in phytoplankton biomass over time or in 2019 specifically compared to baseline conditions. Biomass trends were also compared between the exposure and reference sites to determine whether a low action level was exceeded according to the Response Framework.

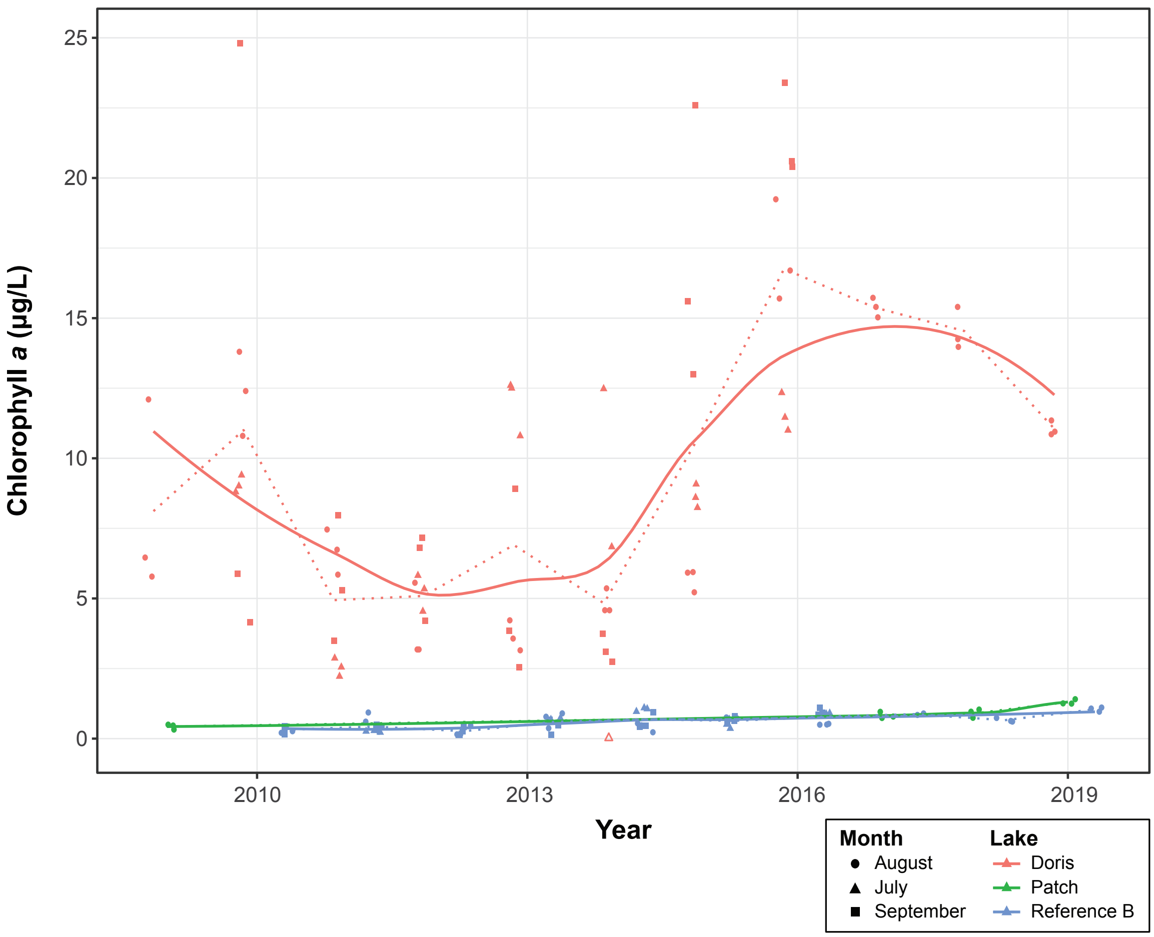
Phytoplankton biomass data collected in 2019 are presented in Appendix A, and all statistical analysis results are presented in Appendix C.

3.5.1 Phytoplankton Biomass as Chlorophyll a

Chlorophyll *a* concentrations were markedly higher in Doris Lake than in either Patch Lake or Reference Lake B between 2009 and 2019 (Figure 3.5-1). Phytoplankton biomass was highly inter- and intra-annually variable in Doris Lake. Between 2009 and 2019, mean monthly chlorophyll *a* concentrations in Doris Lake ranged from a minimum of 2.5 µg chl *a*/L (July 2011) to a maximum of 21.5 µg chl *a*/L (September 2016), while mean annual chlorophyll *a* concentrations ranged from 4.8 µg chl *a*/L (2014) to 16.8 µg chl *a*/L (2016). The mean 2019 August concentration of 11.1 µg chl *a*/L was approximately mid-range compared to historical monthly and annual means.

The statistical analysis of phytoplankton biomass in Doris Lake indicated that the trend in chlorophyll *a* concentrations over time was significantly different from a slope of zero ($p < 0.0001$), and significantly different from the chlorophyll *a* trend in Reference Lake B ($p = 0.0214$). However, the graphical analysis of biomass levels from 2009 to 2019 shows that 2019 chlorophyll *a* concentrations were similar to 2009 and 2010 concentrations, and the trend in biomass seems to show an oscillating or cyclical pattern over a decadal time scale rather than an increase or decrease over time (Figure 3.5-1). Mean annual chlorophyll *a* concentrations reached a minimum between 2012 and 2014, then increased to a peak in 2016, and have declined steadily from 2016 to 2019, with 2019 concentrations returning to a similar magnitude as in 2009 and 2010 (Figure 3.5-1). Given that 2019 chlorophyll a concentrations were within the range of historical concentrations and did not show a clear increasing or decreasing trend over time, a low action level response for phytoplankton biomass was not triggered.

Chlorophyll *a* concentrations in Patch Lake were generally consistent over time, and nearly identical to those in Reference Lake B (annual means ranging from 0.43 to 1.3 µg chl *a*/L in Patch Lake and 0.27 to 1.0 µg chl *a*/L in Reference Lake B; Appendix C and Figure 3.5-1). The before-after analysis of chlorophyll *a* concentrations in Patch Lake showed that there was no significant difference in chlorophyll *a* concentrations between before (2009 to 2018) and after (2019) periods ($p = 0.308$), indicating that construction and operation activities in the Madrid North area have not affected phytoplankton biomass levels in Patch Lake. Therefore, a low action level response for phytoplankton biomass in Patch Lake was not triggered.



Notes: Observations are slightly jittered along the x-axis for legibility.
Open symbols represent values below analytical detection limits, which are plotted at half the detection limit.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.5-1: Phytoplankton Biomass (as Chlorophyll *a*) in AEMP Monitored Lakes, Hope Bay Project, 2009 to 2019

According to a widely used trophic classification system developed by Vollenweider and Kerekes (1982) and cited in Environment Canada's *Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems* (2004; Table 3.5-1), the range of chlorophyll *a* concentrations measured in the study lakes corresponds closely with what would be expected based on the total phosphorus concentrations in these lakes. Doris Lake would be classified as meso-eutrophic based on the mean total phosphorus concentration measured in this lake between 2004 and 2019 (0.026 mg/L; Section 3.3-9), and the mean and maximum chlorophyll a concentrations in Doris Lake are consistent with the ranges given in Table 3.5-1 for meso-eutrophic lakes. Based on the mean total phosphorus concentrations measured in Patch Lake (0.006 mg/L; Section 3.3-9) and Reference Lake B (0.005 mg/L; Section 3.3-9), these lakes would both be classified as oligotrophic (CCME 2019c) or oligo-mesotrophic (Table 3.5-1) depending on the classification system used, and the mean and maximum chlorophyll *a* concentrations in these lakes also correspond with the levels expected for these trophic categories (Table 3.5-1).

Table 3.5-1: Trophic Classification of Lakes, with Corresponding Total Phosphorus and Chlorophyll *a* Concentrations

Trophic Level	Total Phosphorus (mg/L)		Mean Chlorophyll *a* (µg/L)	Max Chlorophyll *a* (µg/L)
Source:	Wetzel (2001)	Vollenweider and Kerekes (1982)	Vollenweider and Kerekes (1982)	
Ultra-oligotrophic	< 0.005	< 0.004	< 1	< 2.5
Oligo-mesotrophic	0.005 to 0.010	0.004 to 0.010	< 2.5	< 8
Meso-eutrophic	0.010 to 0.030	0.010 to 0.035	2.5 to 8.0	8.0 to 25
Eutrophic	0.030 to 0.100	0.035 to 0.100	8.0 to 25	27 to 75
Hypereutrophic	< 0.100	< 0.100	> 25	> 75

Source: Environment Canada (2004)

3.6 Benthic Invertebrates

Benthic invertebrate (benthos) samples were collected from two exposure lakes (Doris Lake and Patch Lake) and one reference lake (Reference Lake B) in August 2019, and benthos density, taxa richness, Simpson's evenness index, and the Bray-Curtis index (a measure of similarity between sites) were calculated for each lake. The level of taxonomic resolution used to calculate community descriptors was family level, as recommended by Environment Canada's *Metal Mining Technical Guidance for Environmental Effects Monitoring* (Environment Canada 2012).

Benthos data have been collected since 1996 in the Project area (Figure 2.2-6). However, all of the historical data collected from 1996 to 2008 were excluded from the benthos analyses because sampling locations in the study lakes differed from locations sampled from 2009 to 2019, or because of differences in sampling depths since benthos density and assemblage can vary greatly with depth and location within the lake. The current AEMP benthos sampling depths are approximately 13 to 15 m in Doris Lake, 8 to 9 m in Patch Lake, and 10 to 11 m in Reference Lake B. Benthos data from 2009 collected in Patch and Doris lakes were similar to the current AEMP sampling locations both spatially and in terms of depth; however, 2009 benthos sampling methods differed from the methods used from 2010 to 2019. In 2009, benthos sampling consisted of collecting three discrete replicates per site with no composite sampling, while the sampling procedure that has been followed since 2010 consists of collecting three discrete samples and subsequently pooling these three subsamples to make up a composite replicate sample, and collecting a total of five composite replicates per site. To make 2009 data more comparable to data collected since 2010 (since the pooling of subsamples affects sample variability, as well as diversity components such as richness and evenness), the 2009 data were re-analyzed by manually pooling the three replicates to obtain a single composite replicate sample comparable to each of the five replicates collected during sampling efforts since 2010. Therefore, in the analyses and figures presented in this section, data from 2009 are represented by a single data point, while data from 2010 to 2019 are represented by five replicates for each year that samples were collected.

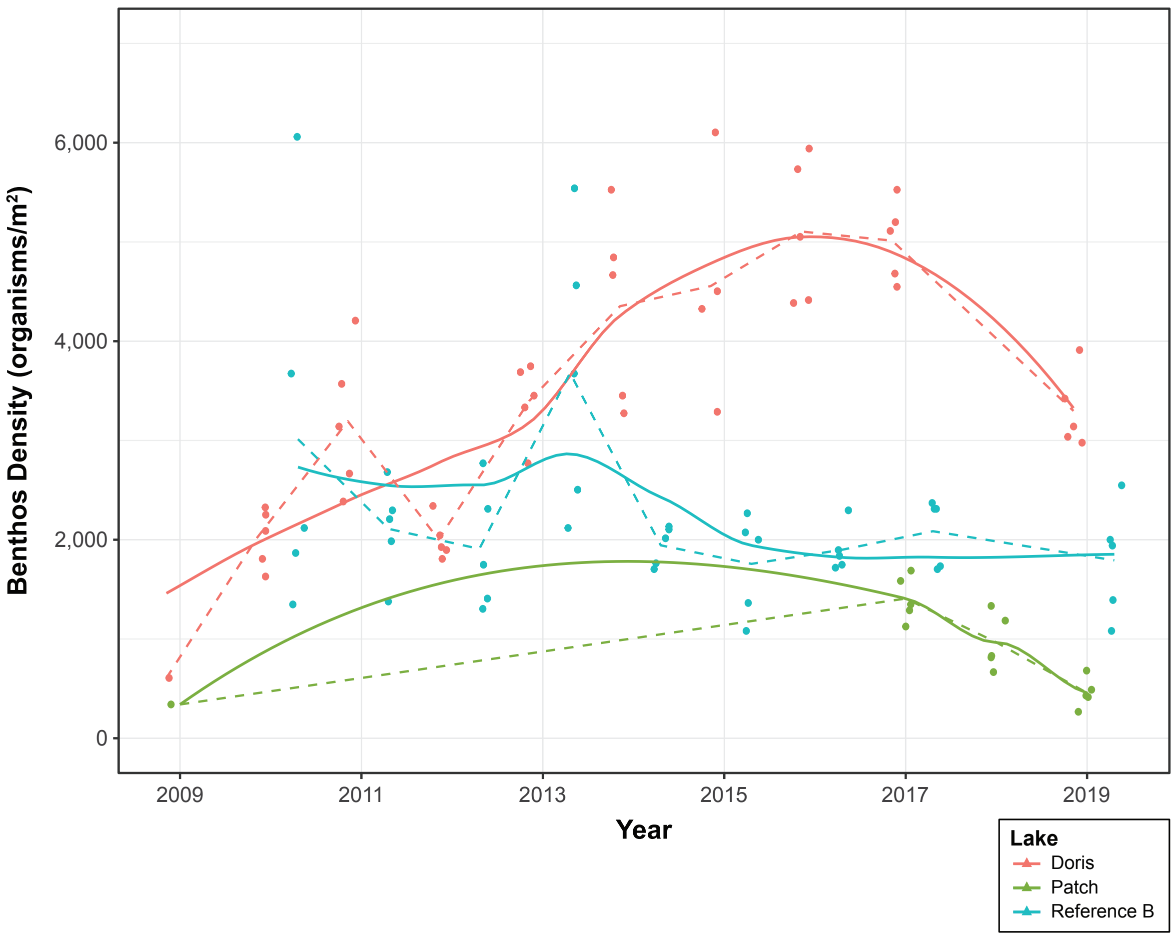
For Patch Lake, benthos data collected between 2009 and 2018 are considered to represent baseline conditions prior to the start to Madrid North construction activities in 2019. For Doris Lake, benthos data collected in 2009 are considered to represent baseline conditions prior to the start of Doris construction activities in 2010.

Statistical and graphical analyses were used to determine if there were changes in benthos community descriptors over time from 2009 to 2019. Trends were also compared between the exposure and reference site to determine whether a low action level was triggered according to the Response Framework. Benthos data collected in 2019 and calculated benthic community metrics are presented in Appendix A, and statistical analysis results are presented in Appendix C.

3.6.1 Density

Benthos density in recent years has been higher in Doris Lake than in either Reference Lake B or Patch Lake (Figure 3.6-1). Given the higher productivity of Doris Lake and its classification as meso-eutrophic compared to the oligotrophic/oligo-mesotrophic Reference Lake B and Patch Lake (see Sections 3.3.9 and 3.5.1), it would be reasonable to expect that benthos density would naturally be higher in Doris Lake than in Reference Lake B or Patch Lake, since high lake productivity and nutrient concentrations are typically related to elevated abundance of benthic invertebrates (e.g., Nalepa, Lang, and Fanslow 2000).

Benthos density increased over time in Doris Lake North from 607 organisms/m^2 in 2009 to a maximum mean density of approximately 5,000 organisms/m^2 from 2015 to 2017 (Figure 3.6-1). This increase over time observed in Doris Lake differs from the more consistent densities over time observed in both Reference Lake B and Patch Lake (Figure 3.6-1). This potential Project-related increase in density in Doris Lake triggered a low action level response in the 2017 AEMP, and the follow up from this was the preparation of the *Aquatic Response Plan for Benthos Density* (ERM 2018). A review of the monitoring data collected as part of the 2017 AEMP did not reveal an obvious cause for the observed increase in benthos density. There were no apparent Project-related increases in water column nutrient concentrations that might be indicative of eutrophication, nor to any indicators of enhanced productivity such as sediment total organic carbon content and chlorophyll *a* concentrations (ERM 2018). Several hypotheses were proposed in the Response Plan to explain the increase in density, including higher than usual under-ice dissolved oxygen concentrations that could have stimulated invertebrate density through increased reproduction, survival, growth, or emergence; a naturally occurring cyclical pattern of abundance; or natural variability (ERM 2018). The ecological implications of the observed increase in benthos density without a co-occurring change in an indicator of eutrophication (e.g., phytoplankton biomass, nutrient concentrations) and without any discernible change in benthos family composition, richness, or diversity was considered to be low (ERM 2018).



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.6-1: Benthos Density in AEMP Monitored Lakes, Hope Bay Project, 2009 to 2019

Doris Lake benthos density dropped from the unusually high levels reached from 2015 to 2017 to a mean of approximately 3,300 organisms/m^2 in 2019. The overall trend in Doris Lake benthos density differed from a slope of zero ($p < 0.0001$) and from the trend in Reference Lake B ($p < 0.0001$). The 2019 density of 3,300 organisms/m^2 is approximately mid-range compared to the minimum of 607 organisms/m^2 in 2009 and the maximum mean of 5,100 organisms/m^2 in 2016. An adverse change in benthos density is considered to be a decrease because benthic invertebrates serve as prey items for bottom-feeding fish. Most monitoring programs that have studied the effects of mine discharges on freshwater benthos communities have reported declines in benthos density as a result of the toxic effects of metals in effluents (see AETE Program (1999) for a review). An increase in density is not considered to be adverse per say, unless it co-occurs with other changes in benthic community indicators (such as a decrease in richness, diversity, and evenness), changes in indicators of eutrophication, or other potentially adverse ecosystem changes. Since density levels in this lake have dropped since 2017, but remain higher than the 2009 baseline density, these is no apparent Project-related decrease in benthos density in Doris Lake, and a low action level response for benthos density was not triggered.

In Patch Lake, the mean benthos density in 2019 (456 organisms/m^2) was similar to the 2009 density (341 organisms/m^2), and the before-after analysis showed that the 2019 mean was not significantly different from the 2009 to 2018 mean ($p = 0.514$). Therefore, there was no evidence of a Project-related decrease in density, and a low action level response was not triggered.

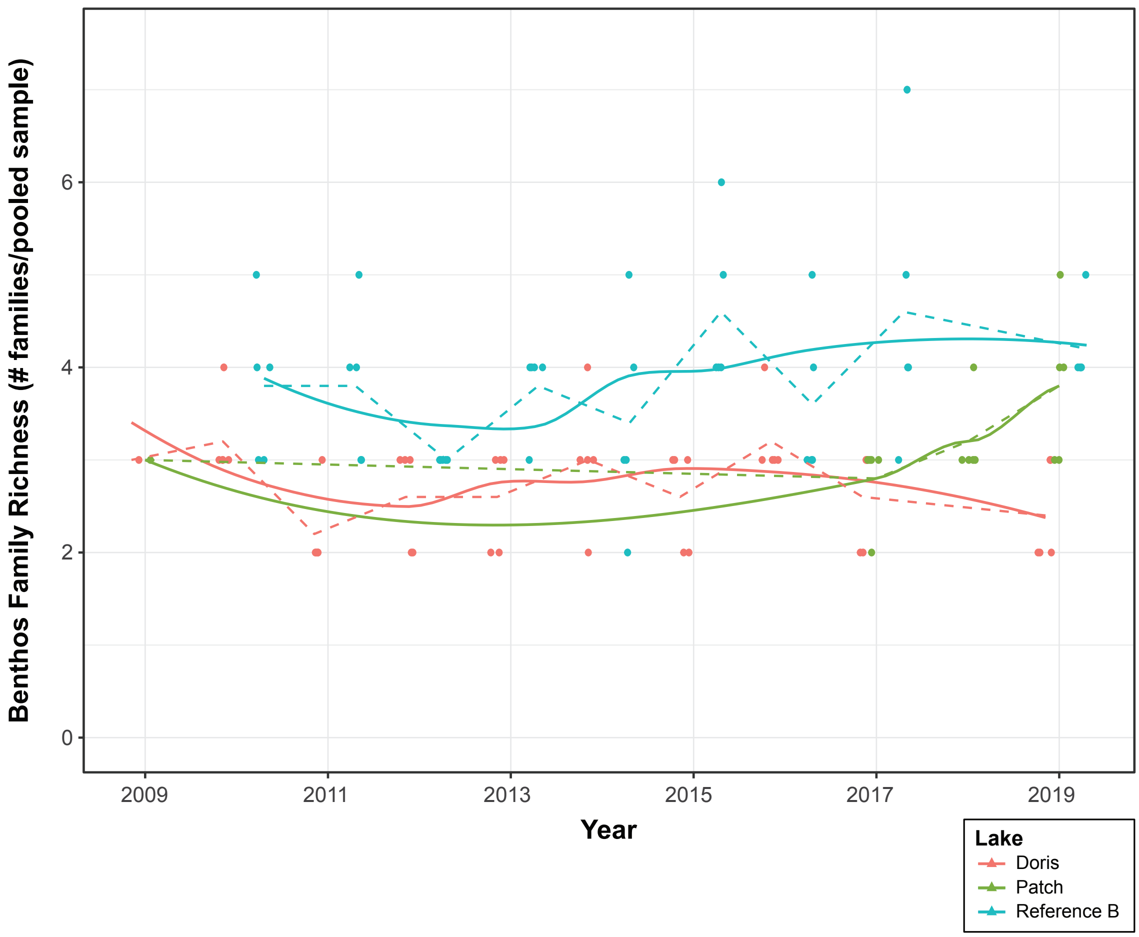
3.6.2 Family Richness

Benthos family richness is the total number of benthos families (e.g., Chironomidae, Pisidiidae, Naididae, etc.) represented in each composite replicate sample. Mean benthos family richness was relatively consistent within each lake over time (Figure 3.6-2). Between 2009 and 2019, mean richness ranged from 2.4 to 3.2 families/replicate in Doris Lake, 2.8 to 3.8 families/replicate in Patch Lake, and 3.0 to 4.6 families/replicate in Reference Lake B (Figure 3.6-2). The trend in family richness in Doris Lake was not significantly different from a slope of zero ($p = 0.825$), suggesting that there was no evidence of a Project-related decrease in richness over time. Similarly, the before-after analysis for Patch Lake showed that the pre-2019 mean richness was not significantly different from the 2019 mean ($p = 0.412$). Therefore, there was no indication of a decrease in benthos richness, and a low action level response for richness was not triggered.

3.6.3 Family Evenness

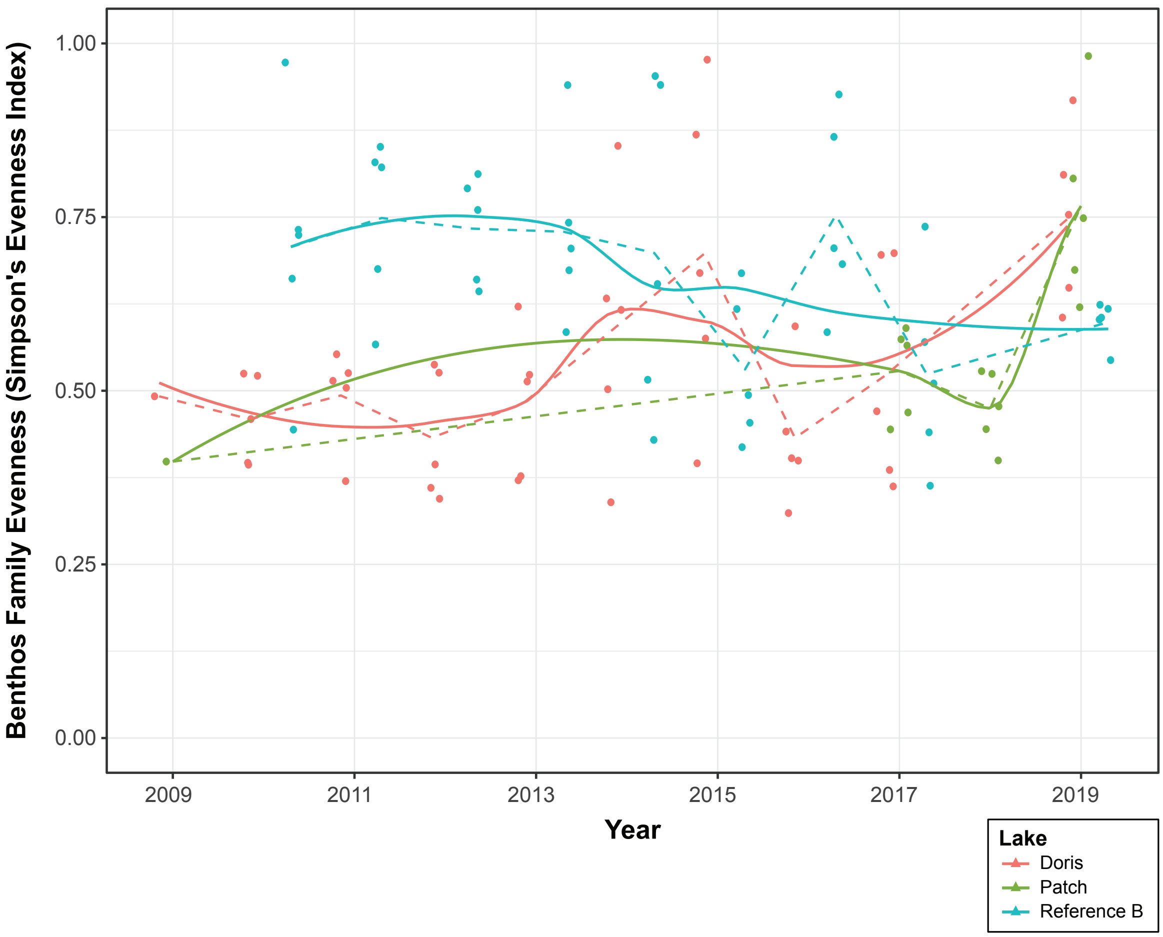
Benthos family evenness (as estimated using the Simpson's Evenness index) is a measure of how evenly distributed families are within the benthos assemblage. The index ranges from 0 to 1, with 1 representing complete evenness. For example, given two hypothetical communities (A and B) each consisting of 100 individuals belonging to four benthos families but with differing family distributions of 25%, 25%, 25%, and 25% in Community A and 97%, 1%, 1%, and 1% in Community B, Community A would have an evenness index of 1, while Community B would have an evenness index of 0.27.

Family evenness was generally variable both inter-annually as well as among replicates within a given year (Figure 3.6-3). In Patch Lake, although the mean 2019 evenness of 0.77 was higher than the mean baseline range of 0.40 to 0.53, the before-after analysis showed that there was no significant difference in means ($p = 0.185$), likely because of the high variability among replicates.



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.6-2: Benthos Richness in AEMP Monitored Lakes, Hope Bay Project, 2009 to 2019



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.6-3: Benthos Evenness in AEMP Monitored Lakes, Hope Bay Project, 2009 to 2019

In Doris Lake, the mean 2019 evenness of 0.75 was also higher than the historical range of 0.43 to 0.70, and the trend analysis showed that there was a significant non-zero trend in evenness over time ($p = 0.0382$), which differed from the evenness trend in Reference Lake B ($p = 0.0049$). The mean Simpson's evenness index in Doris Lake in 2019 was within the range of mean evenness values previously calculated for the reference site (e.g., in 2011 and 2016), and a slight increase in evenness over time with no corresponding change in richness is not of environmental concern. The introduction of contaminants into aquatic systems typically results in a reduction in richness and evenness of benthic communities as sensitive species disappear and the community becomes dominated by relatively few opportunistic species capable of tolerating adverse environmental conditions (e.g., Rygg 1985; Johnston and Roberts 2009).

As family evenness did not decrease in any of the exposure lakes, there was no apparent adverse effect of the Project on benthos evenness, and the a low action level response was not triggered.

3.6.4 Bray-Curtis Index

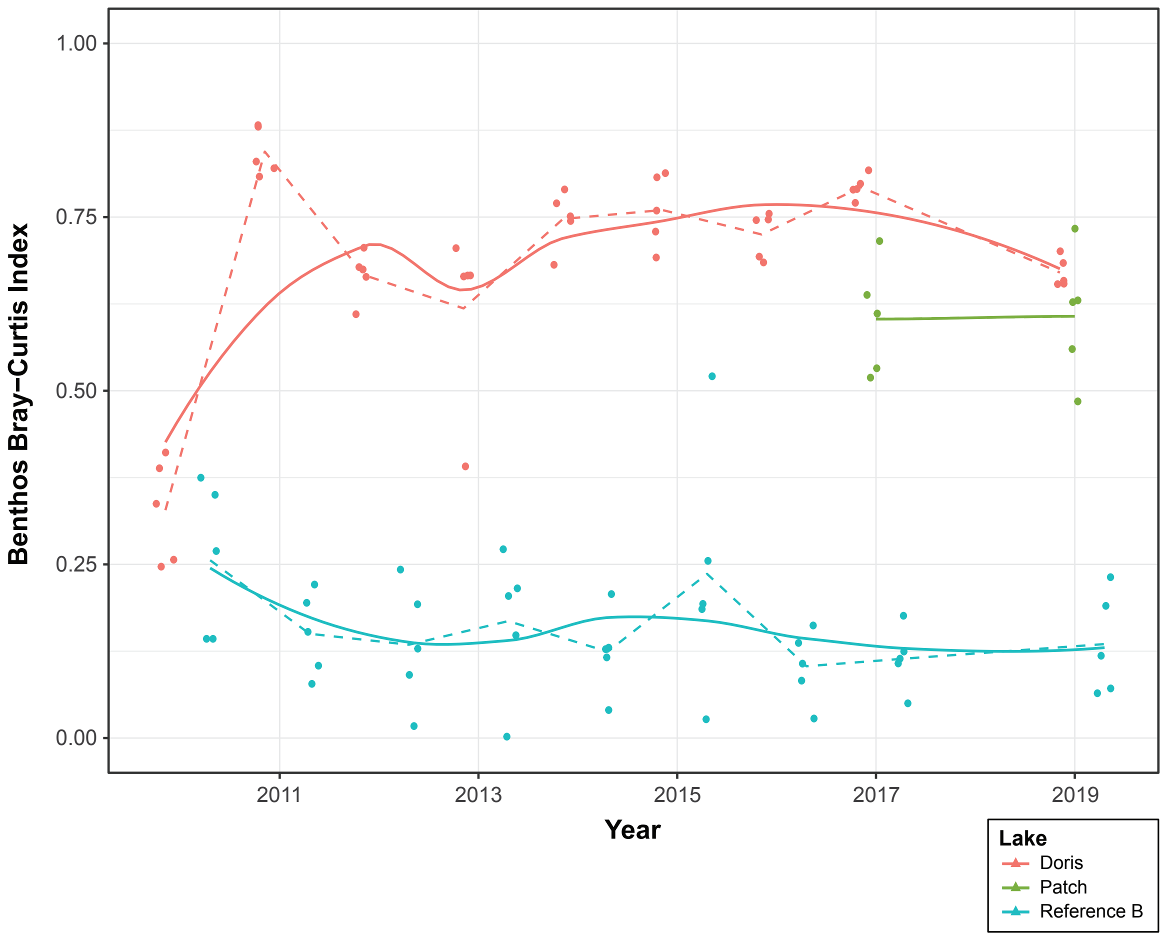
The Bray-Curtis dissimilarity index is an estimate of the percentage of difference in the community composition between sites (Environment Canada 2012). The Bray-Curtis index compares the community composition at each exposure or reference site to the median reference community composition. Since the Bray-Curtis index measures the percent difference between sites, the greater the dissimilarity value between a site and the median reference community, the more dissimilar those benthos communities are. The Bray-Curtis index ranges from 0 to 1, with 0 representing identical communities and 1 representing completely dissimilar communities.

The Bray-Curtis index calculated for the reference site and the median reference community composition are auto-correlated (they are both calculated from the reference site replicates and thus are not independent; Borcard and Legendre 2013); therefore, the Bray-Curtis index for the reference site will generally be closer to zero (i.e., more similar to the median reference community composition) than the index calculated for each exposure site. This was the pattern observed between Doris Lake, Patch Lake, and Reference Lake B (Figure 3.6-4). There is one year of baseline Bray-Curtis data available for Patch Lake (2017) and no baseline Bray-Curtis data available for Doris Lake, as the sampling site at Reference Lake B in 2009 was not comparable in location or depth to the current Reference Lake B sampling site (Figure 2.2-6).

The evaluation of effects is based on a determination of whether differences between exposure and reference sites are increasing over time, which would suggest that communities are become increasingly divergent or less similar over time. For Doris Lake, the trend analysis showed that the Bray-Curtis index is not changing over time (i.e., trend was not significantly different from a slope of zero; $p = 0.0942$; Figure 3.6-4). Similarly for Patch Lake, the before-after analysis showed that the Bray-Curtis index did not change significantly from 2017 to 2019 ($p = 0.964$). Therefore, there was no evidence of a Project-related decrease in community similarity over time between either of the exposure lakes and the reference lake, and a low action level response was not triggered for the Bray-Curtis index.

3.6.5 Benthic Invertebrate Summary

Tables 3.6-1 and 3.6-2 provide summaries of the evaluation of effects for benthos indicators in Patch and Doris lakes. The conclusions of the AEMP evaluation of effects feed into the Response Framework to identify potential Project effects that may require management action to prevent adverse environmental consequences. Table 3.6-3 presents a summary of the screening of the results of the evaluation of effects against the conditions that must be met to trigger a 'low action level' response under the Response Framework (as described in Section 2.2.3.3).



Notes: Observations are slightly jittered along the x-axis for legibility.
Dotted lines drawn through the scatter plots represent the annual means.
Solid lines drawn through the scatter plots represent LOESS smoothing curves.

Figure 3.6-4: Benthos Bray-Curtis Index for Exposure Lakes Relative to Reference Lake B, Hope Bay Project, 2009 to 2019

Table 3.6-1: Summary of Evaluation of Effects for Patch Lake Benthos Indicators, Hope Bay Project, 2019

Benthos Indicator	Statistical Analysis: BA or BACI Analysis		Graphical Analysis/ Interpretation	Conclusion of Effect [b]
	Within Lake Before-After Change (BA Analysis)? [a]	Difference in Before-After Trend Relative to Reference Lake (BACI Analysis)? [a]	Evidence of a Decrease from Baseline?	
Density	No	☐	No	No effect
Richness	No	☐	No	No effect
Evenness	No	☐	No	No effect
Similarity	No	☐	No	No effect

Notes:
BA = Before-After, BACI = Before-After/Control-Impact
[a] Statistically significant difference at p<0.05
[b] Conclusion of effect is based on statistical analysis, graphical analysis, comparison to normal baseline range, and professional judgment.
Square (☐) indicates that the statistical comparison to Reference Lake B is not reported because the first step of the statistical analysis indicated no significant difference between before and after periods.

Table 3.6-2: Summary of Evaluation of Effects for Doris Lake Benthos Indicators, Hope Bay Project, 2019

Benthos Indicator	Statistical Analysis: Linear Mixed Model or Tobit Regression		Graphical Analysis/ Interpretation	Conclusion of Effect [b]
	Different from Slope 0? [a]	Different from Reference Lake B Slope? [a]	Evidence of a Decrease from Baseline?	
Density	Yes	Yes	No	No effect
Richness	No	☐	Yes	No effect
Evenness	Yes	Yes	No	No effect
Similarity	No	☐	No baseline data available	No effect

Notes:
[a] Statistically significant difference at p<0.05
[b] Conclusion of effect is based on statistical analysis, graphical analysis, comparison to normal baseline range, and professional judgment.
Square (☐) indicates that the statistical comparison to Reference Lake B is not reported because the first step of the statistical analysis indicated no significant difference from a slope of zero.

The evaluation of effects concluded that there were no Project-related changes in benthos indicators in 2019 in either Patch or Doris lakes. As shown in Table 3.6-3, at least one condition was not met for each evaluated lake/indicator combination; therefore, no low action level responses were triggered for benthos during the 2019 assessment year.

Table 3.6-3: Comparison of Benthos Indicators to Response Framework Conditions for Triggering a Low Action Level Response, Hope Bay Project, 2019

Exposure Lake:	Patch Lake			Doris Lake			Low Action Level Response Triggered for Any Lake?
Conditions for Low Action Level Response:	Conditions Met	Conditions Not Met	Conditions Not Evaluated[a]	Conditions Met	Conditions Not Met	Conditions Not Evaluated[a]	
Benthos Indicator							
Density	2b	1	3, 4		1, 2	3, 4	No
Richness		1, 2	3, 4	2b	1	3, 4	No
Evenness		1, 2	3, 4		1, 2	3, 4	No
Similarity	2b	1	3, 4		1	2, 3, 4	No

Notes:
Condition 1: the identification of a statistically significant decrease in density, evenness, richness, or similarity from baseline conditions.
Condition 2: the benthos indicator is less that the normal range based on baseline conditions.
Condition 3: if a decrease is detected at the exposure site, the absence of a similar decrease at the reference location.
Condition 4: the magnitude of the decrease exceeds the critical effects size of ± 2 within-reference-area standard deviations (SD), as recommended by Environment Canada (2012a).
[a] Condition was not evaluated either because it was not necessary (i.e., at least one other condition was not met), or because there was not enough information for the evaluation (e.g., because of high proportion of censored data, or absence of baseline data).
[b] Condition 2 is met if at least one replicate is lower that the baseline range.

4. SUMMARY OF EFFECTS ANALYSIS

In 2019, physical profiles, water and sediment samples, and biological samples were collected from several exposure lakes and one reference lake to evaluate the potential for Project-related effects to the following components of the freshwater environment:

- water level and ice thickness;
- physical limnology (dissolved oxygen and water temperature);
- water quality;
- sediment quality;
- phytoplankton biomass; and
- benthic invertebrates.

Physical, chemical, and biological data from 2019 (the third year of Doris operations and the first year of Madrid North construction/operations) were evaluated against historical data and reference site data to determine if there was any evidence of Project-related effects to the freshwater environment. The evaluation of effects was based on graphical and statistical analyses of trends over time both within each exposure lake and between exposure lakes and the reference lake, comparisons to baseline conditions, and professional judgement. Results of the evaluation of effects were then screened against the conditions that must be met to trigger a 'low action level' response under the Response Framework to identify potential Project effects that may require management action to prevent adverse environmental consequences.

No adverse Project-related effects to under-ice water level, under-ice dissolved oxygen concentrations, water temperature, sediment quality, phytoplankton biomass, or benthic invertebrate community indicators were detected in the exposure lakes.

The evaluation of effects concluded that there were potential Project-related effects to under-ice total ammonia and under-ice total molybdenum concentrations in the water column of Doris Lake, as both water quality variables increased relative to baseline levels and increasing trends were not apparent in the reference lake. Concentrations of these variables remained below CCME guidelines for the protection of freshwater aquatic life indicating that concentrations of total ammonia and total molybdenum remain protective of aquatic life in Doris Lake. Low action level responses were not triggered for these variables. Table 4-1 presents a summary of the conclusions of the effects analysis.

There were no Project-related effects identified in Patch Lake; therefore, the spill incident that occurred in June 2019 (Section 1.4) did not result in any residual adverse changes to water quality, sediment quality, or to the biological communities (sampled two months after the spill in August 2019) in this lake.

Table 4-1: Summary of Evaluation of Effects for Hope Bay Project, 2019

Variable	Exposure Lakes Included in Evaluation of Effects	Conclusion of Effect	Low Action Level Triggered?
Water Level and Ice Thickness			
Under-ice water level and ice thickness	Windy Lake, Glenn Lake, Patch Lake, Doris Lake, Little Roberts Lake	No Effect	No
Physical Limnology			
Under-ice dissolved oxygen	Windy Lake, Patch Lake, Doris Lake	No Effect	No
Temperature		No Effect	No
Water Quality			
pH	Windy Lake, Patch Lake, Doris Lake	No Effect	No
Total Suspended Solids		No Effect	No
Turbidity		No Effect	No
Chloride		No Effect	No
Fluoride		No Effect	No
Total Ammonia		Possible Effect (Doris Lake, ice-covered season)	No
Nitrate		No Effect	No
Nitrite		No Effect	No
Total Phosphorus		No Effect	No
Total Aluminum		No Effect	No
Total Arsenic		No Effect	No
Total Boron		No Effect	No
Total Cadmium		No Effect	No
Total Chromium		No Effect	No
Total Copper		No Effect	No
Total Iron		No Effect	No
Total Lead		No Effect	No
Total Mercury		No Effect	No
Total Molybdenum		Possible Effect (Doris Lake, ice-covered season)	No
Total Nickel		No Effect	No
Total Selenium		No Effect	No
Total Silver		No Effect	No
Total Thallium		No Effect	No
Total Uranium		No Effect	No
Dissolved Zinc		No Effect	No

Variable	Exposure Lakes Included in Evaluation of Effects	Conclusion of Effect	Low Action Level Triggered?
Sediment Quality			
Arsenic	Patch Lake, Doris Lake	No Effect	No
Cadmium		No Effect	No
Chromium		No Effect	No
Copper		No Effect	No
Lead		No Effect	No
Mercury		No Effect	No
Zinc		No Effect	No
Phytoplankton Biomass			
Chlorophyll *a*	Windy Lake, Patch Lake, Doris Lake	No Effect	No
Benthic Invertebrates			
Density	Patch Lake, Doris Lake	No Effect	No
Family Richness		No Effect	No
Simpson's Evenness Index		No Effect	No
Bray-Curtis Index		No Effect	No

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APPENDIX A 2019 DATA REPORT

February 2020

HOPE BAY PROJECT

2019 Aquatic Effects Monitoring Program Report

Appendix A: 2019 Data Report

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Appendix A: 2019 Data Report

This data report presents the sampling methodology, the raw data, and summary graphs and tables of the results of the 2019 Aquatic Effects Monitoring Program (AEMP) for the Hope Bay Project (the Project). Section A.1 presents the methodology, and Sections A.2 to A.7 present the 2019 data and summary tables and figures.

The 2019 AEMP included the collection of the following data in lakes with the potential to be affected by Project activities (i.e., exposure lakes): water level, ice thickness, Secchi depth, temperature and dissolved oxygen profiles, water quality, sediment quality, phytoplankton biomass, and benthic invertebrate density and taxonomic composition. Note that all methods and data relating to water level monitoring are presented in Appendix B, and will not be repeated here. The 2019 AEMP was conducted according to the *Hope Bay Project: Aquatic Effects Monitoring Plan* (TMAC 2018). The evaluation of effects is provided in the main body of the AEMP report.

A.1 Sampling Methodology and Data Analysis

A.1.1 Sampling Locations

Figure A.1-1 provides an overview of sampling sites included in the 2019 AEMP, and Figures A.1-2 to A.1-5 show detailed maps of the sampling components and bathymetric contours in each sampled lake.

A.1.2 Sampling Program Summary

Table A.1-1 presents a summary of the AEMP components and methods, including: the variables assessed, the within-year sampling frequency, sampling replication, sampling dates, and the sampling devices used.

A.1.3 Ice Thickness

Ice thickness was measured between April 6 and 18, 2019, at the lakes indicated in Figure A.1-1. A 25-cm diameter hole was drilled through the ice using a motorized auger; ice chips and snow were cleared from the surface, and the ice thickness was then measured using a metered rod.

A.1.3.1 Quality Assurance and Quality Control

Field crews were trained in the measurement of ice thickness to ensure that measurement methods are reliable and consistent, and that data are comparable across years.

A.1.4 Physical Limnology

A.1.4.1 Ice-covered Season

During the ice-covered season (April), lake water at the sampling sites was accessed by drilling a 25-cm diameter hole through the ice using a motorized auger. The water column depth under the ice was measured using a depth sounder.

Temperature and dissolved oxygen (DO) measurements were collected using a YSI ProODO meter equipped with an optical DO sensor. Profiles extended from the bottom of the ice layer to approximately 1 m above the sediment surface to reduce suspension of bottom sediments. Depth was monitored using markings on the cable and data were recorded manually at 0.5-m intervals.

Table A.1-1: Sampling Program Summary, Hope Bay Project

Monitoring Component	Sampling Frequency	Sample Replication and Depths	Sampling Dates / Timing	Sampling Device
Ice Thickness				
Ice thickness measurement	1× per year	n = 1 measurement/site	April	Motorized auger, metred rod
Physical Limnology				
Secchi depth; dissolved oxygen and temperature profiles	2× per year	n = 1 profile/site throughout water column	April (profiles only), August	Secchi disk, YSI ProODO optical dissolved oxygen and temperature probe
Water Quality				
Physical parameters, nutrients, metals	2× per year	n = 1 @ 1 m below the surface, n = 1 @ 2 m above water-sediment interface, + 10% replication per sampling event	April, August	Niskin or GO-FLO sampling bottle
Sediment Quality				
Particle size, metals	1× every 3 years	n = 3/site	August	Ekman grab
Phytoplankton				
Biomass (chlorophyll *a*)	1× per year	n = 3/site @ 1 m below the surface	August	GO-FLO sampling bottle, filtration equipment
Benthic Invertebrates				
Density and taxonomy	1× every 3 years	n = 5/site (3 composite subsamples/replicate)	August	Ekman grab, 500-µm sieve bag

A.1.4.2 Open-water Season

Open-water season temperature and DO profiles were collected from a boat at the same sites as in the ice-covered season. Profiles were collected using a YSI ProODO meter, depth was monitored using markings on the cable and data were recorded manually at 0.5-m intervals as the probe was lowered into the water.

Figure A.1-1
AEMP Sampling Locations, Hope Bay Project, 2019

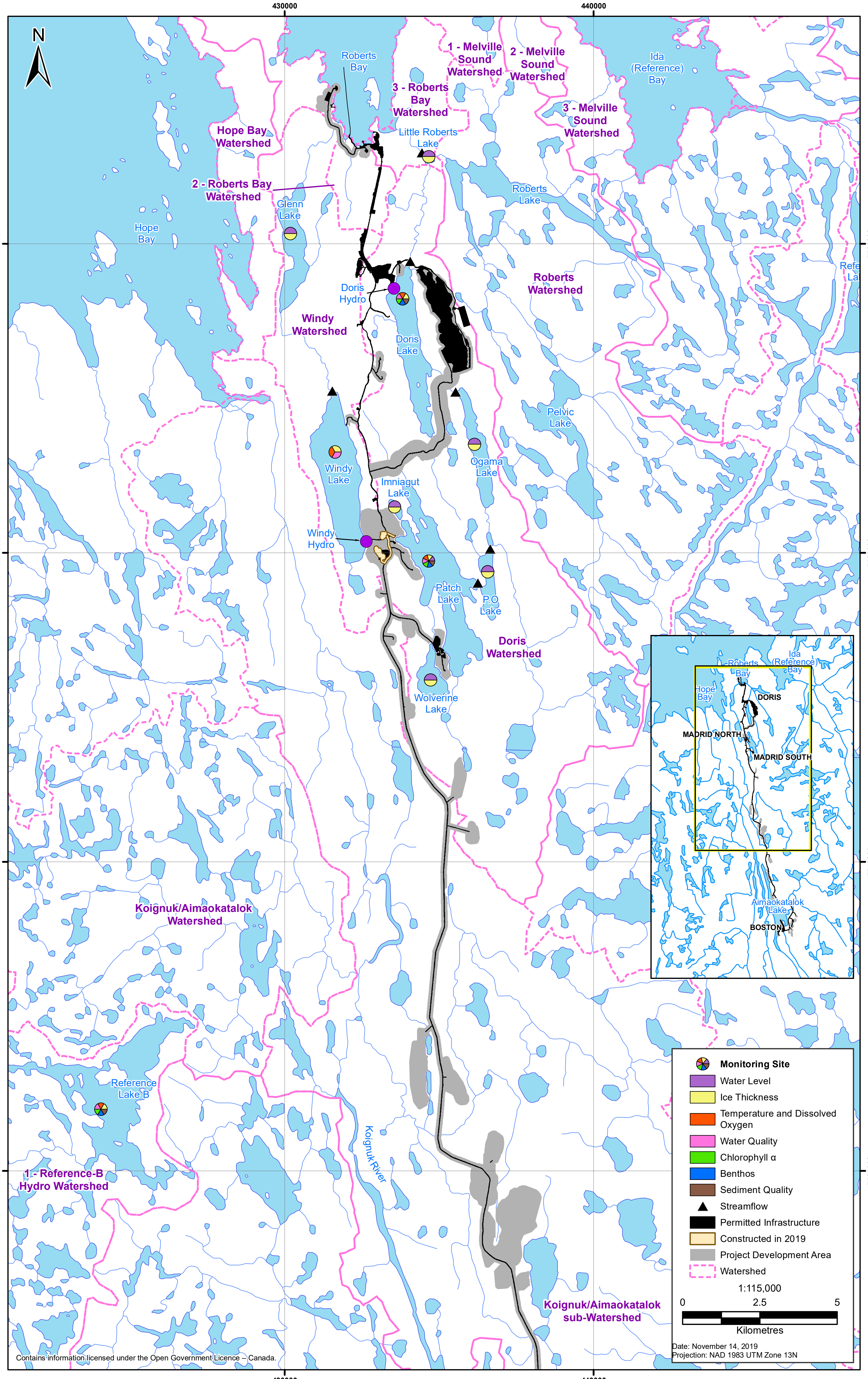
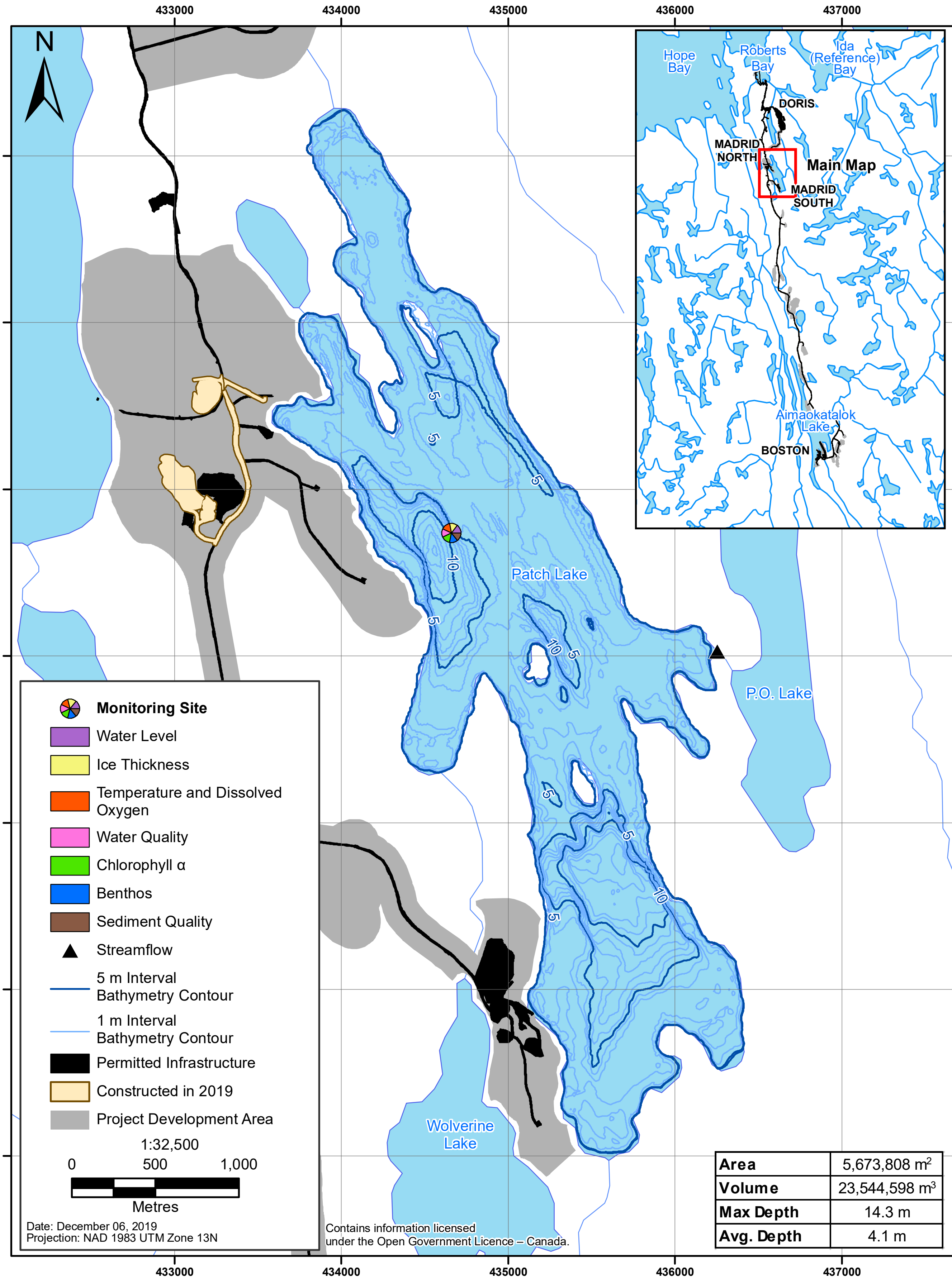


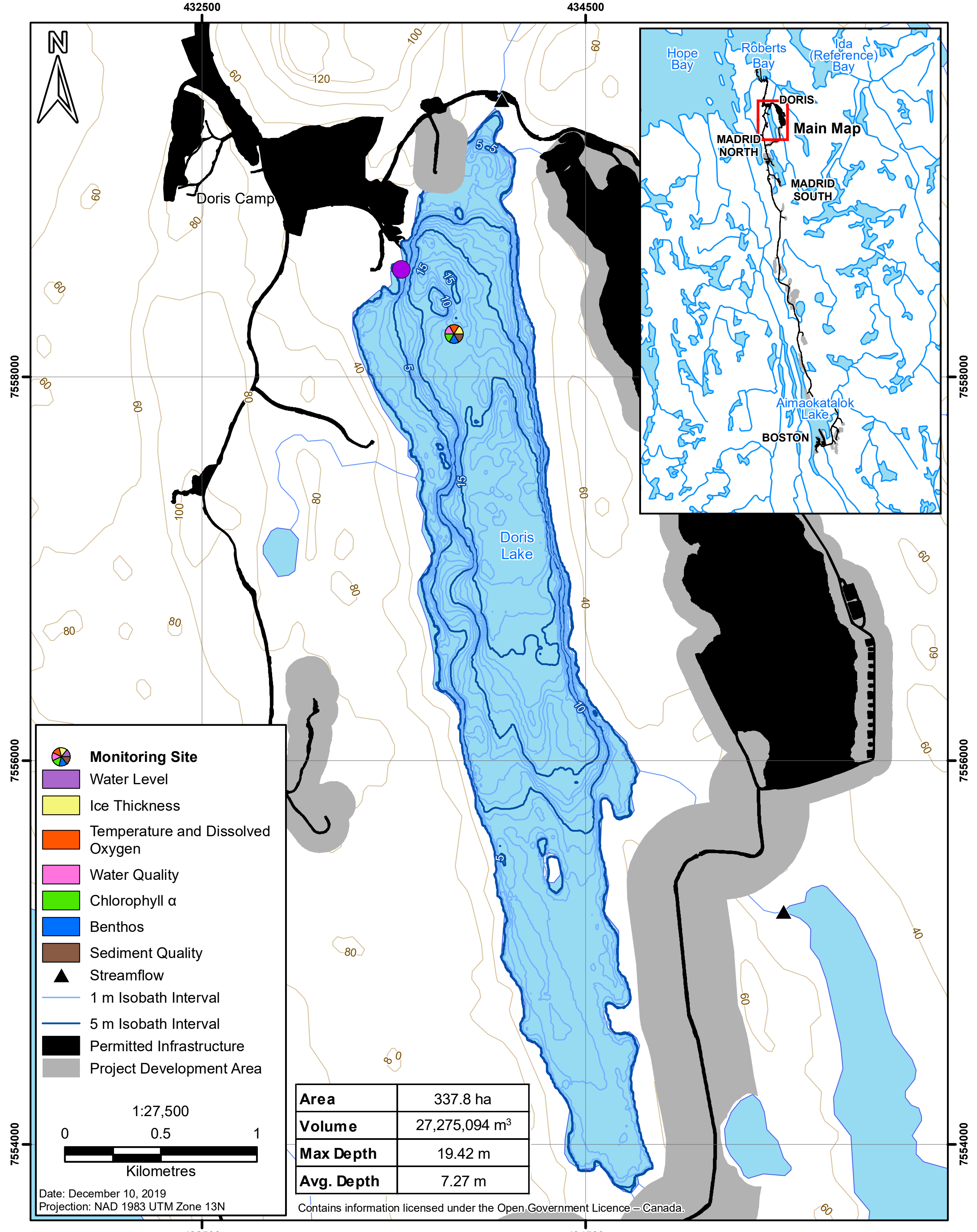
Figure A.1-2

Patch Lake AEMP Sampling Location, Hope Bay Project, 2019



Area	5,673,808 m^2
Volume	23,544,598 m^3
Max Depth	14.3 m
Avg. Depth	4.1 m

Figure A.1-3
Doris Lake AEMP Sampling Location, Hope Bay Project, 2019



Area	337.8 ha
Volume	27,275,094 m^3
Max Depth	19.42 m
Avg. Depth	7.27 m

Figure A.1-4

Windy Lake AEMP Sampling Location, Hope Bay Project, 2019

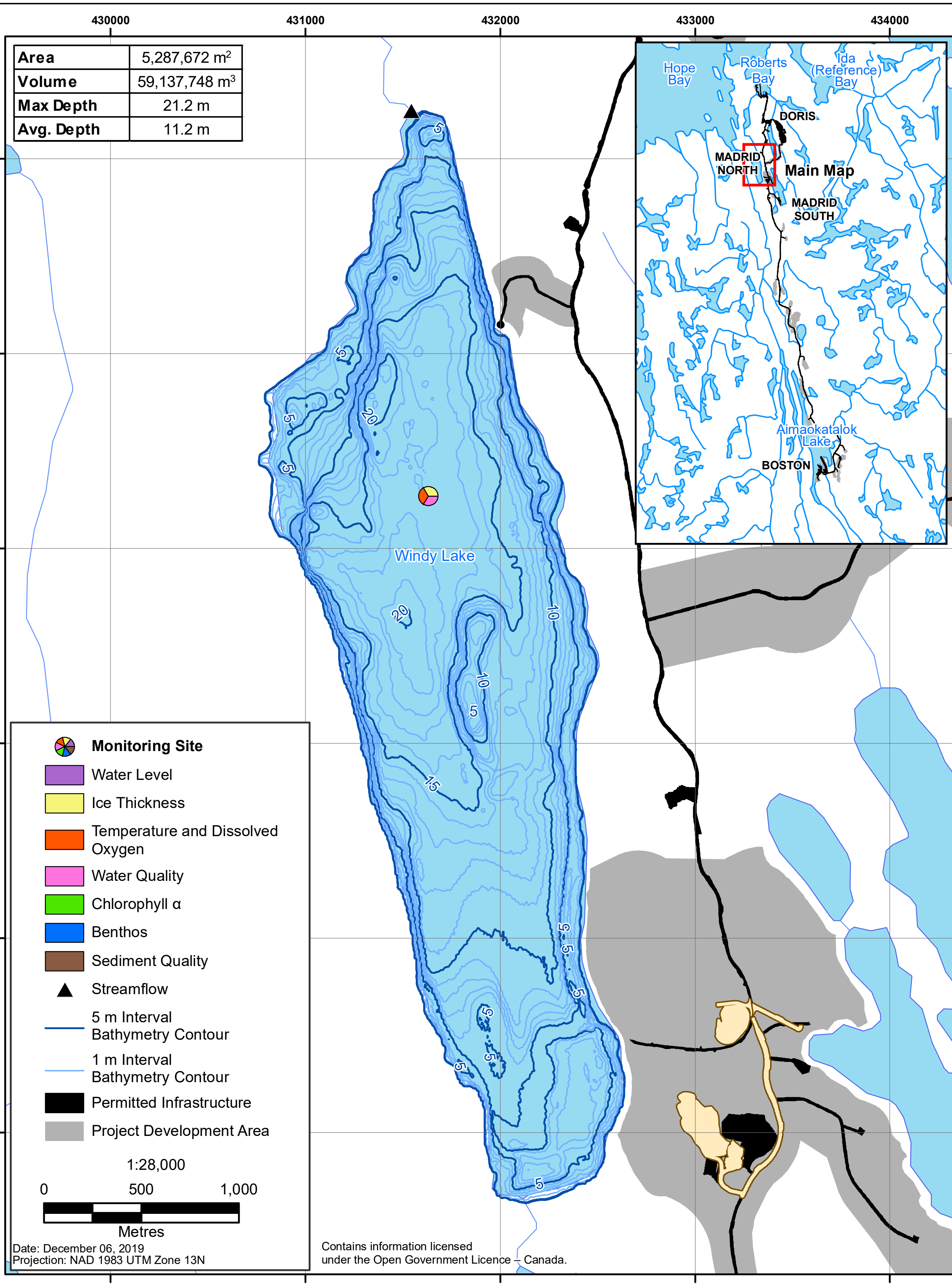
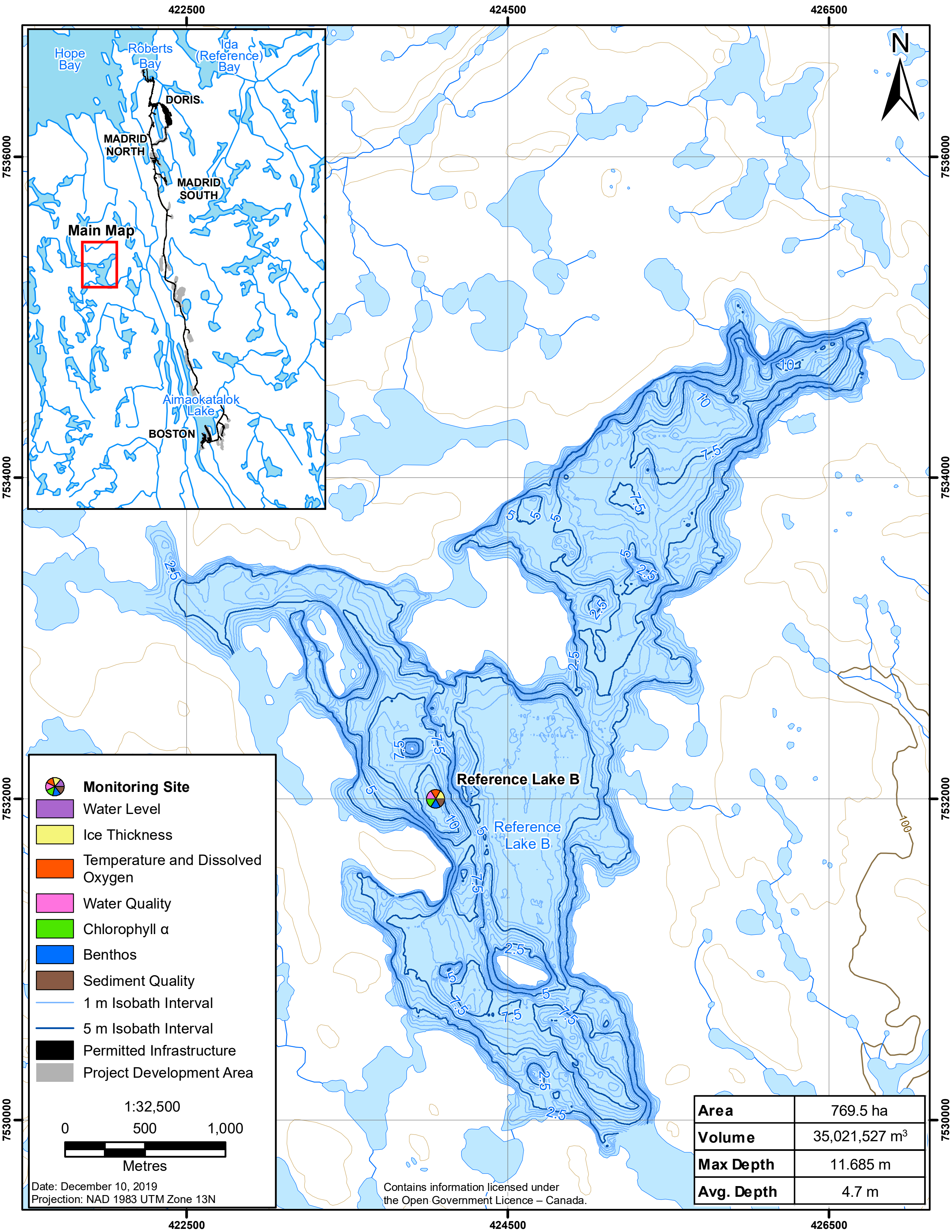


Figure A.1-5
Reference Lake B AEMP Sampling Location, Hope Bay Project, 2019



The euphotic zone depth was estimated from the light attenuation in each lake using a Secchi disk. Light attenuation measurements were collected at each site by lowering the 20-cm black and white Secchi disk on a metred line through the water column on the shaded side of the boat until it disappeared from sight. The depth of disappearance was recorded. The disk was lowered further and then slowly raised until it once again became visible and this depth was also recorded. These depths were averaged to obtain an estimate of the Secchi depth (D_s). The 1% euphotic zone depth ($Z_{1\%}$) was computed by first calculating the light extinction coefficient (k) from D_s, and then calculating the euphotic zone depth based on the appropriate light extinction coefficient. The 1% euphotic zone depth is the depth of the water column to which 1% of the surface irradiance reaches. It represents the depth at which the integrated gross water column photosynthetic production is equivalent to the integrated gross water column respiration; thus, there is net photosynthesis above this depth. The 1% euphotic zone depth is often referred to as the compensation depth, and is calculated as follows (Parsons, Takahashi, and Hargrave 1984):

Light extinction coefficient: $k\ (m^{-1}) = 1.7/D_s$

Euphotic Depth (1%): $Z_{1\%}\ (m) = 4.6/k$

A.1.4.3 Quality Assurance and Quality Control

The quality assurance and quality control (QA/QC) measures undertaken to ensure the reliability of physical limnology data included calibrating the YSI ProODO meter prior to use, and reviewing the data for anomalous readings of water temperature or dissolved oxygen concentrations.

A.1.5 Water Quality

Water quality samples were collected at lake sites during the ice-covered season in April and the open-water season in August, 2019. The sampling dates and depths for all sites are presented in Table A.1-2 and the analyzed variables are presented in Table A.1-3. Sampling locations are presented in Figure A.1-1.

Table A.1-2: Physical Limnology and Water Quality Sampling Dates and Depths, Hope Bay Project, 2019

Site	Sampling Date	Physical Limnology Sampling Depths	Water Quality Sampling Depth(s) (m)
Windy Lake	13-Apr-2019	Throughout water column	2.47, 14.0
	16-Aug-2019	Throughout water column	1.0, 16.0
Patch Lake	13-Apr-2019	Throughout water column	2.4, 5.0
	18-Aug-2019	Throughout water column	1.0, 6.0
Doris Lake North	13-Apr-2019	Throughout water column	2.65, 10.0
	15-Aug-2019	Throughout water column	1.0, 12.0
Reference Lake B	13-Apr-2019	Throughout water column	2.26, 7.5
	18-Aug-2019	Throughout water column	1.0, 8.5

Table A.1-3: Water Quality Variables and Realized Detection Limits, Hope Bay Project, 2019

Variable	Units	Realized Detection Limits		Variable	Units	Realized Detection Limits	
Physical Tests				**Metals** *(cont'd)*		Total	Dissolved
Conductivity	µS/cm	2.0		Cobalt (Co)	mg/L	0.000050	0.000050
Hardness (as $CaCO_3$)	mg/L	0.50		Copper (Cu)	mg/L	0.00050	0.00020
pH	pH	0.10		Gallium (Ga)	mg/L	0.000050	0.000050
Total Suspended Solids	mg/L	1.0		Iron (Fe)	mg/L	0.030	0.030
Turbidity	NTU	0.10		Lead (Pb)	mg/L	0.000050	0.000050
Anions and Nutrients				Lithium (Li)	mg/L	0.00050	0.00050
Alkalinity, Total (as $CaCO_3$)	mg/L	1.0		Magnesium (Mg)	mg/L	0.10	0.10
Ammonia, Total (as N)	mg/L	0.0050		Manganese (Mn)	mg/L	0.00020	0.00020
Bromide (Br)	mg/L	0.050		Mercury (Hg)	µg/L	0.00050	
Chloride (Cl)	mg/L	0.50		Molybdenum (Mo)	mg/L	0.000050	0.000050
Fluoride (F)	mg/L	0.020		Nickel (Ni)	mg/L	0.00020	0.00020
Nitrate (as N)	mg/L	0.0050		Phosphorus (P)	mg/L	0.30	0.30
Nitrite (as N)	mg/L	0.0010		Potassium (K)	mg/L	2.0	2.0
Orthophosphate (as P)	mg/L	0.0010		Rhenium (Re)	mg/L	0.000005	0.000005
Total Phosphorus	mg/L	0.0020		Rubidium (Rb)	mg/L	0.000020	0.000020
Sulphate (SO_4)	mg/L	0.30		Selenium (Se)	mg/L	0.00020	0.00020
Organic Carbon				Silicon (Si)	mg/L	0.10	0.050
Dissolved Organic Carbon	mg/L	0.50		Silver (Ag)	mg/L	0.000005	0.000005
Total Organic Carbon	mg/L	0.50		Sodium (Na)	mg/L	2.0	2.0
Metals		Total	Dissolved	Strontium (Sr)	mg/L	0.00020	0.00010
Aluminum (Al)	mg/L	0.0030	0.001	Tellurium (Te)	mg/L	0.000050	0.000050
Antimony (Sb)	mg/L	0.000030	0.000030	Thallium (Tl)	mg/L	0.000005	0.000005
Arsenic (As)	mg/L	0.000050	0.000050	Thorium (Th)	mg/L	0.000005	0.000005
Barium (Ba)	mg/L	0.00010	0.00010	Tin (Sn)	mg/L	0.00020	0.00020
Beryllium (Be)	mg/L	0.000005	0.000005	Titanium (Ti)	mg/L	0.00020	0.00020
Bismuth (Bi)	mg/L	0.000050	0.000050	Tungsten (W)	mg/L	0.000010	0.000010
Boron (B)	mg/L	0.010	0.0050	Uranium (U)	mg/L	0.000002	0.000002
Cadmium (Cd)	mg/L	0.000005	0.000005	Vanadium (V)	mg/L	0.000050	0.000050
Calcium (Ca)	mg/L	0.050	0.050	Yttrium (Y)	mg/L	0.000005	0.000005
Cesium (Cs)	mg/L	0.000005	0.000005	Zinc (Zn)	mg/L	0.0030	0.0010
Chromium (Cr)	mg/L	0.00050	0.00050	Zirconium (Zr)	mg/L	0.000050	0.000050

A.1.5.1 Under-ice Season

In April, the underlying water was accessed through an augured hole in the ice, following the collection of water column profiles. A 2.5-L Niskin bottle was used to collect water from under the ice layer. This bottle was designed to "trip" and collect discrete samples during freezing temperatures. To avoid metal contamination, the tripping mechanism used acid-cleaned silicone tubing within the interior of the bottle. A dual rope system was used to trigger the bottle to close and to ensure the collection of discrete samples. Prior to the collection of water quality samples, the Niskin bottle was rinsed three times with lab-provided deionized water, and thoroughly rinsed with site-specific water as the Niskin was lowered into the water column in an open configuration allowing lake water to pass through the sampler.

Samples for the various water quality components (e.g., physical parameters, anions and nutrients, and total and dissolved metals) were drawn from the water sampler, with care taken not to bring the bottle or cap into contact with the plastic spigot or other possible sources of contamination. All samples were processed in the field (e.g., filtered, preserved) as appropriate for analysis by the analytical laboratory. Dissolved metals samples were decanted from the general parameters bottle and field filtered using clean syringe filters, the general parameters sample was then discarded and refilled with sample water.

All samples were kept cold and in the dark while in the field and were refrigerated at Doris Camp until the first available transport off-site. Samples were sent to ALS Laboratory Group (ALS) in Yellowknife and subsequently transferred to ALS Burnaby for analysis. The variables analyzed and realized detection limits are summarized in Table A.1-3.

A.1.5.2 Open-water Season

During open-water season sampling, water samples were collected using an acid-washed, Teflon-lined 5-L GO-FLO sampling bottle, which was rinsed with deionized water and site-specific water prior to sample collection as described for the Niskin bottle. The GO-FLO was securely attached to a metred line, terminally weighted to suspend the sampler vertically in the water column, and lowered to the appropriate sampling depth. It was then triggered close to collect a discrete water sample at that depth using a Teflon-coated brass messenger and brought aboard the boat for distribution of the collected water into sample containers.

Sample collection, processing, storage, and transportation off site to ALS for analysis followed the same methods as during the ice-covered season.

A.1.5.3 Quality Assurance and Quality Control

The QA/QC program for water quality sampling included the collection of replicates to account for within-site variability (~10% of total samples) and the use of chain of custody forms to track samples. A set of travel, field, and equipment blanks were also collected/processed during each trip (~25% of total samples) and submitted with the water samples as part of the QA/QC program. These blanks were used to identify potential sources of contamination to the field samples.

The relative percent difference (RPD) between field duplicate water quality samples was calculated as described in Clark (2003) according to the formula:

$$RPD = 2*|A-B|/(A+B)*100\%$$

where A and B represent the concentrations of the water quality variable in each duplicate sample.

As recommended by Clark (2003), RPDs were calculated for specific water quality variables if at least one duplicate concentration was greater than five times the analytical detection limit, with RPD values >20% indicating a potential issue (caution interpreting results), and >50% indicating a problem (most likely sample contamination or lack of sample representativeness) that requires follow-up (e.g., determination of cause, effect on sample data).

The laboratory QA/QC program included reviews of maximum holding times, and the use of method blanks, laboratory replicates, certified reference materials, internal reference materials, laboratory control samples, matrix spikes, and calibration verification standards. ALS has set data quality objectives (DQOs) for QA/QC samples with acceptable limits for sample recovery, precision, and accuracy. When DQOs are not met, ALS flags the sample for follow-up or adjusts the detection limit as required.

A.1.6 Sediment Quality

Sediment quality samples were collected during the open-water season in August 2019. This sampling coincided with benthic invertebrate sampling. Sampling dates are presented in Table A.1-4 and sampling locations are indicated in Figure A.1-1.

Lake sediments were collected using an Ekman grab sampler with the three replicates collected approximately 5 to 20 m apart. Sampling depths are provided in Table A.1-4. The Ekman was opened and the trigger mechanism carefully set, the sampler was then lowered gradually onto the sediment surface using a metred line, and triggered to close with a messenger. The sampler was brought aboard the boat and inspected to ensure the collection of an intact, undisturbed sample. Water from the surface of the sediments was carefully decanted and the sample was transferred into a clean tray, where the top 2 to 3 cm of sediment was collected using a plastic spoon and transferred into a plastic bowl. The sample was homogenized in the plastic bowl and placed into two Whirl-Pak bags: one for particle size, and one for sediment chemistry. Samples were refrigerated (in darkness) until they were shipped to ALS Yellowknife and subsequently transferred to ALS Burnaby for analysis. The sediment quality variables that were analyzed and their corresponding detection limits are presented in Table A.1-5.

Table A.1-4: Sediment Quality and Benthic Invertebrate Sampling Dates and Depths, Hope Bay Project, 2019

Site	Sampling Date	Average Depth (m)
Patch Lake	18-Aug-2019	8.3
Doris Lake North	16-Aug-2019	13.9
Reference Lake B	17-Aug-2019	10.4

A.1.6.1 Quality Assurance and Quality Control

The QA/QC program for sediment quality sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples.

A.1.7 Phytoplankton Biomass

Chlorophyll *a* samples were collected as an estimate of phytoplankton biomass levels to assess potential changes in phytoplankton standing stocks due to eutrophication (i.e., excess nutrients) or toxicity (i.e., presence of deleterious substances). Chlorophyll *a* samples were collected at each lake site during the open-water season (August 15 to 18, 2019). This sampling coincided with the physical limnology and water quality sampling. Chlorophyll *a* samples were collected in triplicate in opaque, clean, 1-L sample bottles that were thoroughly rinsed with surface water at each site. For each chlorophyll *a* sample, the water sampler (5-L GO-FLO) was lowered to the appropriately 1 m below the water surface and triggered to close with a messenger. Once retrieved, a subsample was drawn from the sampler for chlorophyll *a* determination.

Table A.1-5: Sediment Quality Variables and Realized Detection Limits, Hope Bay Project, August 2019

Variable	Units	Realized Detection Limit	Variable	Units	Realized Detection Limit
Physical Tests			**Metals** *(cont'd)*		
Moisture	%	0.25	Cobalt (Co)	mg/kg	0.10
pH (1:2 soil:water)	pH	0.10	Copper (Cu)	mg/kg	0.50
Particle Size			Iron (Fe)	mg/kg	50
% Gravel (>2 mm)	%	1.0	Lead (Pb)	mg/kg	0.50
% Sand (2.0 mm - 0.063 mm)	%	1.0	Lithium (Li)	mg/kg	2.0
% Silt (0.063 mm – 4 um)	%	1.0	Magnesium (Mg)	mg/kg	20
% Clay (<4 um)	%	1.0	Manganese (Mn)	mg/kg	1.0
Texture	-	-	Mercury (Hg)	mg/kg	0.0050
Anions and Nutrients			Molybdenum (Mo)	mg/kg	0.10
Total Nitrogen by LECO	%	0.020	Nickel (Ni)	mg/kg	0.50
Organic / Inorganic Carbon (Soil)			Phosphorus (P)	mg/kg	50
Total Organic Carbon	%	0.050	Potassium (K)	mg/kg	100
Metals			Selenium (Se)	mg/kg	0.20
Aluminum (Al)	mg/kg	50	Silver (Ag)	mg/kg	0.10
Antimony (Sb)	mg/kg	0.10	Sodium (Na)	mg/kg	50
Arsenic (As)	mg/kg	0.10	Strontium (Sr)	mg/kg	0.50
Barium (Ba)	mg/kg	0.50	Sulfur (S)-Total	mg/kg	500
Beryllium (Be)	mg/kg	0.10	Thallium (Tl)	mg/kg	0.050
Bismuth (Bi)	mg/kg	0.20	Tin (Sn)	mg/kg	2.0
Boron (B)	mg/kg	5.0	Titanium (Ti)	mg/kg	1.0
Cadmium (Cd)	mg/kg	0.050	Uranium (U)	mg/kg	0.050
Calcium (Ca)	mg/kg	50	Vanadium (V)	mg/kg	0.20
Chromium (Cr)	mg/kg	0.50	Zinc (Zn)	mg/kg	2.0

The sample water was kept cold and dark and transported to Doris Camp, where the samples were filtered using gentle vacuum filtration (hand pump). The chlorophyll *a* samples were filtered onto 47-mm diameter, 0.45-μm pore size nitrocellulose membrane filters until there was an observed colour change on the filter. The filters were folded carefully in half using forceps, and placed into a black plastic tube to prevent light penetration. The filters were kept frozen and sent to ALS Yellowknife and subsequently transferred to ALS Burnaby for analysis.

A.1.7.1 Quality Assurance and Quality Control

The QA/QC program for chlorophyll *a* sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples.

A.1.8 Benthic Invertebrates

Benthic invertebrate (benthos) samples were collected during the open-water season in August 2019, coincident with the collection of sediment quality samples. Sampling dates are presented in Table A.1-4 and sampling locations are indicated in Figure A.1-1.

Five replicate benthos samples were collected at each site, each sample consisted of three separate subsamples that were collected and pooled for each replicate sample. Samples were obtained using an Ekman grab sampler (surface sampling area of 0.0225 m^2), with subsamples collected from the same general area and replicates collected approximately 5 to 20 m apart. The Ekman was opened and the trigger mechanism carefully set, the sampler was then lowered slowly onto the sediment using a metred line, and triggered to close with a messenger. Average sampling depths are provided in Table A.1-4. The sampler was brought aboard the boat and each grab was transferred into a 500 µm sieve bag and rinsed with site-specific lake water until free of sediments. The material retained within the sieve was then placed into a labelled plastic jar and preserved with buffered formalin to a final concentration of 10%. Benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification.

Raw benthic invertebrate counts were pre-processed to exclude a number of organisms: cladocerans and copepods were excluded as these groups are generally planktonic, and ostracods and nematodes were excluded as these groups belong to the meiofauna size class (invertebrates ranging in size between 63 µm and 500 µm) and are not adequately sampled using a 500-µm sieve bucket. Community descriptors including total benthic invertebrate density, family richness, Simpson's evenness index, and the Bray-Curtis similarity index were calculated from the taxonomic data according to the methods described in Environment Canada (Environment Canada 2012).

Total benthic invertebrate density in each replicate was calculated by taking the sum of all benthic organisms remaining after the pre-processing step that removed planktonic or meiobenthic invertebrates, and dividing this sum by three times the surface area of the Ekman sampler (i.e., 3 × 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Ekman samples). Family richness was calculated as the total number of benthic invertebrate families present in each composite replicate sample.

The Simpson's Evenness Index (E) was calculated as:

$$E = 1 \,/\, \sum_{i=1}^{F} (p_i)^2 \,/\, \mathrm{F}$$

where F is the number of families present (i.e., family richness), and p_i is the relative density of each family calculated as n_i/N (where n_i is the number of individuals in family i, and N is the total number of individuals).

The Bray-Curtis dissimilarity index is an estimate of the percentage of difference in the community composition between sites (Environment Canada 2012). The Bray-Curtis Index compares the community composition in a benthos replicate sample to the median reference community composition. This median reference composition is generated from the median density of each represented family from all of the reference site replicates (in this case, replicates collected at Reference Lake B). Since the median reference composition is generated from the median of five reference site replicates, the comparison of a single reference site replicate community composition to the median reference community composition will produce a dissimilarity value (although generally a much lower value than exposure site replicates). Because the Bray-Curtis Index measures the percent difference between sites, the greater the dissimilarity value between a site and the median reference community, the more dissimilar those benthos communities are. The Bray-Curtis Index ranges from zero to one, with zero representing identical communities and one representing completely dissimilar communities.

This index is calculated as:

$$\text{Bray-Curtis Index (BC)} = \sum_{i=1}^{n} |y_{i1} - y_{i2}| \,/\, \sum_{i=1}^{n} (y_{i1} + y_{i2})$$

where BC is the Bray-Curtis distance between Sites 1 and 2, *n* is the total number of families present at the two sites, y_{i1} is the count for family *i* at Site 1, and y_{i2} is the count for family *i* at Site 2.

A.1.8.1 Quality Assurance and Quality Control

The QA/QC program for benthos sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track samples.

A re-sorting of randomly selected sample residues was conducted by taxonomists on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. The criterion for an acceptable sorting was that more than 95% of the total number of organisms was recovered during the initial sort. The number of organisms initially recovered from the sample was expressed as a percentage of the total number after the re-sort (total of initial and re-sort count). Any sample not meeting the 95% removal criterion was re-sorted a third time.

A.2 Ice Thickness

Table A.2-1 presents the ice thickness measurements collected in April 2019.

Table A.2-1: Ice Thickness Measurements, Hope Bay Project, 2019

Lake	Sampling Date	Measured Ice Thickness (m)
Windy Lake	April 13, 2019	1.47
Glenn Lake	April 6, 2019	1.62
Wolverine Lake	April 18, 2019	1.40
Patch Lake	April 13, 2019	1.40
Imniagut Lake	April 15, 2019	1.54
P.O. Lake	April 15, 2019	1.50
Ogama Lake	April 15, 2019	1.58
Doris Lake	April 13, 2019	1.65
Little Roberts Lake	April 15, 2019	1.41
Reference Lake B	April 14, 2019	1.27

A.3 Physical Limnology

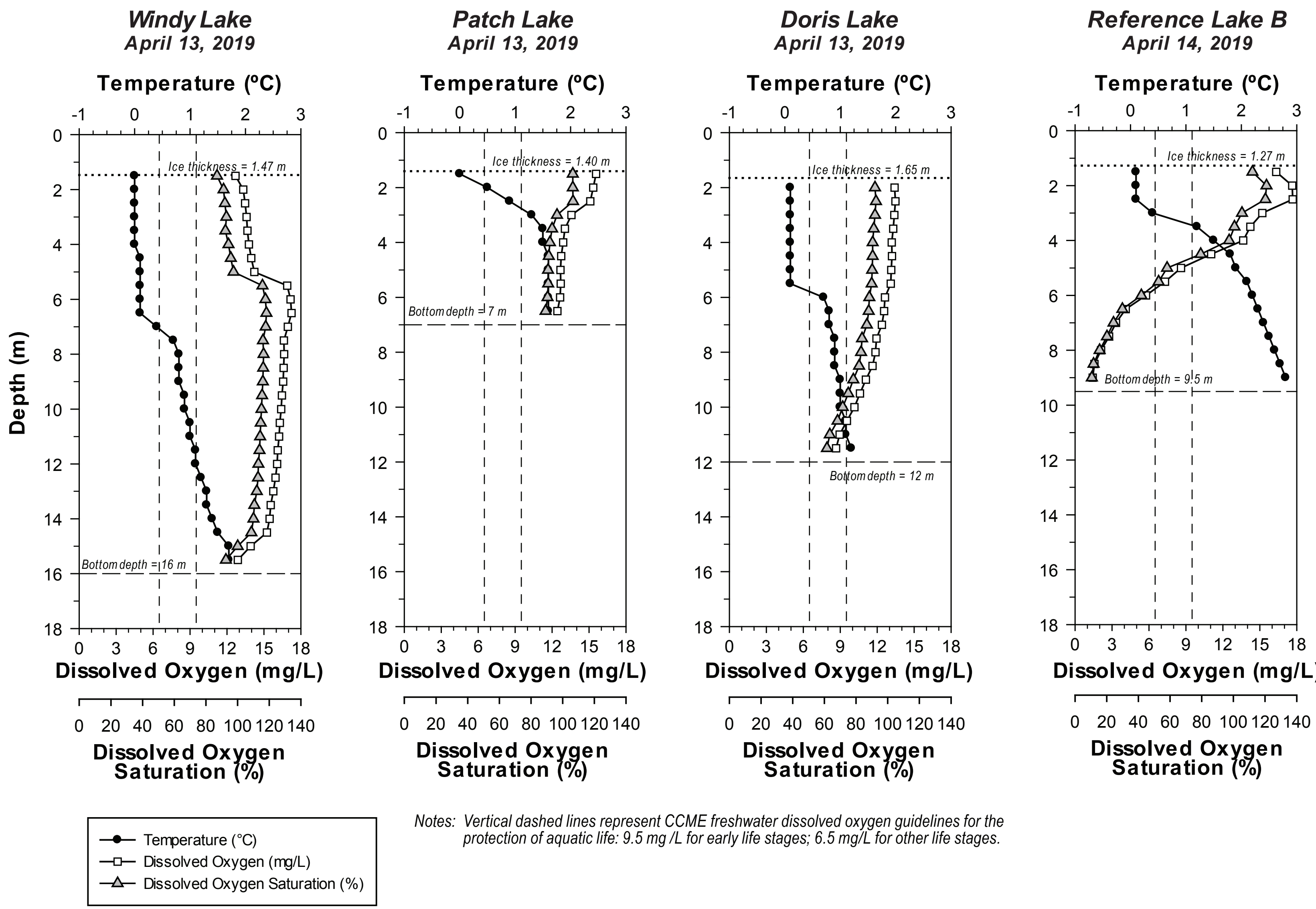
The Secchi depth data and physical profiles collected in 2019 are presented in this section.

Secchi depths and calculated euphotic zone depths (1% light level) are shown in Table A.3-1. Figures A.3-1 and A.3-2 show the temperature and DO profiles collected at lake sites in April and August 2019; Annex A.3-1 provides the profile data in tabular form.

Table A.3-1: Secchi Depths and Euphotic Zone Depths, Hope Bay Project, 2019

Lake Site	Sampling Date	Secchi Depth (Ds; m)	Euphotic Zone Depth 1% Light Level (m)	Bottom Depth (m)
Windy Lake	August 16, 2019	3.6	9.7	17.8
Patch Lake	August 18, 2019	3.2	8.7*	8.4
Doris Lake North	August 15, 2019	1.7	4.6	13.8
Reference Lake B	August 17, 2019	7.1	19.2*	10.8

** Indicates that the euphotic zone extended to the bottom of the water column.*



Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages.

Figure A.3-1: Under-ice Temperature and Dissolved Oxygen Profiles, Hope Bay Project, April 2019

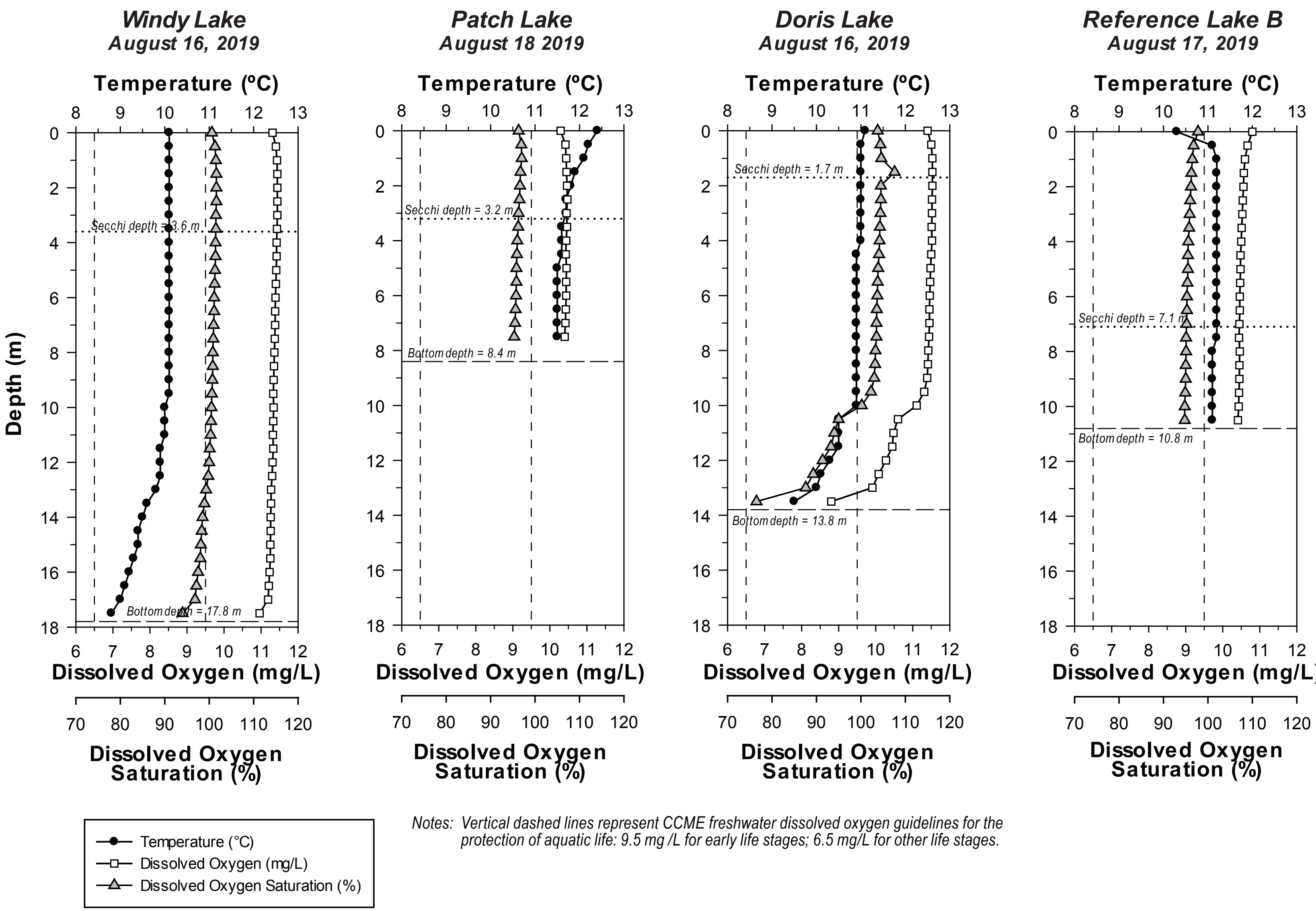


Figure A.3-2: Open-water Temperature and Dissolved Oxygen Profiles, Hope Bay Project, August 2019

Annex A.3-1: Temperature and Dissolved Oxygen Profiles, Hope Bay Project, 2019

Doris Lake North			
April 13, 2019			
Ice Thickness = 1.65 m			
Maximum Depth = 12 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
2.0	0.1	13.41	92.0
2.5	0.1	13.48	92.6
3.0	0.1	13.39	92.0
3.5	0.1	13.30	91.2
4.0	0.1	13.18	90.5
4.5	0.1	13.20	90.5
5.0	0.1	13.14	90.2
5.5	0.1	13.10	89.9
6.0	0.7	12.63	88.4
6.5	0.8	12.56	88.0
7.0	0.8	12.38	86.8
7.5	0.9	11.94	83.8
8.0	0.9	11.86	83.2
8.5	0.9	11.62	81.9
9.0	1.0	11.08	78.3
9.5	1.0	10.60	75.1
10.0	1.0	10.15	71.6
10.5	1.1	9.54	68.3
11.0	1.1	8.95	63.4
11.5	1.2	8.66	61.6

Patch Lake			
April 13, 2019			
Ice Thickness = 1.40 m			
Maximum Depth = 7 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
1.5	0.0	15.57	106.4
2.0	0.5	15.34	106.4
2.5	0.9	15.10	106.5
3.0	1.3	13.56	96.4
3.5	1.5	13.04	93.3
4.0	1.5	12.90	91.9
4.5	1.6	12.74	91.2
5.0	1.6	12.68	90.7
5.5	1.6	12.70	90.8
6.0	1.6	12.64	90.4
6.5	1.6	12.43	89.2

Annex A.3-1: Temperature and Dissolved Oxygen Profiles, Hope Bay Project, 2019

Windy Lake			
April 13, 2019			
Ice Thickness = 1.47 m			
Maximum Depth = 16 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
1.5	0.0	12.69	87.0
2.0	0.0	13.32	91.1
2.5	0.0	13.47	92.0
3.0	0.0	13.59	92.9
3.5	0.0	13.66	92.3
4.0	0.0	13.78	94.2
4.5	0.1	13.97	95.7
5.0	0.1	14.22	97.4
5.5	0.1	16.89	115.7
6.0	0.1	17.16	117.6
6.5	0.1	17.24	118.2
7.0	0.4	16.94	117.7
7.5	0.7	16.62	116.0
8.0	0.8	16.64	116.4
8.5	0.8	16.60	116.2
9.0	0.8	16.56	115.9
9.5	0.9	16.46	115.5
10.0	0.9	16.40	115.1
10.5	1.0	16.29	114.6
11.0	1.0	16.23	114.2
11.5	1.1	16.12	113.8
12.0	1.1	16.07	113.1
12.5	1.2	15.94	112.9
13.0	1.3	15.76	112.1
13.5	1.3	15.55	110.6
14.0	1.4	15.46	110.0
14.5	1.5	15.24	108.7
15.0	1.7	13.92	100.1
15.5	1.7	12.88	92.6

Reference Lake B			
April 14, 2019			
Ice Thickness = 1.27 m			
Maximum Depth = 9.5 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
1.5	0.1	16.33	112.0
2	0.1	17.63	120.9
2.5	0.1	17.67	120.2
3	0.4	15.20	105.4
3.5	1.2	14.23	100.7
4	1.5	13.65	97.3
4.5	1.8	11.05	79.4
5	1.9	8.60	58.1
5.5	2.1	7.30	52.8
6	2.2	5.76	41.9
6.5	2.3	4.11	29.9
7	2.4	3.32	24.3
7.5	2.5	2.76	20.2
8	2.6	2.11	15.5
8.5	2.7	1.57	11.7
9	2.8	1.43	10.6

Annex A.3-1: Temperature and Dissolved Oxygen Profiles, Hope Bay Project, 2019

Doris Lake North			
August 15, 2019			
Secchi Depth = 1.7 m			
Maximum Depth = 13.8 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	11.1	11.40	103.8
0.5	11.0	11.50	104.4
1.0	11.0	11.53	104.6
1.5	11.0	11.53	107.6
2.0	11.0	11.53	104.5
2.5	11.0	11.52	104.5
3.0	11.0	11.52	104.4
3.5	11.0	11.51	104.3
4.0	11.0	11.52	104.2
4.5	10.9	11.50	104.1
5.0	10.9	11.48	103.9
5.5	10.9	11.47	103.8
6.0	10.9	11.46	103.7
6.5	10.9	11.45	103.6
7.0	10.9	11.45	103.5
7.5	10.9	11.44	103.5
8.0	10.9	11.42	103.3
8.5	10.9	11.41	103.2
9.0	10.9	11.39	103.0
9.5	10.9	11.31	102.3
10.0	10.9	11.11	100.2
10.5	10.5	10.60	95.0
11.0	10.5	10.48	94.0
11.5	10.5	10.45	93.3
12.0	10.3	10.28	91.4
12.5	10.1	10.08	89.3
13.0	10.0	9.91	87.6
13.5	9.5	8.80	76.5

Windy Lake			
August 16, 2019			
Secchi Depth = 3.6 m			
Maximum Depth = 17.8 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0	10.1	11.31	100.6
0.5	10.1	11.4	101.3
1	10.1	11.43	101.5
1.5	10.1	11.44	101.6
2	10.1	11.44	101.6
2.5	10.1	11.44	101.6
3	10.1	11.44	101.5
3.5	10.1	11.43	101.5
4	10.1	11.42	101.4
4.5	10.1	11.42	101.4
5	10.1	11.41	101.3
5.5	10.1	11.4	101.2
6	10.1	11.39	101.1
6.5	10.1	11.38	101.1
7	10.1	11.38	101.0
7.5	10.1	11.37	100.9
8	10.1	11.36	100.8
8.5	10.1	11.35	100.8
9	10.1	11.34	100.7
9.5	10.1	11.33	100.6
10	10	11.34	100.5
10.5	10	11.33	100.4
11	10	11.32	100.3
11.5	9.9	11.33	100.1
12	9.9	11.31	100.0
12.5	9.9	11.3	99.8
13	9.8	11.27	99.3
13.5	9.6	11.27	98.9
14	9.5	11.26	98.5
14.5	9.4	11.26	98.3
15	9.4	11.25	98.1
15.5	9.3	11.25	98.0
16	9.2	11.23	97.5
16.5	9.1	11.21	97.1
17	9	11.19	96.8
17.5	8.8	10.96	94.0

Annex A.3-1: Temperature and Dissolved Oxygen Profiles, Hope Bay Project, 2019

Reference Lake B			
August 17, 2019			
Secchi Depth = 7.1 m			
Maximum Depth = 10.8 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	10.3	10.80	97.8
0.5	11.1	10.67	96.8
1.0	11.2	10.60	96.5
1.5	11.2	10.57	96.3
2.0	11.2	10.56	96.2
2.5	11.2	10.54	96.0
3.0	11.2	10.53	95.9
3.5	11.2	10.51	95.8
4.0	11.2	10.50	95.6
4.5	11.2	10.48	95.5
5.0	11.2	10.48	95.5
5.5	11.2	10.47	95.4
6.0	11.2	10.46	95.3
6.5	11.2	10.46	95.3
7.0	11.2	10.45	95.2
7.5	11.2	10.44	95.1
8.0	11.1	10.46	95.1
8.5	11.1	10.45	95.0
9.0	11.1	10.45	95.0
9.5	11.1	10.44	94.9
10.0	11.1	10.43	94.8
10.5	11.1	10.41	94.8

Patch Lake			
August 18, 2019			
Secchi Depth = 3.2 m			
Maximum Depth = 8.4 m			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen Saturation (%)
0.0	12.4	10.29	96.3
0.5	12.2	10.42	96.9
1.0	12.1	10.44	97.0
1.5	11.9	10.45	96.7
2.0	11.8	10.46	96.6
2.5	11.7	10.47	96.5
3.0	11.7	10.45	96.3
3.5	11.6	10.46	96.2
4.0	11.6	10.44	96.0
4.5	11.6	10.43	95.9
5.0	11.5	10.45	95.8
5.5	11.5	10.44	95.8
6.0	11.5	10.44	95.7
6.5	11.5	10.43	95.6
7.0	11.5	10.42	95.5
7.5	11.5	10.40	95.3

A.4 Water Quality

This section presents the water quality data collected in April and August 2019, as well as the findings of the QA/QC program for water quality. Only the variables that were subjected to an evaluation of effects (see main body of the report) are shown graphically. All water quality variables were screened against Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life (CCME 2019b). CCME guidelines are included in all graphs and annexes.

At each monitoring site, water quality data were collected from the surface (1 m) and approximately 2 m from the bottom in AEMP lakes. Samples were collected in April (ice-covered season) and August (open-water season) 2019. Figures A.4-1 to A.4-7 show seasonal and spatial trends for each evaluated water quality variable. Annex A.4-1 presents the full 2019 lake water quality dataset.

A.4.1 Quality Assurance/Quality Control Data

A.4.1.1 Field QA/QC

Relative Percent Difference Calculations

Within-site variability was accounted for by collecting two field duplicates, one in April at Patch Lake and one in August at Reference Lake B, which made up 11% of total samples. Relative percent difference (RPD) calculations for duplicate water quality samples are presented in Annex A.4-2.

A total of 54 RPD calculations were made. The majority (51 out of 54) of the calculated RPD values were below 20%, and there were no RPD values greater than 50%, indicating that there was no evidence of substantial contamination or lack of sample representativeness. Only three sets of duplicate variable concentrations had an RPD of >20% but <50% in 2019: dissolved aluminum and dissolved yttrium in Patch Lake in April (both RPDs were 20.2%), and total aluminum in Reference Lake B in August (RPD of 32.2%). Of these variables, only total aluminum is an evaluated variable. As there was no evidence of a change in total aluminum concentrations over time in any of the exposure lakes (Doris, Patch, and Windy lakes), the 2019 total aluminum data from Reference Lake B were not used in any of the statistical analyses (the reference site data are only incorporated into the second step of the statistical analysis if the results of the first step [comparison to slope of zero for Doris Lake and before-after comparisons for Patch and Windy Lake] show a significant difference). Although the reference site total aluminum concentrations were not used in the evaluation of effects, concentrations of total aluminum in Reference Lake B were generally consistent over time and 2019 concentrations were not particularly elevated (see Figure 3.3-10 of main report); therefore, total aluminum concentrations in Reference Lake B were not adjusted or qualified. Overall, the RPD calculations showed that there was generally good agreement between variable concentrations in duplicate samples.

Blank QA/QC Data

Annex A.4-3 presents the results of the QA/QC blank data (equipment, field, and travel blanks) collected to identify possible sources of contamination to water quality samples. QA/QC data collected for each sampling event represented a minimum of 20% of the samples collected.

There was a small subset of variables that were detectable in at least one equipment, field, or travel blank: conductivity, total ammonia, nitrate, total aluminum, total barium, and total mercury. In some cases, the detectable concentrations were low relative to concentrations measured in lake water samples, and would have a negligible effect on the water quality data (i.e., conductivity, total barium). The remaining variables were investigated further to determine if the potential contamination introduced by sampling equipment, sample handling, storage, and/or transportation could have influenced the findings of the evaluation of effects.

Total aluminum was detected in the two equipment blanks that were collected in August from the GO-FLO sampler. The highest equipment blank concentration was 0.0105 mg/L, while the concentrations in the exposure lakes in August were at least four times higher, ranging from 0.0441 to 0.112 mg/L. Further, the GO-FLO sampler is thoroughly rinsed with site-specific water before a sample is collected. It is therefore considered unlikely that the relatively low level of aluminum contamination of the GO-FLO sampler would have significantly affected the lake sample concentrations. The evaluation of effects found that there was no evidence of an increase in total aluminum concentrations in lakes in 2019 (see Section 3.3-10 of main report), so there is no need to qualify or adjust the data as total aluminum concentrations were not unusually high compared to historical ranges.

Nitrate (as N) concentrations in the travel blank from August 18, 2019, was relatively high at 0.104 mg/L; however, there is no evidence that sample transportation caused samples to be contaminated with nitrate, as all nitrate as N concentrations in the exposure and reference lake samples collected in August 2019 were below the detection limit of 0.005 mg/L. Rather, the lab-provided deionized water used in the travel blank may have been contaminated by nitrate.

Concentrations of total ammonia were above the analytical detection limit in two blank samples in 2019: the April equipment blank (0.0139 mg/L ammonia), and the August field blank (0.0694 mg/L). These concentrations were similar to lake sample concentrations, which ranged from below the detection limit (<0.005 mg/L) to 0.114 mg/L. Given that the blank concentrations of total ammonia were within the range of measured concentrations, the potential exists that total ammonia data for the AEMP lakes may have been biased high due to contamination. The evaluation of effects did conclude that there was evidence of an increase in ice-covered season total ammonia concentrations over time in Doris Lake, as 2019 concentrations were higher than the historical range. It is possible that the apparent increase in 2019 may be at least partially attributable to contamination; therefore, total ammonia concentrations were qualified in the main report text (see Section 3.3-6).

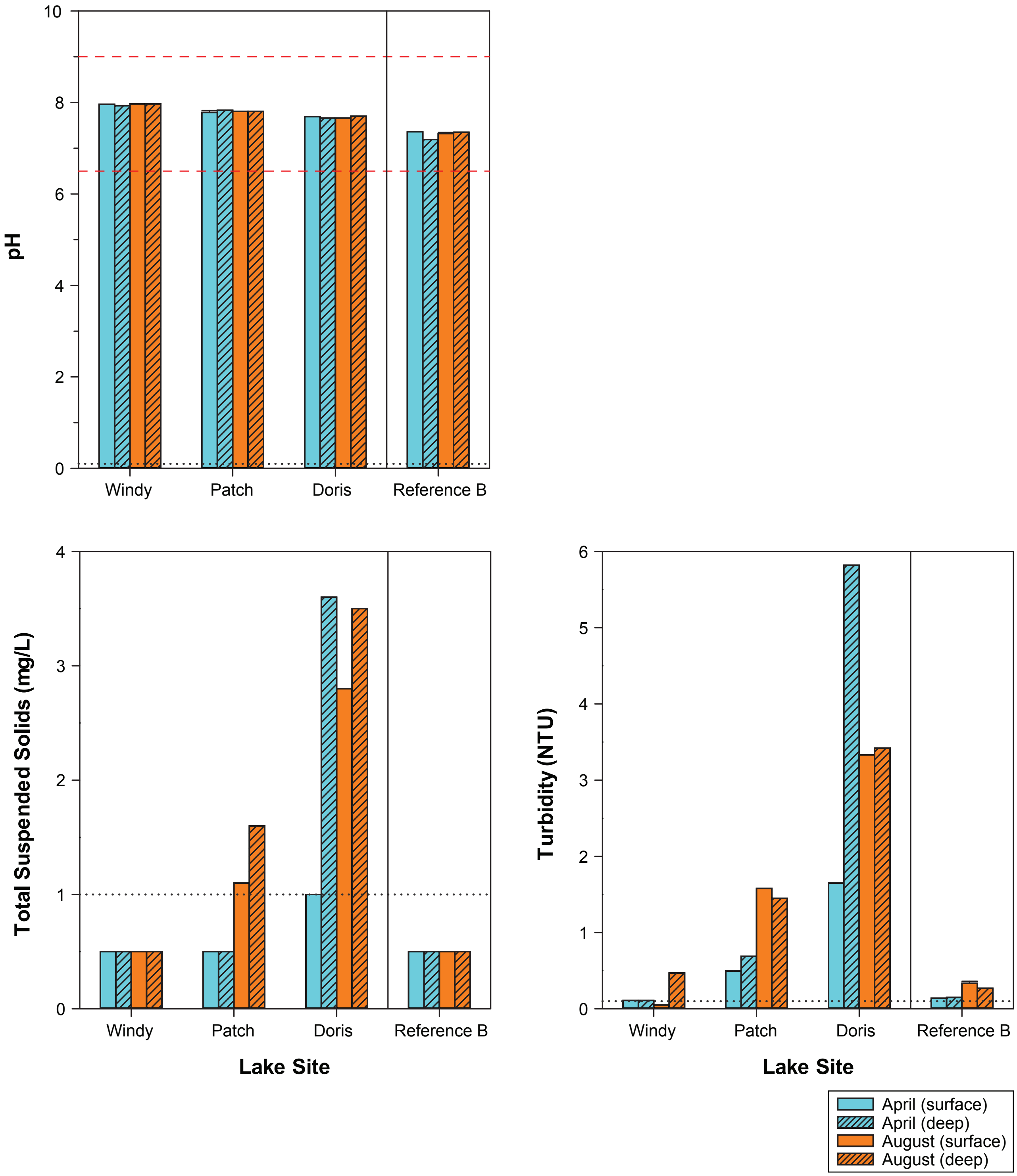
Similar to total ammonia, total mercury concentrations were above the detection limit in two equipment blanks collected in April (0.002 µg/L) and in August (0.00071 µg/L), and the blank concentrations were similar to or greater than concentrations measured in lake samples (ranging from below the detection limit (<0.0005 µg/L) to 0.00107 µg/L). While this could have led to total mercury concentrations being biased high because of mercury contamination, the conclusions of the evaluation of effects (which found no evidence of an increase in 2019 total mercury concentrations from historical levels) suggest that any mercury contamination of samples was not significant enough to cause an increase in 2019 concentrations relative to historical levels, and mercury concentrations did not need to be qualified or adjusted.

A.4.1.2 Laboratory QA/QC

The laboratory QA/QC program included reviews of maximum holding times, and the use of method blanks, laboratory replicates, certified reference materials, internal reference materials, laboratory control samples, matrix spikes, and calibration verification standards. A summary of occurrences of when laboratory QA/QC samples did not meet DQOs is presented in Annex A.4-4.

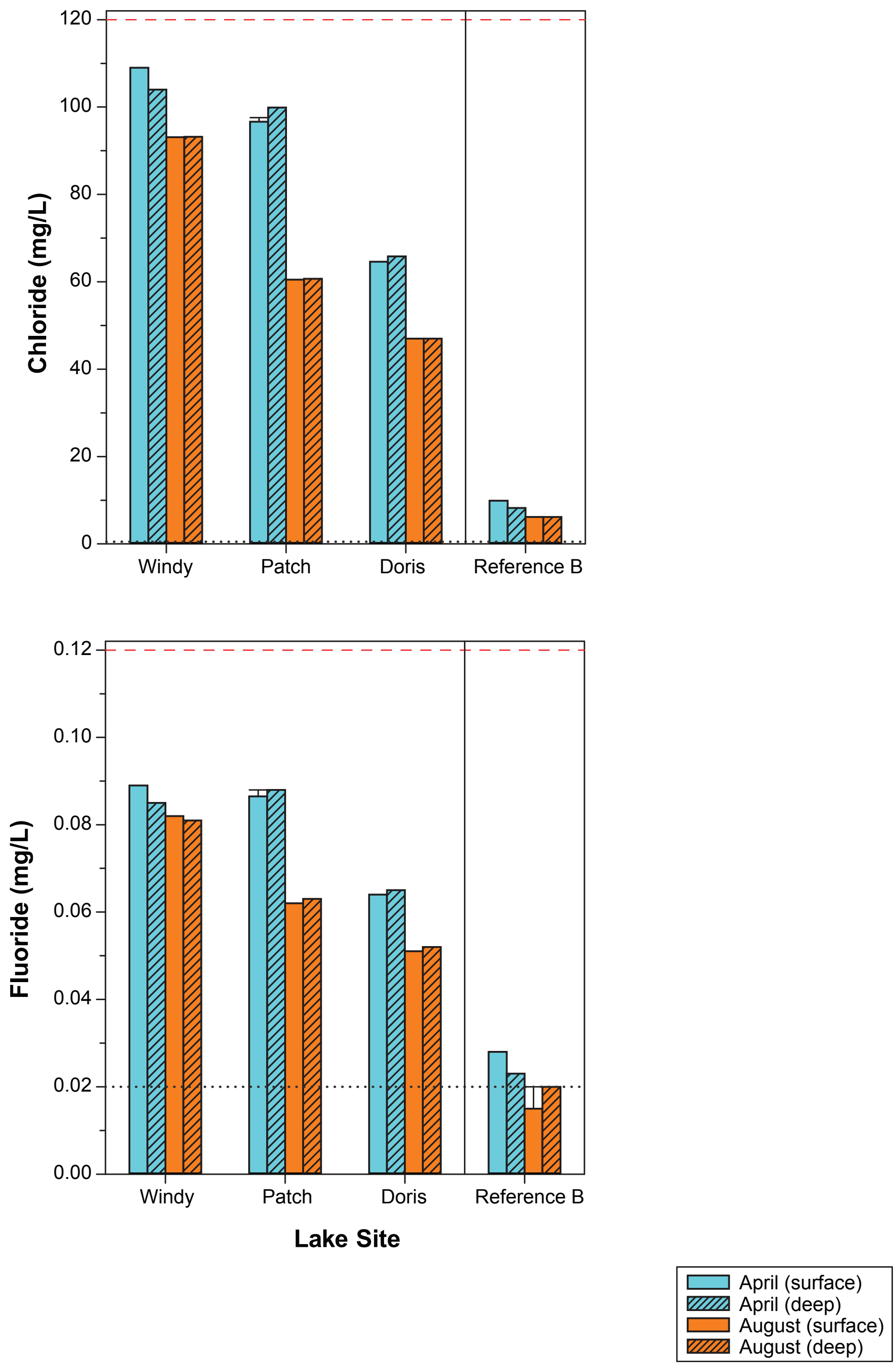
Holding time recommendations were consistently not met for the same subset of variables (pH, turbidity, nitrate, nitrite) during both sampling sessions (April and August), as well as for additional variables during the April sampling session (total suspended solids (TSS) and orthophosphate; Annex A.4-4). Recommended hold times for these variables range from 15 minutes for pH to 7 days for TSS, with most of these variables having a 3-day recommended holding time. These recommended holding times are often unattainable when sampling in remote environments and having to ship samples long distances from the study area to the analytical laboratory.

The total lead method blank concentration of 0.000133 mg/L in August exceeded the DQO for total lead (Annex A.4-4). Associated sample results that are either below the detection limit (<0.00005 mg/L) or greater than five times the blank level are considered reliable. There was only one concentration of total lead measured in August that was above that the detection limit: 0.000054 mg/L in Doris Lake surface sample. Because this concentrations is within five times the blank level, it is considered unreliable and was qualified in the main AEMP report.



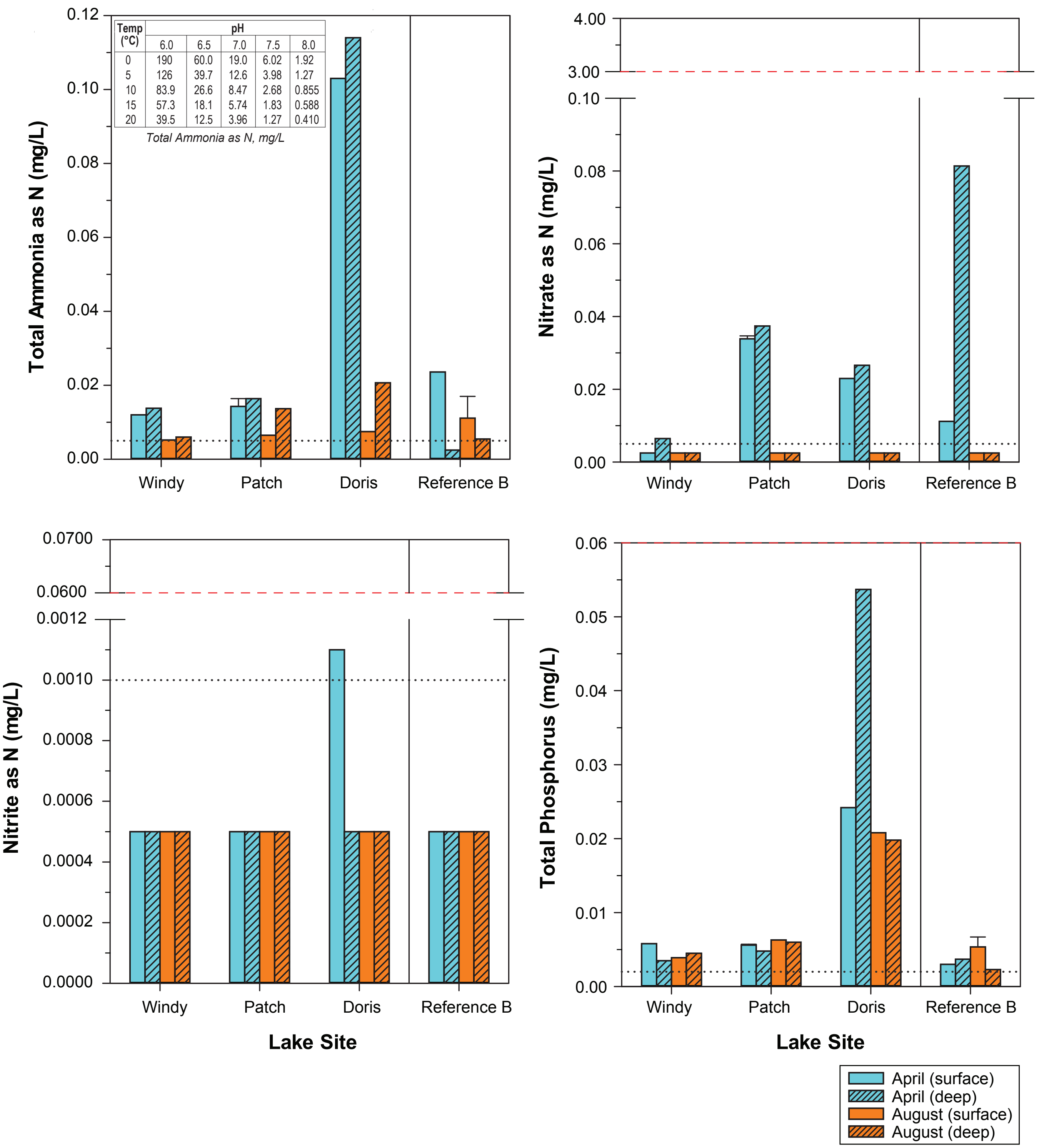
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME guideline pH range (6.5–9.0).
The CCME guidelines for total suspended solids and turbidity are dependent upon background levels.

Figure A.4-1: pH, Total Suspended Solids, and Turbidity in Lakes, Hope Bay Project, 2019



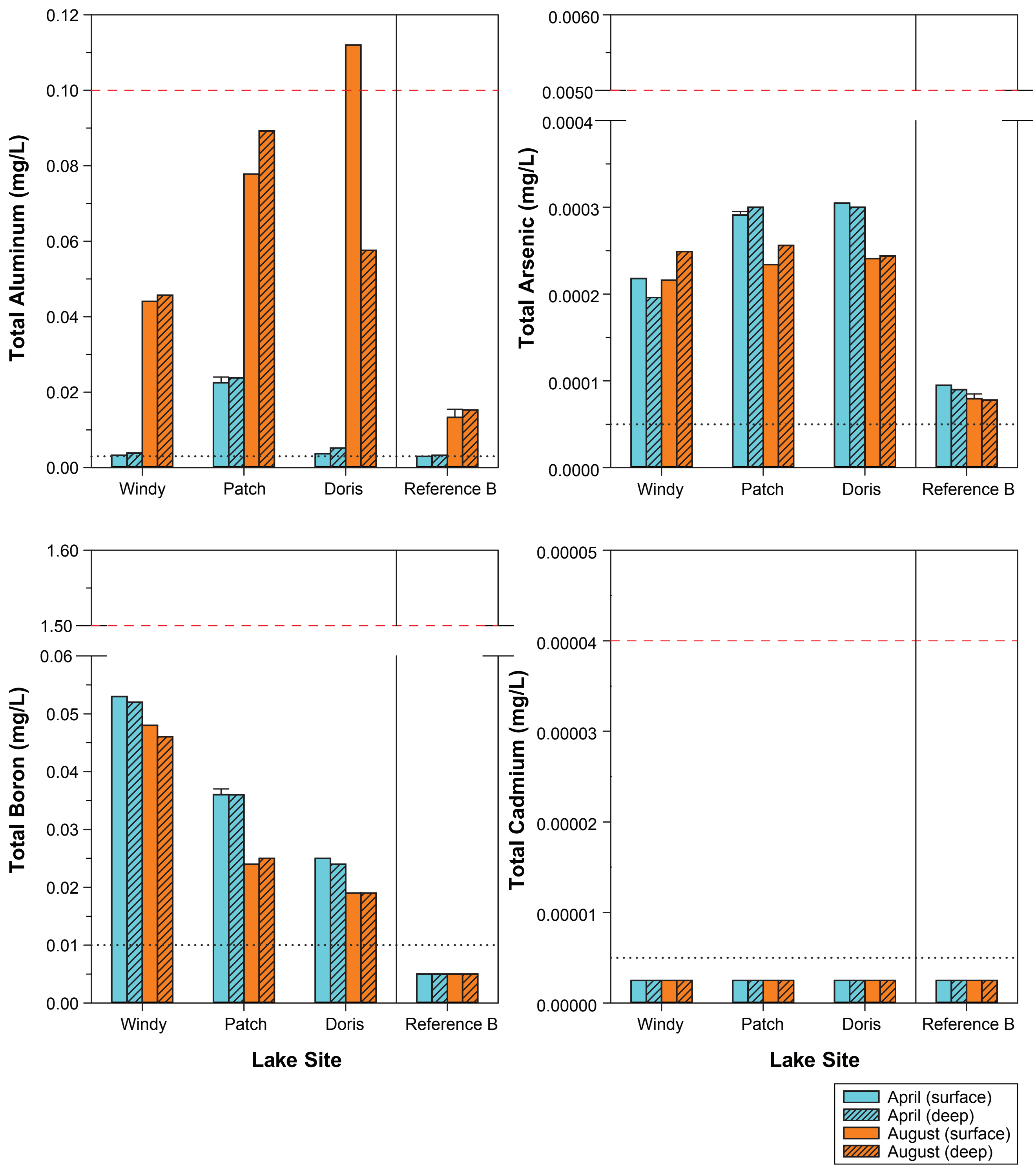
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent CCME guidelines for chloride (120 mg/L; long-term concentration) and fluoride (0.12 mg.L; interim guideline).

Figure A.4-2: Chloride and Fluoride Concentrations in Lakes, Hope Bay Project, 2019



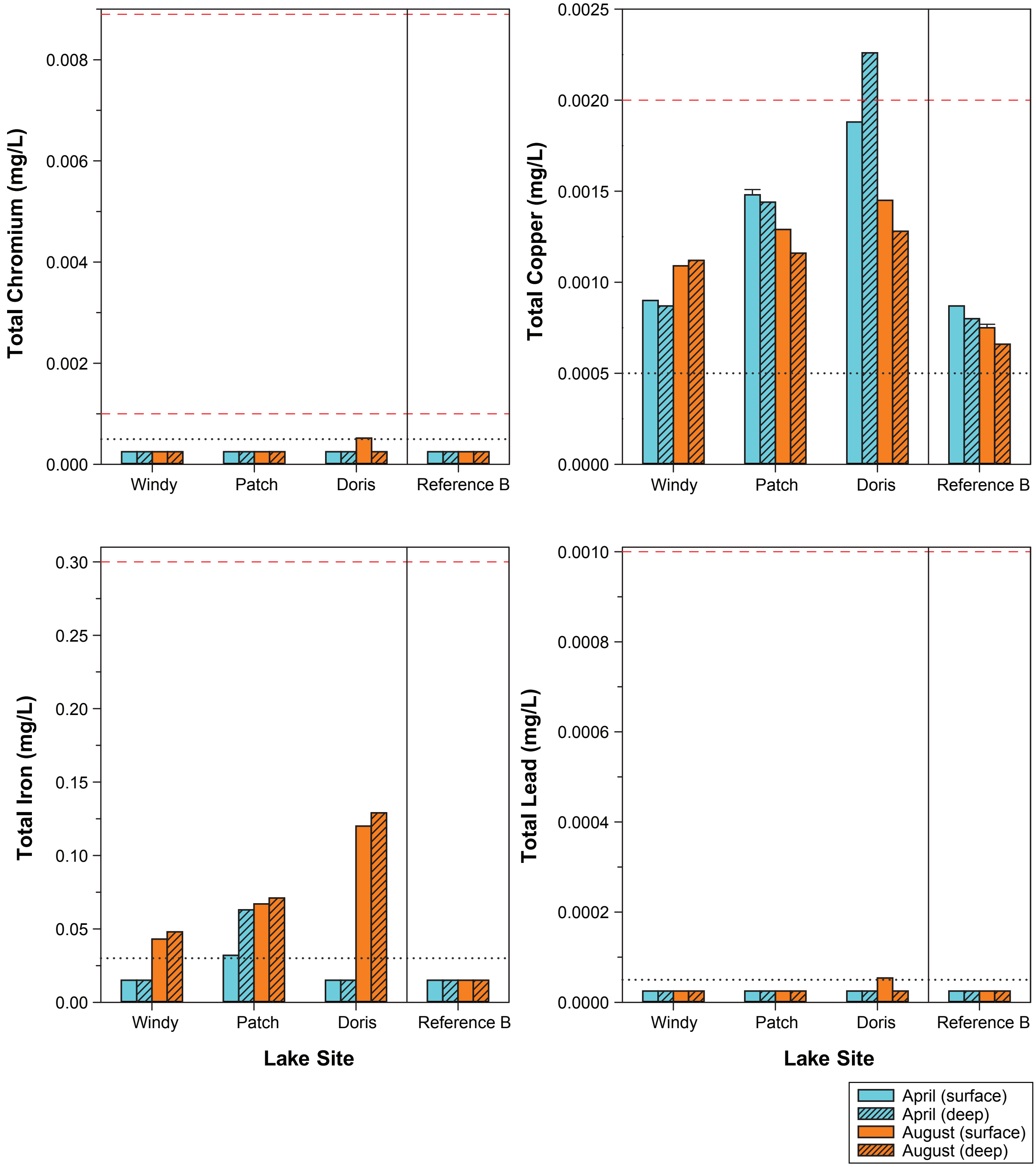
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Inset table shows the pH- and temperature-dependent CCME guideline for total ammonia as N.
Red dashed lines represent the CCME guidelines for nitrate as N (3.0 mg/L; long-term exposure) and nitrite as N (0.06 mg/L).

Figure A.4-3: Ammonia, Nitrate, Nitrite, and Phosphorus Concentrations in Lakes, Hope Bay Project, 2019



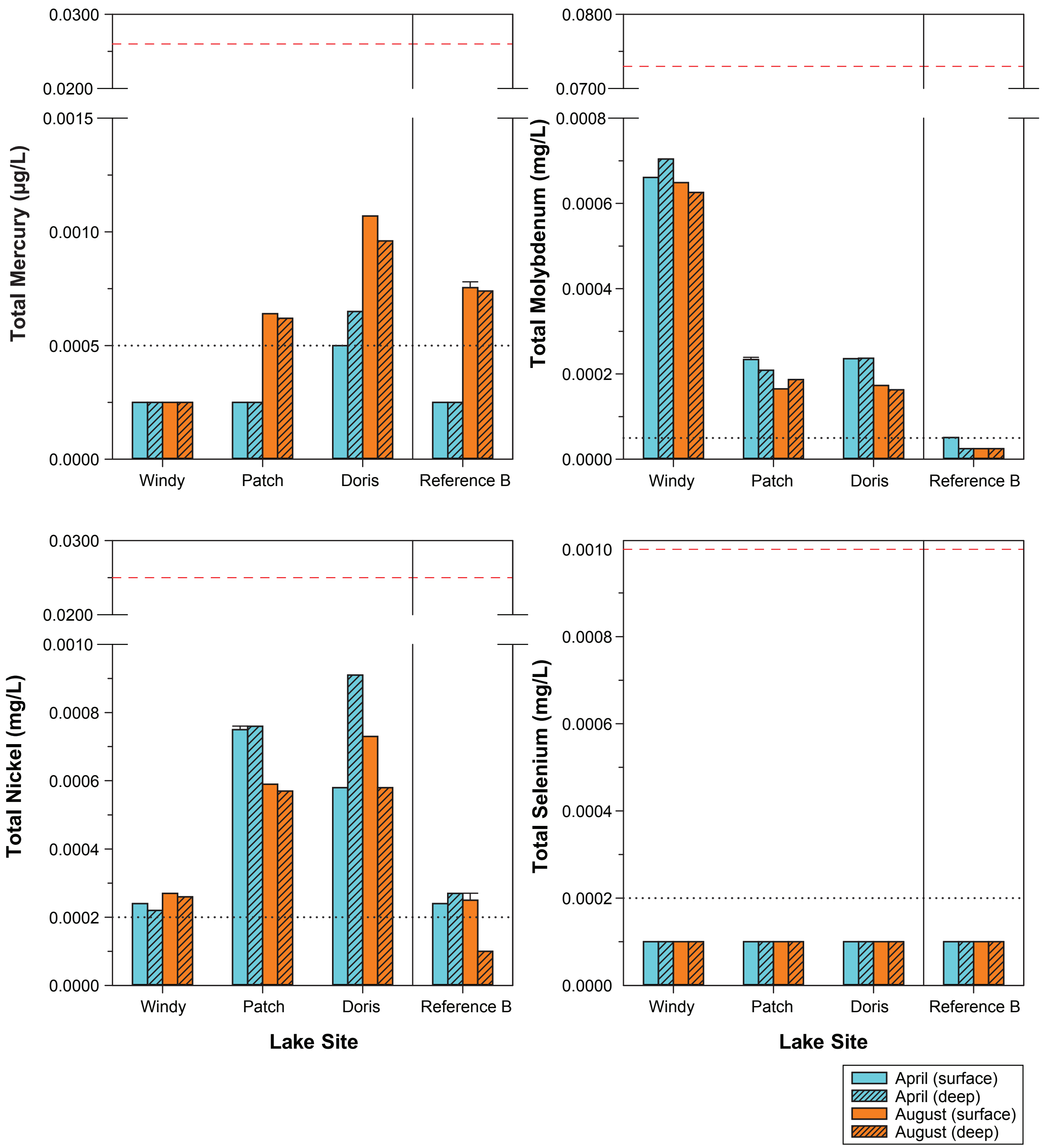
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME guideline for total aluminum (0.1 mg/L at pH ≥ 6.5; pH was greater than 6.5 in all lake samples), the CCME guidelines for total arsenic (0.005 mg/L) and total boron (1.5 mg/L; long-term concentration), and the minimum hardness-dependent CCME guideline for total cadmium (0.00004 mg/L; long-term concentration).

Figure A.4-4: Aluminum, Arsenic, Boron, and Cadmium Concentrations in Lakes, Hope Bay Project, 2019



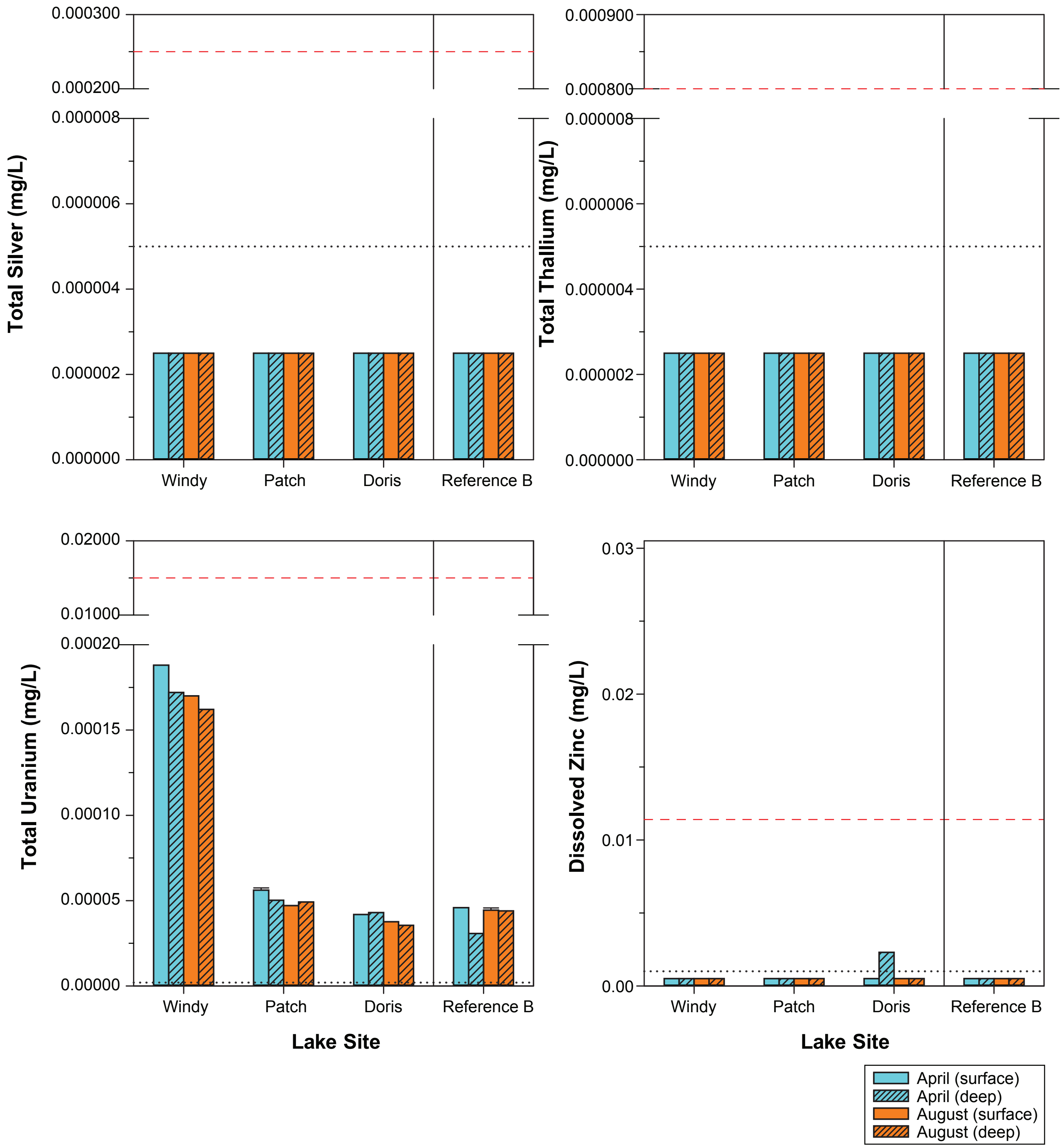
Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME guidelines for trivalent chromium (0.0089 mg/L), hexavalent chromium (0.001 mg/L), and total iron (0.3 mg/L), and the minimum hardness-dependent CCME guidelines for total copper (0.002 mg/L) and lead (0.001 mg/L).

Figure A.4-5: Chromium, Copper, Iron, and Lead Concentrations in Lakes, Hope Bay Project, 2019



Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME guidelines for total inorganic mercury (0.026 µg/L) and total selenium (0.001 mg/L), the interim CCME guideline for total molybdenum (0.073 mg/L), and the minimum hardness-dependent CCME guideline for total nickel (0.025 mg/L).

Figure A.4-6: Mercury, Molybdenum, Nickel, and Selenium in Lakes, Hope Bay Project, 2019



Notes: Error bars represent the standard error of the mean of replicates.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME guidelines for total silver (0.00025 mg/L; long-term concentration), total thallium (0.0008 mg/L), total uranium (0.015 mg/L; long-term concentration), and the minimum pH-, DOC-, and hardness-dependent guideline for dissolved zinc for the range of pH, DOC, and hardness measured in exposure lakes in 2019 (0.0114 mg/L; long-term concentration).

Figure A.4-7: Silver, Thallium, Uranium, and Zinc Concentrations in Lakes, Hope Bay Project, 2019

Annex A.4-1: Water Quality Data, Hope Bay Project, 2019

Lake:				Doris Lake North		Patch Lake			Windy Lake		Reference Lake B	
Replicate:				1	1	1	2	1	1	1	1	1
Depth Sampled (m):				2.65	10	2.4	2.4	5	2.47	14	2.26	7.5
Date Sampled:		CCME Guideline for the Protection	Realized Detection	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019
ALS Sample ID:	Units	of Aquatic life[a]	Limit	L2258739-1	L2258739-2	L2258739-3	L2258739-12	L2258739-4	L2258739-5	L2258739-6	L2258739-7	L2258739-8
Physical Tests												
Conductivity	uS/cm		2.0	302	304	431.0	439.0	450.0	504	474	76.0	65.2
Hardness (as $CaCO_3$)	mg/L		0.50	62	68	92	90	88	87	87	23	19
pH	pH	6.5 to 9.0	0.10	7.69	7.66	7.83	7.74	7.83	7.96	7.93	7.36	7.19
Total Suspended Solids	mg/L	dependent on background levels	1.0	1.0	3.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Turbidity	NTU	dependent on background levels	0.10	1.65	5.82	0.50	0.49	0.69	0.11	0.11	0.14	0.15
Anions and Nutrients												
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0	36.2	36.3	52.6	49.7	54.7	59.4	56.1	16.7	14.5
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.005	0.1030	0.1140	0.0164	0.0122	0.0164	0.012	0.0138	0.0236	<0.0050
Bromide (Br)	mg/L		0.050	0.203	0.209	0.29	0.297	0.299	0.397	0.381	<0.050	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	64.6	65.8	95.70	97.60	99.90	109.0	104.0	9.89	8.23
Fluoride (F)	mg/L	0.12[b]	0.020	0.064	0.065	0.085	0.088	0.088	0.089	0.085	0.028	0.023
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	0.0230	0.0266	0.0347	0.0331	0.0374	<0.0050	0.0065	0.0112	0.0814
Nitrite (as N)	mg/L	0.06	0.0010	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.001	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0242	0.0537	0.0057	0.0055	0.0048	0.0058	0.0035	0.0030	0.0037
Sulphate (SO_4)	mg/L		0.30	2.94	3.00	3.25	2.96	3.29	9.31	8.82	2.46	2.02
Organic/Inorganic Carbon												
Dissolved Organic Carbon	mg/L		0.50	6.77	7.50	6.37	6.17	6.69	2.27	2.05	3.69	2.94
Total Organic Carbon	mg/L		0.50	7.13	7.44	6.68	6.31	6.59	2.30	2.09	3.67	3.04
Total Metals												
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0037	0.0052	0.0210	0.0240	0.0238	0.0033	0.0039	0.0030	0.0033
Antimony (Sb)	mg/L		0.000030	<0.000030	0.00005	0.000038	<0.000030	<0.000030	0.000068	0.000068	<0.000030	<0.000030
Arsenic (As)	mg/L	0.005	0.000050	0.000305	0.000300	0.000295	0.000287	0.000300	0.000218	0.000196	0.000095	0.000090
Barium (Ba)	mg/L		0.00010	0.00289	0.00306	0.00326	0.00313	0.00344	0.00242	0.00245	0.00213	0.00240
Beryllium (Be)	mg/L		0.0000050	<0.0000050	0.0000067	<0.0000050	0.000006	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.010	0.025	0.024	0.035	0.037	0.036	0.053	0.052	<0.010	<0.010
Cadmium (Cd)	mg/L	short-term: 0.00011 to 0.00770; long-term: 0.00004 to 0.00037[d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	10.50	10.1	14.80	15.60	14.80	14.90	15.20	4.91	4.43
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002 to 0.004[e]	0.00050	0.00188	0.00226	0.00151	0.00145	0.00144	0.00090	0.00087	0.00087	0.00080
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	<0.030	<0.030	0.032	0.032	0.063	<0.030	<0.030	<0.030	<0.030
Lead (Pb)	mg/L	0.001 to 0.007[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00050	0.00397	0.00378	0.00596	0.00616	0.00604	0.00331	0.00328	0.00065	0.00057
Magnesium (Mg)	mg/L		0.10	8.23	8.07	12.10	12.40	12.40	12.60	12.20	2.05	1.83
Manganese (Mn)	mg/L		0.00020	0.00389	0.00381	0.00433	0.00429	0.0082	0.0007	0.0009	0.00094	0.02340
Mercury (Hg)	µg/L	Inorganic Hg: 0.026	0.00050	0.00050	0.00065	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000236	0.000237	0.000229	0.000239	0.000209	0.000661	0.000704	0.000051	<0.000050
Nickel (Ni)	mg/L	0.025 to 0.15[g]	0.00020	0.00058	0.00091	0.00076	0.00074	0.00076	0.00024	0.00022	0.00024	0.00027
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.6	2.6	3.7	3.8	3.8	4.5	4.3	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

Annex A.4-1: Water Quality Data, Hope Bay Project, 2019

Lake:				Doris Lake North		Patch Lake			Windy Lake		Reference Lake B	
Replicate:				1	1	1	2	1	1	1	1	1
Depth Sampled (m):			Realized	2.65	10	2.4	2.4	5	2.47	14	2.26	7.5
Date Sampled:		CCME Guideline for the Protection	Detection	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019
ALS Sample ID:	Units	of Aquatic life[a]	Limit	L2258739-1	L2258739-2	L2258739-3	L2258739-12	L2258739-4	L2258739-5	L2258739-6	L2258739-7	L2258739-8
Total Metals *(cont'd)*												
Rubidium (Rb)	mg/L		0.000020	0.00164	0.00161	0.00207	0.00205	0.00211	0.00217	0.00201	0.001110	0.001020
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.10	1.60	1.61	0.48	0.48	0.55	0.39	0.41	0.12	0.46
Silver (Ag)	mg/L	long-term : 0.00025	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	37.0	36.8	54.3	52.9	55.1	65.6	63.1	6.1	5.2
Strontium (Sr)	mg/L		0.00020	0.0427	0.0431	0.0673	0.0663	0.0660	0.0600	0.0591	0.0233	0.0208
Tellurium (Te)	mg/L		0.000010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thallium (Tl)	mg/L	0.0008	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Thorium (Th)	mg/L		0.0000050	0.0000118	0.0000104	0.0000249	0.0000164	0.0000218	0.0000082	0.0000064	0.0000091	0.0000062
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	<0.00020	<0.00020	0.0004	0.00039	0.00052	<0.00020	<0.00020	<0.00020	<0.00020
Tungsten (W)	mg/L		0.000010	<0.000010	0.000011	0.000011	0.000012	0.000011	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000419	0.0000430	0.0000549	0.0000574	0.0000502	0.0001880	0.0001720	0.0000459	0.0000307
Vanadium (V)	mg/L		0.000050	0.000126	0.000134	0.000106	0.000113	0.000118	0.000100	0.000125	0.000066	0.000056
Yttrium (Y)	mg/L		0.0000050	0.0000173	0.0000185	0.0000199	0.0000204	0.0000186	<0.0000050	0.0000070	0.0000103	0.0000094
Zinc (Zn)	mg/L		0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Dissolved Metals (Field-filtered)												
Aluminum (Al)	mg/L		0.0010	0.0022	0.0019	0.0136	0.0111	0.0101	0.0021	0.0018	0.0023	0.0020
Antimony (Sb)	mg/L		0.000030	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030	0.000071	0.00007	<0.000030	<0.000030
Arsenic (As)	mg/L		0.00005	0.000280	0.000361	0.000301	0.000277	0.000295	0.000222	0.000208	0.000126	0.000065
Barium (Ba)	mg/L		0.00010	0.00301	0.00344	0.00346	0.00334	0.00343	0.00247	0.00258	0.00229	0.00234
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000051	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000131
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L		0.0050	0.025	0.028	0.0364	0.0352	0.0348	0.054	0.051	0.0071	0.0054
Cadmium (Cd)	mg/L		0.0000050	0.0000059	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	10.90	12.1	16.10	15.80	15.40	15.50	15.10	5.55	4.75
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L		0.00020	0.00165	0.00221	0.00155	0.00147	0.00139	0.00092	0.00089	0.00092	0.00073
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L		0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00050	0.00403	0.00448	0.00641	0.00655	0.00620	0.00340	0.00341	0.00073	0.00063
Magnesium (Mg)	mg/L		0.10	8.43	9.08	12.60	12.30	12.00	11.60	12.00	2.31	1.68
Manganese (Mn)	mg/L		0.00020	0.00290	0.00330	0.00180	0.00168	0.0021	<0.00020	<0.00020	0.00070	0.02510
Molybdenum (Mo)	mg/L		0.000050	0.000255	0.000295	0.000241	0.000239	0.000223	0.000726	0.000698	0.000054	<0.000050
Nickel (Ni)	mg/L		0.00020	0.00052	0.00064	0.00076	0.00073	0.00073	0.00023	0.00022	0.00022	0.00025
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.8	3.2	4.1	4	4.1	4.6	4.6	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00178	0.00200	0.00228	0.00218	0.00220	0.00220	0.00222	0.001220	0.001090
Selenium (Se)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.71	1.95	0.49	0.45	0.53	0.39	0.39	0.09	0.45
Silver (Ag)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

Annex A.4-1: Water Quality Data, Hope Bay Project, 2019

Lake:				Doris Lake North		Patch Lake			Windy Lake		Reference Lake B	
Replicate:				1	1	1	2	1	1	1	1	1
Depth Sampled (m):				2.65	10	2.4	2.4	5	2.47	14	2.26	7.5
Date Sampled:				13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019	13-Apr-2019
ALS Sample ID:	Units	CCME Guideline for the Protection of Aquatic life[a]	Realized Detection Limit	L2258739-1	L2258739-2	L2258739-3	L2258739-12	L2258739-4	L2258739-5	L2258739-6	L2258739-7	L2258739-8
Sodium (Na)	mg/L		2.0	36.8	41.7	53.2	52.6	52.9	61.1	59.4	5.9	4.7
Dissolved Metals (Field-filtered; *cont'd*)												
Strontium (Sr)	mg/L		0.00010	0.0450	0.0540	0.0756	0.0723	0.0736	0.0660	0.0640	0.0251	0.0213
Tellurium (Te)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thallium (Tl)	mg/L		0.0000050	<0.0000050	0.0000062	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Thorium (Th)	mg/L		0.0000050	0.0000087	0.0000122	0.0000071	0.0000095	0.0000069	<0.0000050	<0.0000050	0.0000064	0.0000096
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tungsten (W)	mg/L		0.000010	<0.000010	0.000021	<0.000010	0.00001	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L		0.0000020	0.0000441	0.0000521	0.0000546	0.0000536	0.0000486	0.0001880	0.0001750	0.0000471	0.0000268
Vanadium (V)	mg/L		0.000050	0.000095	0.000106	0.000051	<0.000050	<0.000050	0.000064	0.000059	<0.000050	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000164	0.0000178	0.0000196	0.0000160	0.0000124	0.0000066	0.0000055	0.0000127	0.0000100
Zinc (Zn)	mg/L	pH-, hardness-, and DOC-dependent[h]	0.0010	<0.0010	0.0023	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050

Notes:

Shaded cells indicate values that are both above analytical detection limits and exceed CCME water quality guidelines for the protection of freshwater aquatic life.

[a] Canadian water quality guidelines (CWQG) for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed 2019.

[b] Interim guideline.

[c] Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004–0.01 = Oligotrophic; 0.01–0.02 = Mesotrophic; 0.02–0.035 = Meso-eutrophic; 0.035–0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

[d] Cadmium guideline is hardness dependent (hardness as $CaCO_3$). For the short-term benchmark, when the water hardness is <5.3 mg/L, the CWQG is 0.00011 mg/L. At hardness ≥5.3 to ≤ 360 mg/L, the CWQG is calculated using this equation: CWQG (mg/L) = $0.001*10^{\{1.016(\log[hardness]) - 1.71\}}$. At hardness >360 mg/L, the CWQG is 0.0077 mg/L. For long term, when the water hardness is <17 mg/L, the CWQG is 0.00004 mg/L. At hardness ≥17 to ≤ 280 mg/L, the CWQG is calculated using this equation: CWQG (mg/L) = $0.001*10^{\{0.83(\log[hardness]) - 2.46\}}$. At hardness >280 mg/L, the CWQG is 0.00037 mg/L.

[e] Copper guideline is hardness dependent (hardness as $CaCO_3$). When the water hardness is <82 mg/L, the CWQG is 0.002 mg/L. At hardness ≥82 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (mg/L) = $0.0002 * e^{\{0.8545[\ln(hardness)]-1.465\}}$. At hardness >180 mg/L, the CWQG is 0.004 mg/L. If the hardness is unknown, the CWQG is 0.002 mg/L.

[f] Lead guideline is hardness dependent (hardness as $CaCO_3$). When the hardness is ≤60 mg/L, the CWQG is 0.001 mg/L. At hardness >60 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (mg/L)= $0.001*e^{\{1.273[\ln(hardness)]-4.705\}}$. At hardness >180 mg/L, the CWQG is 0.007 mg/L. If the hardness is unknown, the CWQG is 0.001 mg/L.

[g] Nickel guideline is hardness dependent (hardness as $CaCO_3$). When the water hardness is ≤60 mg/L, the CWQG is 0.025 mg/L. At hardness >60 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (mg/L) = $0.001*e^{\{0.76[\ln(hardness)]+1.06\}}$. At hardness >180 mg/L, the CWQG is 0.150 mg/L. If the hardness is unknown, the CWQG is 0.025 mg/L.

[h] The dissolved zinc water quality guideline is calculated from the pH, hardness, and dissolved organic carbon (DOC) concentration. The short-term benchmark is calculated using the equation: CWQG (mg/L) = $0.001*e^{\{0.833[\ln(hardness)] +0.240[\ln(DOC)] + 0.526\}}$; this equation is valid between hardness 13.8 and 250.5 mg $CaCO_3$/L and DOC 0.3 and 17.3 mg/L. The long-term benchmark is calculated using the equation: CWQG (mg/L) = $0.001*e^{0.947[\ln(hardness)] - 0.815[pH] + 0.398[\ln(DOC)] + 4.625}$; this equation is valid between hardness 23.4 and 399 mg $CaCO_3$/L, pH 6.5 and 8.13, and DOC 0.3 to 22.9 mg/L.

Annex A.4-1: Water Quality Data, Hope Bay Project, 2019

Lake:				Doris Lake North		Windy Lake		Patch Lake		Reference Lake B		
Replicate:				1	1	1	1	1	1	1	2	1
Depth Sampled (m):				1	12	1	16	1	6	1	1	8.5
Date Sampled:		CCME Guideline for the Protection of	Realized Detection	15-Aug-2019	15-Aug-2019	16-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019
ALS Sample ID:	Units	Aquatic life[a]	Limit	L2332685-6	L2332685-7	L2332685-8	L2332685-9	L2332685-12	L2332685-13	L2332685-10	L2332685-3	L2332685-11
Physical Tests												
Conductivity	uS/cm		2.0	206	205	411.0	410.0	267	267	46.9	46.1	46.3
Hardness (as $CaCO_3$)	mg/L		0.50	39	40	75	71	52	53	13	14	14
pH	pH	6.5 to 9.0	0.10	7.66	7.70	7.97	7.97	7.81	7.81	7.35	7.29	7.35
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.8	3.5	<1.0	<1.0	1.1	1.6	<1.0	<1.0	<1.0
Turbidity	NTU	dependent on background levels	0.10	3.33	3.42	<0.10	0.47	1.58	1.45	0.31	0.36	0.27
Anions and Nutrients												
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0	26.2	26.1	49.4	48.9	33.8	33.7	10.7	10.7	10.4
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.005	0.0075	0.0207	0.0052	0.006	0.0065	0.0137	0.017	0.0053	0.0055
Bromide (Br)	mg/L		0.050	0.154	0.161	0.368	0.361	0.197	0.200	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	47.0	47.0	93.10	93.20	60.5	60.7	6.20	6.16	6.15
Fluoride (F)	mg/L	0.12[b]	0.020	0.051	0.052	0.082	0.081	0.062	0.063	0.02	<0.020	0.02
Nitrate (as N)	mg/L	short-term: 124; long-term: 3.0	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Orthophosphate-Dissolved (as P)	mg/L		0.0010									
Phosphorus (P)-Total	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0208	0.0198	0.0039	0.0045	0.0063	0.0060	0.0040	0.0067	0.0023
Sulphate (SO_4)	mg/L		0.30	2.19	2.19	8.14	8.15	2.20	2.21	1.60	1.61	1.60
Organic/Inorganic Carbon												
Dissolved Organic Carbon	mg/L		0.50	5.53	5.52	1.88	1.93	4.71	4.80	2.83	2.88	2.79
Total Organic Carbon	mg/L		0.50	6.13	6.21	2.05	1.98	4.66	4.87	3.12	3.27	2.84
Total Metals												
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.112	0.0576	0.0441	0.0457	0.0778	0.0892	0.0155	0.0112	0.0153
Antimony (Sb)	mg/L		0.000030	<0.000030	<0.000030	0.000065	0.000062	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030
Arsenic (As)	mg/L	0.005	0.000050	0.000241	0.000244	0.000216	0.000249	0.000234	0.000256	0.000074	0.000085	0.000078
Barium (Ba)	mg/L		0.00010	0.0027	0.00276	0.00240	0.00247	0.00244	0.00253	0.00151	0.00141	0.00143
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.010	0.019	0.019	0.048	0.046	0.024	0.025	<0.010	<0.010	<0.010
Cadmium (Cd)	mg/L	short-term: 0.00011 to 0.00770; long-term: 0.00004 to 0.00037[d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	6.72	6.84	13.00	12.20	8.69	8.90	3.23	3.28	3.29
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	0.0000054	0.0000053	0.0000052	0.0000061	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	0.00052	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.002 to 0.004[e]	0.00050	0.00145	0.00128	0.00109	0.00112	0.00129	0.00116	0.00073	0.00077	0.00066
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.12	0.129	0.043	0.048	0.067	0.071	<0.030	<0.030	<0.030
Lead (Pb)	mg/L	0.001 to 0.007[f]	0.000050	0.000054	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00050	0.00302	0.00305	0.00325	0.00307	0.00416	0.00432	0.00051	0.00051	0.00051
Magnesium (Mg)	mg/L		0.10	5.51	5.52	10.20	9.94	7.31	7.52	1.31	1.28	1.30
Manganese (Mn)	mg/L		0.00020	0.00955	0.0121	0.00195	0.00224	0.0053	0.0054	0.00219	0.00211	0.00210
Mercury (Hg)	µg/L	Inorganic Hg: 0.026	0.00050	0.00107	0.00096	<0.00050	<0.00050	0.00064	0.00062	0.00073	0.00078	0.00074
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000173	0.000163	0.000649	0.000626	0.000165	0.000187	<0.000050	<0.000050	<0.000050
Nickel (Ni)	mg/L	0.025 to 0.15[g]	0.00020	0.00073	0.00058	0.00027	0.00026	0.00059	0.00057	0.00023	0.00027	<0.00020
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	<2.0	<2.0	4	4	2.6	2.6	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

Annex A.4-1: Water Quality Data, Hope Bay Project, 2019

Lake:				Doris Lake North		Windy Lake		Patch Lake		Reference Lake B		
Replicate:				1	1	1	1	1	1	1	2	1
Depth Sampled (m):				1	12	1	16	1	6	1	1	8.5
Date Sampled:				15-Aug-2019	15-Aug-2019	16-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019
ALS Sample ID:	Units	CCME Guideline for the Protection of Aquatic life[a]	Realized Detection Limit	L2332685-6	L2332685-7	L2332685-8	L2332685-9	L2332685-12	L2332685-13	L2332685-10	L2332685-3	L2332685-11
Total Metals *(cont'd)*												
Rubidium (Rb)	mg/L		0.000020	0.00129	0.00129	0.001960	0.002000	0.00153	0.00155	0.000738	0.000761	0.000775
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.10	1.06	1.14	0.45	0.46	0.46	0.51	0.14	0.14	0.14
Silver (Ag)	mg/L	long-term : 0.00025	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	25.2	24.9	53.3	52.4	32.5	32.3	3.7	3.7	3.7
Strontium (Sr)	mg/L		0.00020	0.0324	0.0316	0.0580	0.0576	0.0435	0.0453	0.0168	0.0162	0.0167
Tellurium (Te)	mg/L		0.000010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thallium (Tl)	mg/L	0.0008	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Thorium (Th)	mg/L		0.0000050	0.0000288	0.0000266	0.0000206	0.0000178	0.0000231	0.0000298	0.0000102	0.0000134	0.0000079
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00097	0.0011	0.0023	0.0024	0.00261	0.00273	<0.00020	<0.00020	<0.00020
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000016	0.000014	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000376	0.0000355	0.0001700	0.0001620	0.0000471	0.0000492	0.0000457	0.0000430	0.0000440
Vanadium (V)	mg/L		0.000050	0.000183	0.000213	0.000185	0.000199	0.000236	0.000231	0.000099	0.000058	0.000074
Yttrium (Y)	mg/L		0.0000050	0.0000335	0.0000368	0.0000154	0.0000172	0.0000305	0.0000314	0.0000125	0.0000120	0.0000074
Zinc (Zn)	mg/L		0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	0.000065	0.000071	<0.000050	<0.000050	0.000059	0.000065	<0.000050	<0.000050	<0.000050
Dissolved Metals (Field-filtered)												
Aluminum (Al)	mg/L		0.0010									
Antimony (Sb)	mg/L		0.000030									
Arsenic (As)	mg/L		0.00005									
Barium (Ba)	mg/L		0.00010									
Beryllium (Be)	mg/L		0.0000050									
Bismuth (Bi)	mg/L		0.000050									
Boron (B)	mg/L		0.0050									
Cadmium (Cd)	mg/L		0.0000050									
Calcium (Ca)	mg/L		0.050									
Cesium (Cs)	mg/L		0.0000050									
Chromium (Cr)	mg/L		0.00050									
Cobalt (Co)	mg/L		0.000050									
Copper (Cu)	mg/L		0.00020									
Gallium (Ga)	mg/L		0.000050									
Iron (Fe)	mg/L		0.030									
Lead (Pb)	mg/L		0.000050									
Lithium (Li)	mg/L		0.00050									
Magnesium (Mg)	mg/L		0.10									
Manganese (Mn)	mg/L		0.00020									
Molybdenum (Mo)	mg/L		0.000050									
Nickel (Ni)	mg/L		0.00020									
Phosphorus (P)	mg/L		0.30									
Potassium (K)	mg/L		2.0									
Rhenium (Re)	mg/L		0.0000050									
Rubidium (Rb)	mg/L		0.000020									
Selenium (Se)	mg/L		0.00020									
Silicon (Si)	mg/L		0.050									
Silver (Ag)	mg/L		0.0000050									

Annex A.4-1: Water Quality Data, Hope Bay Project, 2019

Lake:	Units	CCME Guideline for the Protection of Aquatic life[a]	Realized Detection Limit	Doris Lake North		Windy Lake		Patch Lake		Reference Lake B		
Replicate:				1	1	1	1	1	1	1	2	1
Depth Sampled (m):				1	12	1	16	1	6	1	1	8.5
Date Sampled:				15-Aug-2019	15-Aug-2019	16-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019
ALS Sample ID:				L2332685-6	L2332685-7	L2332685-8	L2332685-9	L2332685-12	L2332685-13	L2332685-10	L2332685-3	L2332685-11
Sodium (Na)	mg/L		2.0									
Dissolved Metals (Field-filtered; *cont'd*)												
Strontium (Sr)	mg/L		0.00010									
Tellurium (Te)	mg/L		0.000050									
Thallium (Tl)	mg/L		0.0000050									
Thorium (Th)	mg/L		0.0000050									
Tin (Sn)	mg/L		0.00020									
Titanium (Ti)	mg/L		0.00020									
Tungsten (W)	mg/L		0.000010									
Uranium (U)	mg/L		0.0000020									
Vanadium (V)	mg/L		0.000050									
Yttrium (Y)	mg/L		0.0000050									
Zinc (Zn)	mg/L	pH-, hardness-, and DOC-dependent[h]	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zirconium (Zr)	mg/L		0.000050									

Notes:

Shaded cells indicate values that are both above analytical detection limits and exceed CCME water quality guidelines for the protection of freshwater aquatic life.

[a] *Canadian water quality guidelines (CWQG) for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed 2019.*

[b] *Interim guideline.*

[c] *Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004–0.01 = Oligotrophic; 0.01–0.02 = Mesotrophic; 0.02–0.035 = Meso-eutrophic; 0.035–0.1 = Eutrophic; >0.1 = Hyper-eutrophic.*

[d] *Cadmium guideline is hardness dependent (hardness as $CaCO_3$). For the short-term benchmark, when the water hardness is <5.3 mg/L, the CWQG is 0.00011 mg/L. At hardness ≥5.3 to ≤ 360 mg/L, the CWQG is calculated using this equation: CWQG (mg/L) = $0.001*10^{\{1.016(log[hardness]) - 1.71\}}$. At hardness >360 mg/L, the CWQG is 0.0077 mg/L. For long term, when the water hardness is <17 mg/L, the CWQG is 0.00004 mg/L. At hardness ≥17 to ≤ 280 mg/L, the CWQG is calculated using this equation: CWQG (mg/L) = $0.001*10^{\{0.83(log[hardness]) - 2.46\}}$. At hardness >280 mg/L, the CWQG is 0.00037 mg/L.*

[e] *Copper guideline is hardness dependent (hardness as $CaCO_3$). When the water hardness is <82 mg/L, the CWQG is 0.002 mg/L. At hardness ≥82 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (mg/L) = $0.0002 * e^{\{0.8545[ln(hardness)]-1.465\}}$. At hardness >180 mg/L, the CWQG is 0.004 mg/L. If the hardness is unknown, the CWQG is 0.002 mg/L.*

[f] *Lead guideline is hardness dependent (hardness as $CaCO_3$). When the hardness is ≤60 mg/L, the CWQG is 0.001 mg/L. At hardness >60 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (mg/L)= $0.001*e^{\{1.273[ln(hardness)]-4.705\}}$. At hardness >180 mg/L, the CWQG is 0.007 mg/L. If the hardness is unknown, the CWQG is 0.001 mg/L.*

[g] *Nickel guideline is hardness dependent (hardness as $CaCO_3$). When the water hardness is ≤60 mg/L, the CWQG is 0.025 mg/L. At hardness >60 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (mg/L) = $0.001*e^{\{0.76[ln(hardness)]+1.06\}}$. At hardness >180 mg/L, the CWQG is 0.150 mg/L. If the hardness is unknown, the CWQG is 0.025 mg/L.*

[h] *The dissolved zinc water quality guideline is calculated from the pH, hardness, and dissolved organic carbon (DOC) concentration. The short-term benchmark is calculated using the equation: CWQG (mg/L) = $0.001*e^{\{0.833[ln(hardness)] + 0.240[ln(DOC)] + 0.526\}}$; this equation is valid between hardness 13.8 and 250.5 mg $CaCO_3$/L and DOC 0.3 and 17.3 mg/L. The long-term benchmark is calculated using the equation: CWQG (mg/L) = $0.001*e^{0.947[ln(hardness)] - 0.815[pH] + 0.398[ln(DOC)] + 4.625\}}$; this equation is valid between hardness 23.4 and 399 mg $CaCO_3$/L, pH 6.5 and 8.13, and DOC 0.3 to 22.9 mg/L.*

Annex A.4-2: Relative Percent Difference Calculations for Duplicate Water Quality Samples, Hope Bay Project, 2019

Lake:	Units	Realized Detection Limit	5x Realized Detection Limit	Patch Lake			Reference Lake B		
Replicate:				1	2		1	2	
Depth Sampled (m):				2.4			1		
Date Sampled:				13-Apr-2019			18-Aug-2019		
ALS Sample ID:				L2258739-3	L2258739-12	RPD (%)	L2332685-10	L2332685-3	RPD (%)
Physical Tests									
Conductivity	µS/cm	2	10	431.00	439.00	1.8	46.90	46.10	1.7
Hardness (as $CaCO_3$)	mg/L	0.5	2.5	92.00	90.00	2.2	13.40	13.50	0.7
pH	pH	0.1	0.5	7.83	7.74	1.2	7.35	7.29	0.8
Total Suspended Solids	mg/L	1	5	<1.0	<1.0	n/a	<1.0	<1.0	n/a
Turbidity	NTU	0.1	0.5	0.50	0.49	2.0	0.31	0.36	n/a
Anions and Nutrients									
Alkalinity, Total (as $CaCO_3$)	mg/L	1	5	52.6	49.7	5.7	10.7	10.7	0
Ammonia, Total (as N)	mg/L	0.005	0.025	0.0164	0.0122	n/a	0.017	0.0053	n/a
Bromide (Br)	mg/L	0.05	0.25	0.29	0.297	2.4	<0.050	<0.050	n/a
Chloride (Cl)	mg/L	0.5	2.5	95.7	97.6	2.0	6.2	6.16	0.6
Fluoride (F)	mg/L	0.02	0.1	0.085	0.088	n/a	0.02	<0.020	n/a
Nitrate (as N)	mg/L	0.005	0.025	0.0347	0.0331	4.7	<0.0050	<0.0050	n/a
Nitrite (as N)	mg/L	0.001	0.005	<0.0010	<0.0010	n/a	<0.0010	<0.0010	n/a
Orthophosphate, Dissolved (as P)	mg/L	0.001	0.005	<0.0010	<0.0010	n/a			n/a
Phosphorus, Total (as P)	mg/L	0.002	0.01	0.0057	0.0055	n/a	0.004	0.0067	n/a
Sulphate (SO_4)	mg/L	0.3	1.5	3.25	2.96	9.3	1.6	1.61	0.6
Organic Carbon									
Dissolved Organic Carbon	mg/L	0.5	2.5	6.37	6.17	3.2	2.83	2.88	1.8
Total Organic Carbon	mg/L	0.5	2.5	6.68	6.31	5.7	3.12	3.27	4.7
Total Metals									
Aluminum (Al)	mg/L	0.003	0.015	0.021	0.024	13.3	0.0155	0.0112	**32.2**
Antimony (Sb)	mg/L	0.00003	0.00015	0.000038	<0.000030	n/a	<0.000030	<0.000030	n/a
Arsenic (As)	mg/L	0.00005	0.00025	0.000295	0.000287	2.7	0.000074	0.000085	n/a
Barium (Ba)	mg/L	0.0001	0.0005	0.00326	0.00313	4.1	0.00151	0.00141	6.8
Beryllium (Be)	mg/L	0.000005	0.000025	<0.0000050	0.000006	n/a	<0.0000050	<0.0000050	n/a
Bismuth (Bi)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a	<0.000050	<0.000050	n/a
Boron (B)	mg/L	0.01	0.05	0.035	0.037	n/a	<0.010	<0.010	n/a
Cadmium (Cd)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a	<0.0000050	<0.0000050	n/a

Annex A.4-2: Relative Percent Difference Calculations for Duplicate Water Quality Samples, Hope Bay Project, 2019

Lake:				Patch Lake			Reference Lake B		
Replicate:				1	2		1	2	
Depth Sampled (m):				2.4			1		
Date Sampled:				13-Apr-2019			18-Aug-2019		
ALS Sample ID:	Units	Realized Detection Limit	5x Realized Detection Limit	L2258739-3	L2258739-12	RPD (%)	L2332685-10	L2332685-3	RPD (%)
Total Metals *(cont'd)*									
Calcium (Ca)	mg/L	0.05	0.25	14.8	15.6	5.3	3.23	3.28	1.5
Cesium (Cs)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a	<0.0000050	<0.0000050	n/a
Chromium (Cr)	mg/L	0.0005	0.0025	<0.00050	<0.00050	n/a	<0.00050	<0.00050	n/a
Cobalt (Co)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a	<0.000050	<0.000050	n/a
Copper (Cu)	mg/L	0.0005	0.0025	0.00151	0.00145	n/a	0.00073	0.00077	n/a
Gallium (Ga)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a	<0.000050	<0.000050	n/a
Iron (Fe)	mg/L	0.03	0.15	0.032	0.032	n/a	<0.030	<0.030	n/a
Lead (Pb)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a	<0.000050	<0.000050	n/a
Lithium (Li)	mg/L	0.0005	0.0025	0.00596	0.00616	3.3	0.00051	0.00051	n/a
Magnesium (Mg)	mg/L	0.1	0.5	12.1	12.4	2.4	1.31	1.28	2.3
Manganese (Mn)	mg/L	0.0002	0.001	0.00433	0.00429	0.9	0.00219	0.00211	3.7
Mercury (Hg)	µg/L	0.0005	0.0025	<0.00050	<0.00050	n/a	0.00073	0.00078	n/a
Molybdenum (Mo)	mg/L	0.00005	0.00025	0.000229	0.000239	4.3	<0.000050	<0.000050	n/a
Nickel (Ni)	mg/L	0.0002	0.001	0.00076	0.00074	n/a	0.00023	0.00027	n/a
Phosphorus (P)	mg/L	0.3	1.5	<0.30	<0.30	n/a	<0.30	<0.30	n/a
Potassium (K)	mg/L	2	10	3.7	3.8	n/a	<2.0	<2.0	n/a
Rhenium (Re)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a	<0.0000050	<0.0000050	n/a
Rubidium (Rb)	mg/L	0.00002	0.0001	0.00207	0.00205	1.0	0.000738	0.000761	3.1
Selenium (Se)	mg/L	0.0002	0.001	<0.00020	<0.00020	n/a	<0.00020	<0.00020	n/a
Silicon (Si)	mg/L	0.1	0.5	0.48	0.48	n/a	0.14	0.14	n/a
Silver (Ag)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a	<0.0000050	<0.0000050	n/a
Sodium (Na)	mg/L	2	10	54.3	52.9	2.6	3.7	3.7	n/a
Strontium (Sr)	mg/L	0.0002	0.001	0.0673	0.0663	1.5	0.0168	0.0162	3.6
Tellurium (Te)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a	<0.000050	<0.000050	n/a
Thallium (Tl)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a	<0.0000050	<0.0000050	n/a
Thorium (Th)	mg/L	0.000005	0.000025	0.0000249	0.0000164	n/a	0.0000102	0.0000134	n/a
Tin (Sn)	mg/L	0.0002	0.001	<0.00020	<0.00020	n/a	<0.00020	<0.00020	n/a
Titanium (Ti)	mg/L	0.0002	0.001	0.0004	0.00039	n/a	<0.00020	<0.00020	n/a

Annex A.4-2: Relative Percent Difference Calculations for Duplicate Water Quality Samples, Hope Bay Project, 2019

Lake:				Patch Lake			Reference Lake B		
Replicate:				1	2		1	2	
Depth Sampled (m):				2.4			1		
Date Sampled:				13-Apr-2019			18-Aug-2019		
ALS Sample ID:	Units	Realized Detection Limit	5x Realized Detection Limit	L2258739-3	L2258739-12	RPD (%)	L2332685-10	L2332685-3	RPD (%)
Total Metals *(cont'd)*									
Tungsten (W)	mg/L	0.00001	0.00005	0.000011	0.000012	n/a	<0.000010	<0.000010	n/a
Uranium (U)	mg/L	0.000002	0.00001	0.0000549	0.0000574	4.5	0.0000457	0.000043	6.1
Vanadium (V)	mg/L	0.00005	0.00025	0.000106	0.000113	n/a	0.000099	0.000058	n/a
Yttrium (Y)	mg/L	0.000005	0.000025	0.0000199	0.0000204	n/a	0.0000125	0.000012	n/a
Zinc (Zn)	mg/L	0.003	0.015	<0.0030	<0.0030	n/a	<0.0030	<0.0030	n/a
Zirconium (Zr)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a	<0.000050	<0.000050	n/a
Dissolved Metals (Field-filtered)									
Aluminum (Al)	mg/L	0.001	0.005	0.0136	0.0111	**20.2**			n/a
Antimony (Sb)	mg/L	0.00003	0.00015	<0.000030	<0.000030	n/a			n/a
Arsenic (As)	mg/L	0.00005	0.00025	0.000301	0.000277	8.3			n/a
Barium (Ba)	mg/L	0.0001	0.0005	0.00346	0.00334	3.5			n/a
Beryllium (Be)	mg/L	0.000005	0.000025	<0.0000050	0.0000051	n/a			n/a
Bismuth (Bi)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a			n/a
Boron (B)	mg/L	0.005	0.025	0.0364	0.0352	3.4			n/a
Cadmium (Cd)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a			n/a
Calcium (Ca)	mg/L	0.05	0.25	16.1	15.8	1.9			n/a
Cesium (Cs)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a			n/a
Chromium (Cr)	mg/L	0.0005	0.0025	<0.00050	<0.00050	n/a			n/a
Cobalt (Co)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a			n/a
Copper (Cu)	mg/L	0.0002	0.001	0.00155	0.00147	5.3			n/a
Gallium (Ga)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a			n/a
Iron (Fe)	mg/L	0.03	0.15	<0.030	<0.030	n/a			n/a
Lead (Pb)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a			n/a
Lithium (Li)	mg/L	0.0005	0.0025	0.00641	0.00655	2.2			n/a
Magnesium (Mg)	mg/L	0.1	0.5	12.6	12.3	2.4			n/a
Manganese (Mn)	mg/L	0.0002	0.001	0.0018	0.00168	6.9			n/a
Molybdenum (Mo)	mg/L	0.00005	0.00025	0.000241	0.000239	n/a			n/a
Nickel (Ni)	mg/L	0.0002	0.001	0.00076	0.00073	n/a			n/a

Annex A.4-2: Relative Percent Difference Calculations for Duplicate Water Quality Samples, Hope Bay Project, 2019

Lake:				Patch Lake			Reference Lake B		
Replicate:				1	2		1	2	
Depth Sampled (m):				2.4			1		
Date Sampled:				13-Apr-2019			18-Aug-2019		
ALS Sample ID:	Units	Realized Detection Limit	5x Realized Detection Limit	L2258739-3	L2258739-12	RPD (%)	L2332685-10	L2332685-3	RPD (%)
Dissolved Metals (Field-filtered; *cont'd* **)**									
Phosphorus (P)	mg/L	0.3	1.5	<0.30	<0.30	n/a			n/a
Potassium (K)	mg/L	2	10	4.1	4	n/a			n/a
Rhenium (Re)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a			n/a
Rubidium (Rb)	mg/L	0.00002	0.0001	0.00228	0.00218	4.5			n/a
Selenium (Se)	mg/L	0.0002	0.001	<0.00020	<0.00020	n/a			n/a
Silicon (Si)	mg/L	0.05	0.25	0.487	0.451	7.7			n/a
Silver (Ag)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a			n/a
Sodium (Na)	mg/L	2	10	53.2	52.6	1.1			n/a
Strontium (Sr)	mg/L	0.0001	0.0005	0.0756	0.0723	4.5			n/a
Tellurium (Te)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a			n/a
Thallium (Tl)	mg/L	0.000005	0.000025	<0.0000050	<0.0000050	n/a			n/a
Thorium (Th)	mg/L	0.000005	0.000025	0.0000071	0.0000095	n/a			n/a
Tin (Sn)	mg/L	0.0002	0.001	<0.00020	<0.00020	n/a			n/a
Titanium (Ti)	mg/L	0.0002	0.001	<0.00020	<0.00020	n/a			n/a
Tungsten (W)	mg/L	0.00001	0.00005	<0.000010	0.00001	n/a			n/a
Uranium (U)	mg/L	0.000002	0.00001	0.0000546	0.0000536	1.8			n/a
Vanadium (V)	mg/L	0.00005	0.00025	0.000051	<0.000050	n/a			n/a
Yttrium (Y)	mg/L	0.000005	0.000025	0.0000196	0.000016	**20.2**			n/a
Zinc (Zn)	mg/L	0.001	0.005	<0.0010	<0.0010	n/a	<0.0010	<0.0010	n/a
Zirconium (Zr)	mg/L	0.00005	0.00025	<0.000050	<0.000050	n/a			n/a

Notes:

n/a = not applicable when both duplicate values are less than five times the detection limit.

Relative percent difference (RPD) is only calculated if at least one duplicate concentration is greater than five times the detection limit.

Bold and highlighted values indicate a RPD of greater than 20% but less than 50%.

No RPD values exceeded 50%.

Annex A.4-3: Blank Data for Water Quality Sampling, Hope Bay Project, 2019

Blank Type:		Equipment Blank	Travel Blank	Field Blank	Equipment Blank	Equipment Blank	Travel Blank	Field Blank
Date Sampled:		13-Apr-2019	13-Apr-2019	13-Apr-2019	15-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019
ALS Sample ID:	Units	L2258739-9	L2258739-10	L2258739-11	L2332685-1	L2332685-2	L2332685-4	L2332685-5
Physical Tests								
Conductivity	µS/cm	<2.0	<2.0	<2.0	**2.9**	**2.3**	<2.0	<2.0
Hardness (as $CaCO_3$)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
pH	pH	5.37	5.29	5.31	5.32	5.38	5.54	5.40
Total Suspended Solids	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Turbidity	NTU	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Anions and Nutrients								
Alkalinity, Total (as $CaCO_3$)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ammonia, Total (as N)	mg/L	**0.0139**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	**0.0694**
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrate (as N)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	**0.104**	<0.0050
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Orthophosphate-Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010				
Phosphorus (P)-Total	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulphate (SO_4)	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Organic Carbon								
Dissolved Organic Carbon	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Organic Carbon	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Total Metals								
Aluminum (Al)-Total	mg/L	<0.0030	<0.0030	<0.0030	**0.0105**	**0.0069**	<0.0030	<0.0030
Antimony (Sb)-Total	mg/L	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030
Arsenic (As)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Barium (Ba)-Total	mg/L	<0.00010	<0.00010	<0.00010	**0.00014**	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Total	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cesium (Cs)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)-Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050

Annex A.4-3: Blank Data for Water Quality Sampling, Hope Bay Project, 2019

Blank Type:		Equipment Blank	Travel Blank	Field Blank	Equipment Blank	Equipment Blank	Travel Blank	Field Blank
Date Sampled:		13-Apr-2019	13-Apr-2019	13-Apr-2019	15-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019
ALS Sample ID:	Units	L2258739-9	L2258739-10	L2258739-11	L2332685-1	L2332685-2	L2332685-4	L2332685-5
Total Metals *(cont'd)*								
Cobalt (Co)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)-Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Gallium (Ga)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)-Total	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium (Mg)-Total	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Mercury (Hg)-Total	µg/L	**0.002**	<0.00050	<0.00050	**0.00071**	<0.00050	<0.0050	<0.00050
Molybdenum (Mo)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Nickel (Ni)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Phosphorus (P)-Total	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)-Total	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Selenium (Se)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)-Total	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver (Ag)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)-Total	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thallium (Tl)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Thorium (Th)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Tin (Sn)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tungsten (W)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)-Total	mg/L	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Vanadium (V)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Yttrium (Y)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Zinc (Zn)-Total	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050

Annex A.4-3: Blank Data for Water Quality Sampling, Hope Bay Project, 2019

Blank Type:		Equipment Blank	Travel Blank	Field Blank	Equipment Blank	Equipment Blank	Travel Blank	Field Blank
Date Sampled:		13-Apr-2019	13-Apr-2019	13-Apr-2019	15-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019
ALS Sample ID:	Units	L2258739-9	L2258739-10	L2258739-11	L2332685-1	L2332685-2	L2332685-4	L2332685-5
Dissolved Metals (Field-filtered)								
Aluminum (Al)-Total	mg/L	<0.0010		<0.0010				
Antimony (Sb)-Total	mg/L	<0.000030		<0.000030				
Arsenic (As)-Total	mg/L	<0.000050		<0.000050				
Barium (Ba)-Total	mg/L	<0.00010		<0.00010				
Beryllium (Be)-Total	mg/L	<0.0000050		<0.0000050				
Bismuth (Bi)-Total	mg/L	<0.000050		<0.000050				
Boron (B)-Total	mg/L	<0.0050		<0.0050				
Cadmium (Cd)-Total	mg/L	<0.0000050		<0.0000050				
Calcium (Ca)-Total	mg/L	<0.050		<0.050				
Cesium (Cs)-Total	mg/L	<0.0000050		<0.0000050				
Chromium (Cr)-Total	mg/L	<0.00050		<0.00050				
Cobalt (Co)-Total	mg/L	<0.000050		<0.000050				
Copper (Cu)-Total	mg/L	<0.00020		<0.00020				
Gallium (Ga)-Total	mg/L	<0.000050		<0.000050				
Iron (Fe)-Total	mg/L	<0.030		<0.030				
Lead (Pb)-Total	mg/L	<0.000050		<0.000050				
Lithium (Li)-Total	mg/L	<0.00050		<0.00050				
Magnesium (Mg)-Total	mg/L	<0.10		<0.10				
Manganese (Mn)-Total	mg/L	<0.00020		<0.00020				
Molybdenum (Mo)-Total	mg/L	<0.000050		<0.000050				
Nickel (Ni)-Total	mg/L	<0.00020		<0.00020				
Phosphorus (P)-Total	mg/L	<0.30		<0.30				
Potassium (K)-Total	mg/L	<2.0		<2.0				
Rhenium (Re)-Total	mg/L	<0.0000050		<0.0000050				
Rubidium (Rb)-Total	mg/L	<0.000020		<0.000020				
Selenium (Se)-Total	mg/L	<0.00020		<0.00020				
Silicon (Si)-Total	mg/L	<0.050		<0.050				
Silver (Ag)-Total	mg/L	<0.0000050		<0.0000050				
Sodium (Na)-Total	mg/L	<2.0		<2.0				
Strontium (Sr)-Total	mg/L	<0.00010		<0.00010				
Tellurium (Te)-Total	mg/L	<0.000050		<0.000050				

Annex A.4-3: Blank Data for Water Quality Sampling, Hope Bay Project, 2019

Blank Type:		Equipment Blank	Travel Blank	Field Blank	Equipment Blank	Equipment Blank	Travel Blank	Field Blank
Date Sampled:		13-Apr-2019	13-Apr-2019	13-Apr-2019	15-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019
ALS Sample ID:	Units	L2258739-9	L2258739-10	L2258739-11	L2332685-1	L2332685-2	L2332685-4	L2332685-5
Dissolved Metals (Field-filtered; ***cont'd*** **)**								
Thallium (Tl)-Total	mg/L	<0.0000050		<0.0000050				
Thorium (Th)-Total	mg/L	<0.0000050		<0.0000050				
Tin (Sn)-Total	mg/L	<0.00020		<0.00020				
Titanium (Ti)-Total	mg/L	<0.00020		<0.00020				
Tungsten (W)-Total	mg/L	<0.000010		<0.000010				
Uranium (U)-Total	mg/L	<0.0000020		<0.0000020				
Vanadium (V)-Total	mg/L	<0.000050		<0.000050				
Yttrium (Y)-Total	mg/L	<0.0000050		<0.0000050				
Zinc (Zn)-Total	mg/L	<0.0010		<0.0010	<0.0010	<0.0010		<0.0010
Zirconium (Zr)-Total	mg/L	<0.000050		<0.000050				

Notes:

Bold and highlighted values represent concentrations that are higher than analytical detection limits (pH was excluded from this screening).

"-" indicates paramerter not analyzed

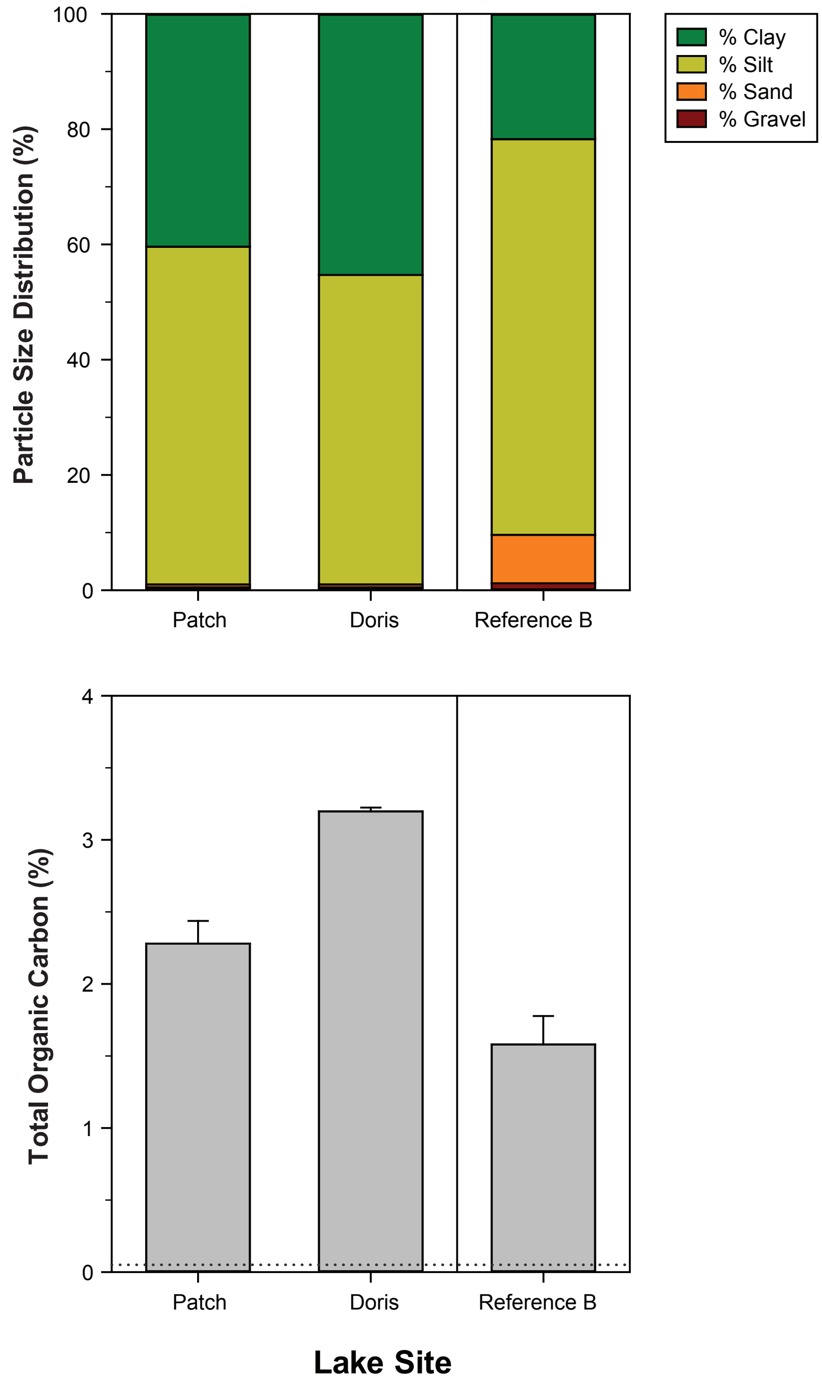
Annex A.4-4: Laboratory QA/QC Results, Hope Bay Project, 2019

Sampling Month	ALS Work Order Number	QC Lot Did Not Meet ALS Hold Time Recommendations	Method Blank Exceeded ALS Data Quality Objective
April	L2258739	pH, TSS, turbidity, nitrate-N, nitrite-N, orthophosphate-P	
August	L2332685	pH, turbidity, nitrate-N, nitrite-N	Total lead

A.5 Sediment Quality

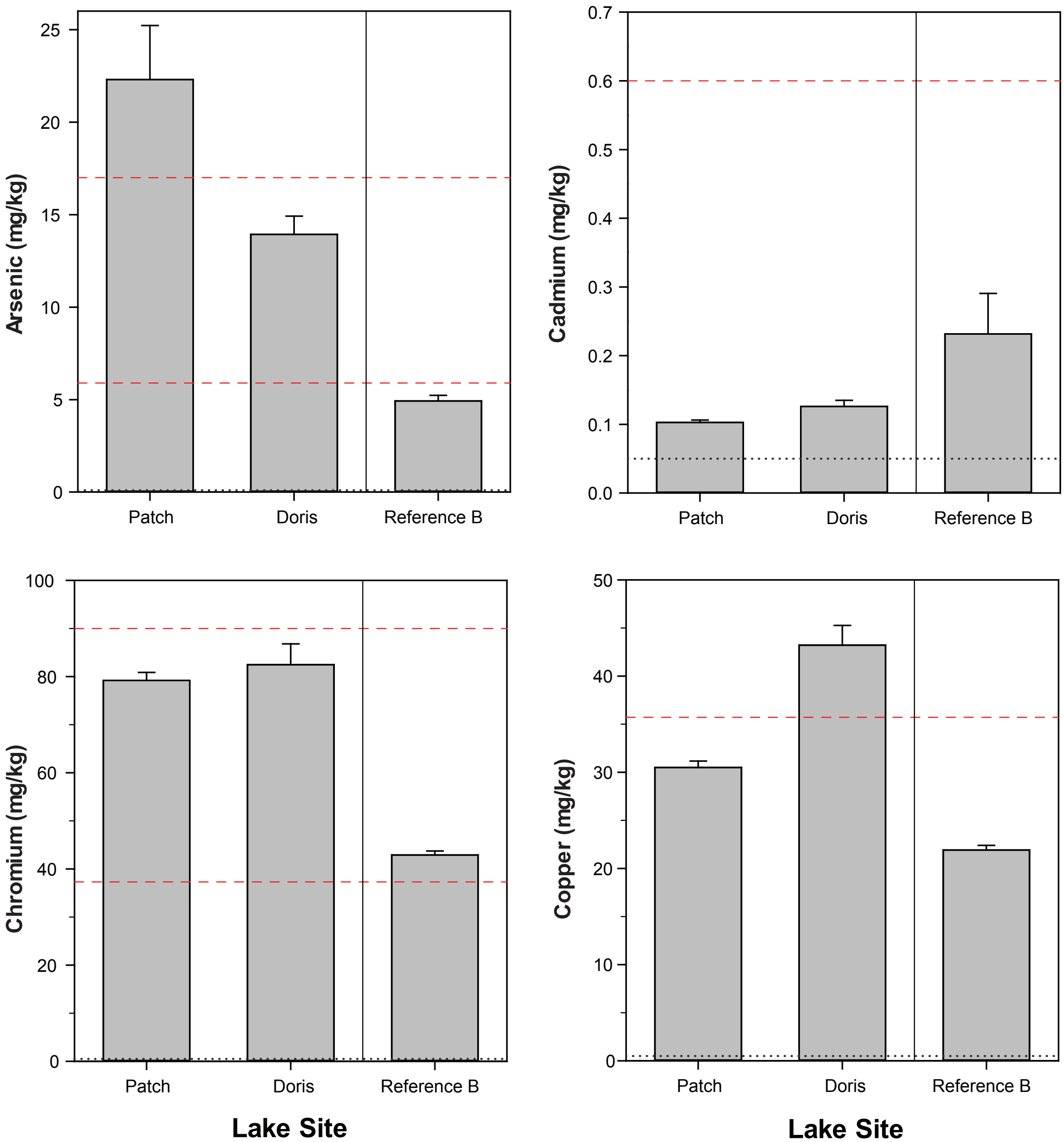
The sediment quality data collected in August 2019 from the AEMP sites are presented here. Only the variables that were subjected to an evaluation of effects (see main body of report) are shown graphically. All sediment quality variables were screened against CCME sediment quality guidelines for the protection of aquatic life (CCME 2019a). CCME guidelines for sediments include interim sediment quality guidelines (ISQGs) and probable effects levels (PELs). The more conservative ISQGs are levels below which adverse biological effects are rarely observed. The higher PELs correspond to concentrations above which negative effects would be expected. CCME guidelines are included in all graphs and annexes.

Figures A.5-1 to A.5-3 show evaluated sediment quality variable concentrations in the AEMP lakes. Annex A.5-1 presents the full lake sediment quality dataset.



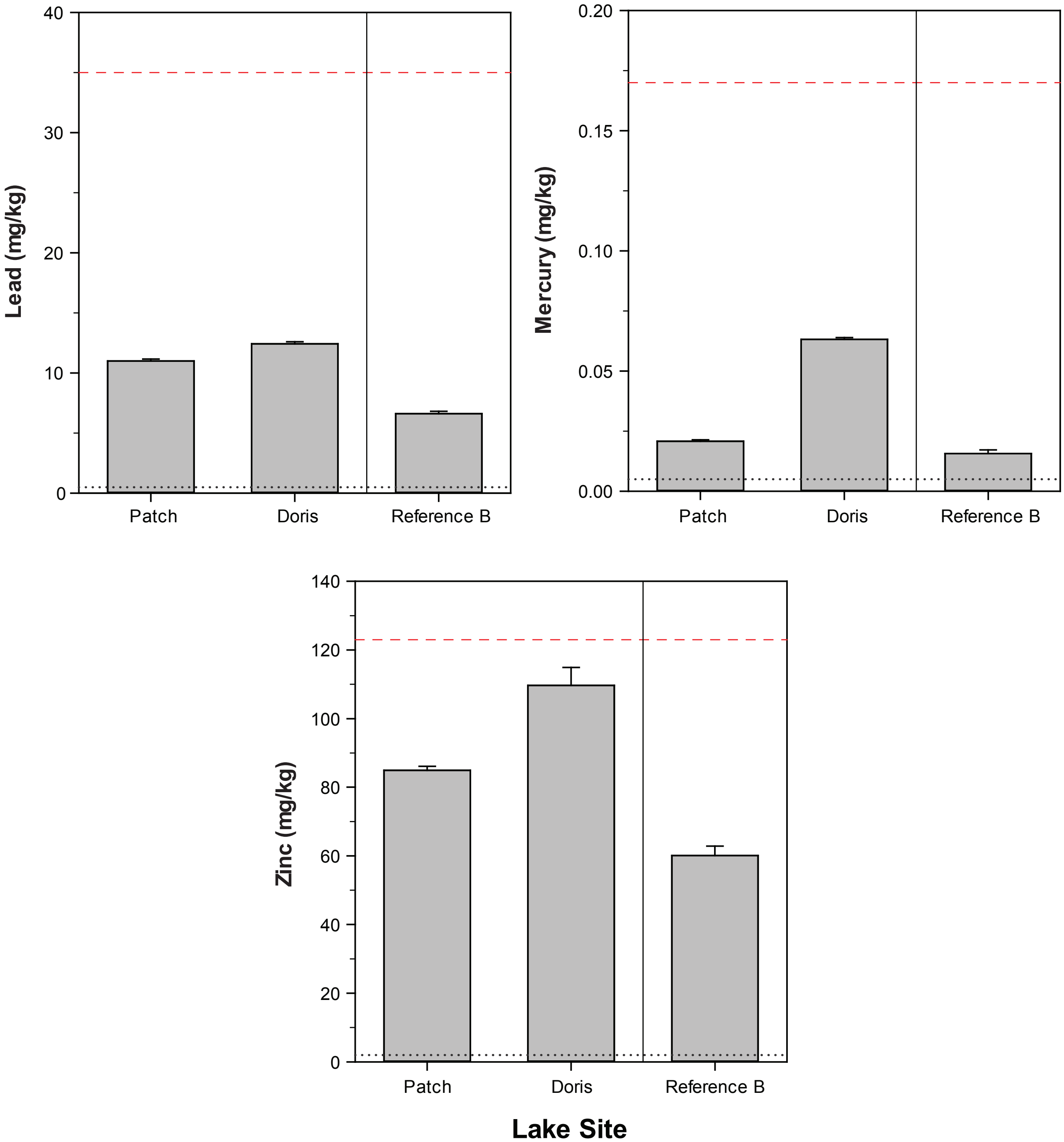
Notes: Error bars represent the standard error of the mean of replicates.
Stacked bars represent the mean of replicate samples.
Dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.

Figure A.5-1: Particle Size Distribution and Total Organic Carbon Concentration in Lake Sediments, Hope Bay Project, August 2019



Notes: Error bars represent the standard error of the mean of replicates.
Dotted lines represent analytical detection limits.
Dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for arsenic (5.9 mg/kg), cadmium (0.6 mg/kg), chromium (37.3 mg/kg), and copper (35.7 mg/kg) and the probable effects levels (PELs) for arsenic (17 mg/kg) and chromium (90 mg/kg); the PELs for cadmium (3.5 mg/kg) and copper (197 mg/kg) are not shown.

Figure A.5-2: Arsenic, Cadmium, Chromium, and Copper Concentrations in Lake Sediments, Hope Bay Project, August 2019



Notes: Error bars represent the standard error of the mean of replicates.
Dotted lines represent analytical detection limits.
Dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for lead (35 mg/kg), mercury (0.170 mg/kg), and zinc (123 mg/kg); probable effects levels (PELs) for lead (91.3 mg/kg), mercury (0.486 mg/kg), and zinc (315 mg/kg) are not shown.

Figure A.5-3: Lead, Mercury, and Zinc Concentrations in Lake Sediments, Hope Bay Project, August 2019

Annex A.5-1: Sediment Quality Data, Hope Bay Project, 2019

Site ID:	Unit	CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Doris Lake North			Patch Lake			Reference Lake B		
Date Sampled:					16-Aug-2019	16-Aug-2019	16-Aug-2019	18-Aug-2019	18-Aug-2019	18-Aug-2019	17-Aug-2019	17-Aug-2019	17-Aug-2019
Replicate:					1	2	3	1	2	3	1	2	3
Depth Sampled (m):					13.9	13.9	13.8	8.1	8.4	8.3	10.3	10.3	10.5
ALS Sample ID:		ISQG[b]	PEL[c]		L2332752-1	L2332752-2	L2332752-3	L2332752-4	L2332752-5	L2332752-6	L2332752-7	L2332752-8	L2332752-9
Physical Tests													
Moisture	%			0.25	77.4	77.2	80.6	78.8	81.7	78.6	68.7	66.1	73.6
pH (1:2 soil:water)	pH			0.10	5.55	5.78	5.71	6.26	5.85	5.87	5.76	5.31	5.44
Particle Size													
% Gravel (>2mm)	%			1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.6	<1.0
% Sand (2.0mm - 0.063mm)	%			1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	10.6	7.2	7.3
% Silt (0.063mm - 4um)	%			1.0	52.8	53.6	54.6	56.6	56.8	62.5	68.1	67.3	70.6
% Clay (<4um)	%			1.0	47.0	46.0	45.0	42.8	42.7	37.1	21.1	22.9	21.9
Texture	-			-	Silt Clay loam / Silty clay	Silty clay loam	Silty clay loam	Silty clay loam	Silty clay loam	Silty clay loam	Silt loam	Silt loam	Silt loam
Anions and Nutrients													
Total Nitrogen by LECO	%			0.020	0.368	0.375	0.383	0.265	0.332	0.251	0.137	0.148	0.205
Organic / Inorganic Carbon													
Total Organic Carbon	%			0.050	3.16	3.18	3.25	2.21	2.58	2.05	1.34	1.43	1.97
Metals													
Aluminum (Al)	mg/kg			50	28000	27500	31500	25600	24900	27300	14700	16000	15800
Antimony (Sb)	mg/kg			0.10	0.10	<0.10	0.1	0.17	0.19	0.18	0.19	0.22	0.15
Arsenic (As)	mg/kg	5.9	17	0.10	12.1	14.2	15.5	27.6	21.8	17.5	4.83	5.50	4.46
Barium (Ba)	mg/kg			0.50	174	167	204	182	187	173	76.7	84.1	84.5
Beryllium (Be)	mg/kg			0.10	1.02	0.95	1.03	0.85	0.88	0.90	0.48	0.54	0.54
Bismuth (Bi)	mg/kg			0.20	0.28	0.26	0.27	0.24	0.25	0.25	<0.20	<0.20	<0.20
Boron (B)	mg/kg			5.0	21.5	19.6	22.5	24.0	27.5	25.2	12.5	13.8	13.3
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.137	0.108	0.133	0.098	0.110	0.100	0.231	0.334	0.130
Calcium (Ca)	mg/kg			50	6810	6360	7190	6590	6500	6750	3870	4160	3990
Chromium (Cr)	mg/kg	37.3	90	0.50	79.1	77.3	91.1	78.5	76.7	82.4	41.3	43.1	44.2
Cobalt (Co)	mg/kg			0.10	15.9	15.5	18.1	16.6	16.4	17.1	12.9	15.9	12.8
Copper (Cu)	mg/kg	35.7	197	0.50	41.3	41.1	47.3	29.4	30.4	31.7	21.0	22.0	22.7
Iron (Fe)	mg/kg			50	53100	55000	60600	53900	49100	47800	33500	30300	37800
Lead (Pb)	mg/kg	35	91.3	0.50	12.5	12.1	12.7	10.7	11.0	11.3	6.29	6.99	6.59
Lithium (Li)	mg/kg			2.0	50.3	48.8	52.6	50.5	51.6	52.8	23.3	26.1	24.3
Magnesium (Mg)	mg/kg			20	16800	16000	18400	16000	16000	16600	7720	8380	7960
Manganese (Mn)	mg/kg			1.0	777	895	988	2650	2130	1510	260	277	307
Mercury (Hg)	mg/kg	0.170	0.486	0.0050	0.0618	0.0644	0.0634	0.0196	0.0215	0.0214	0.0139	0.0143	0.0188
Molybdenum (Mo)	mg/kg			0.10	1.34	1.22	1.36	2.96	2.06	2.16	2.18	2.48	1.93
Nickel (Ni)	mg/kg			0.50	49.1	48.1	56.4	46.2	47.5	49.5	22.7	26.2	23.0
Phosphorus (P)	mg/kg			50	1390	1500	1700	1400	1240	1220	702	669	811
Potassium (K)	mg/kg			100	6940	6730	7600	7050	7270	7210	3490	3600	3490
Selenium (Se)	mg/kg			0.20	0.42	0.36	0.36	0.31	0.33	0.31	0.42	0.49	0.38
Silver (Ag)	mg/kg			0.10	0.25	0.24	0.26	0.26	0.27	0.33	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			50	1700	1540	1880	1420	1510	1530	474	553	517
Strontium (Sr)	mg/kg			0.50	47.7	47.3	52.6	49.7	50.3	49.2	27.9	31.2	30.3
Sulfur (S)-Total	mg/kg			500	1400	1300	1200	1200	1300	1100	1400	1900	1100
Thallium (Tl)	mg/kg			0.050	0.317	0.299	0.321	0.292	0.302	0.294	0.217	0.299	0.185
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1530	1440	1750	1530	1500	1610	906	960	915
Uranium (U)	mg/kg			0.050	2.69	2.56	2.69	2.08	2.14	2.18	2.18	2.42	2.34
Vanadium (V)	mg/kg			0.20	87.0	85.6	100.0	82.2	80.2	84.4	45.7	46.9	48.6
Zinc (Zn)	mg/kg	123	315	2.0	106	103	120	84.4	83.3	87.2	55.9	65.3	59.1

Notes:

Shaded cells indicate values that exceed CCME guidelines (light grey ISQG, dark grey PEL).

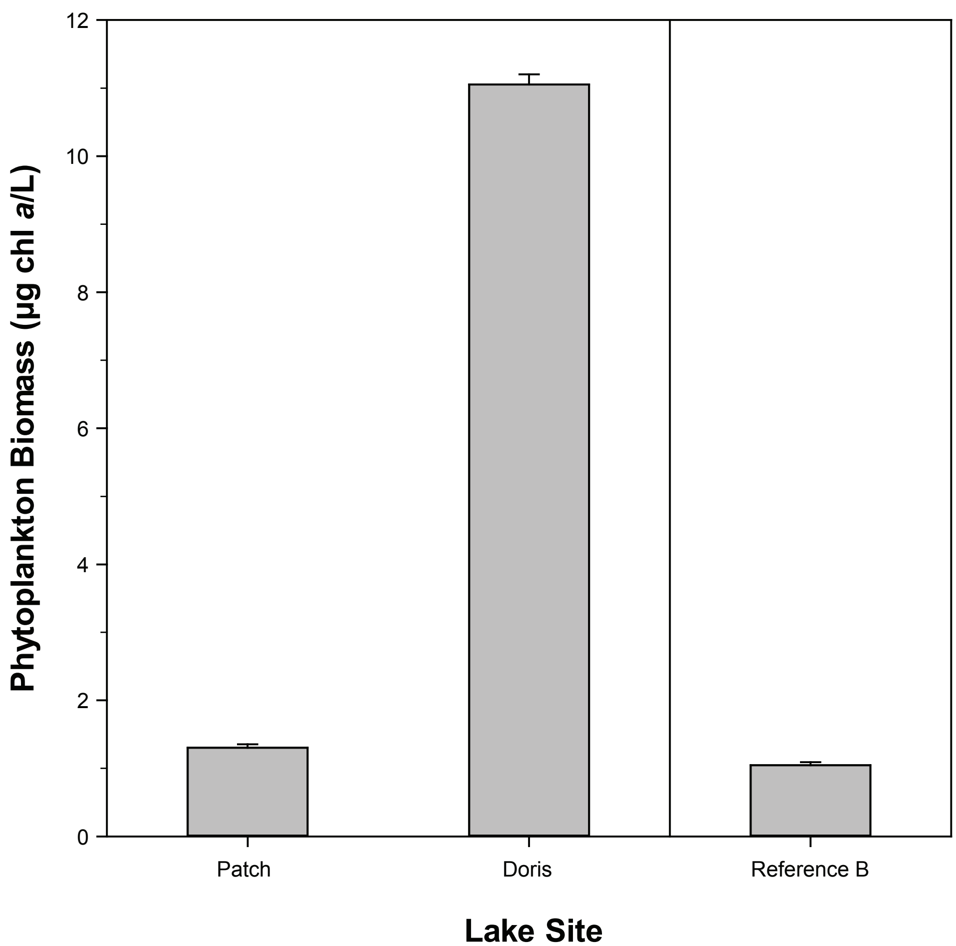
[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment (accessed 2019).*

[b] *ISQG = Interim Sediment Quality Guideline*

[c] *PEL = Probable Effects Level*

A.6 Phytoplankton Biomass

This section presents the phytoplankton biomass (chlorophyll *a*) data collected in August 2019 at the AEMP lake sites. Figure A.6-1 shows the average phytoplankton biomass measured in Patch Lake, Doris Lake, and Reference Lake B. Annex A.6-1 presents the full phytoplankton biomass dataset.



Notes: Error bars represent the standard error of the mean.
The analytical detection limit for chlorophyll a was 0.01 or 0.02 µg; all chlorophyll a concentrations were above analytical detection limits.

Figure A.6-1: Phytoplankton Biomass (as Chlorophyll a), Hope Bay Project, August 2019

Annex A.6-1: Phytoplankton Biomass Data, Hope Bay Project, 2019

Lake	Replicate #	Date Sampled	Depth Sampled (m)	ALS Sample ID	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
Doris Lake North	1	15-Aug-19	1	L2333357-1	10.9	11.1	0.151
	2	15-Aug-19	1	L2333357-2	11.4		
	3	15-Aug-19	1	L2333357-3	11.0		
Patch Lake	1	18-Aug-19	1	L2333357-4	1.4	1.3	0.051
	2	18-Aug-19	1	L2333357-5	1.3		
	3	18-Aug-19	1	L2333357-6	1.2		
Reference Lake B	1	18-Aug-19	1	L2333357-7	1.0	1.0	0.045
	2	18-Aug-19	1	L2333357-8	1.1		
	3	18-Aug-19	1	L2333357-9	1.1		

Note:

SE = standard error of the mean

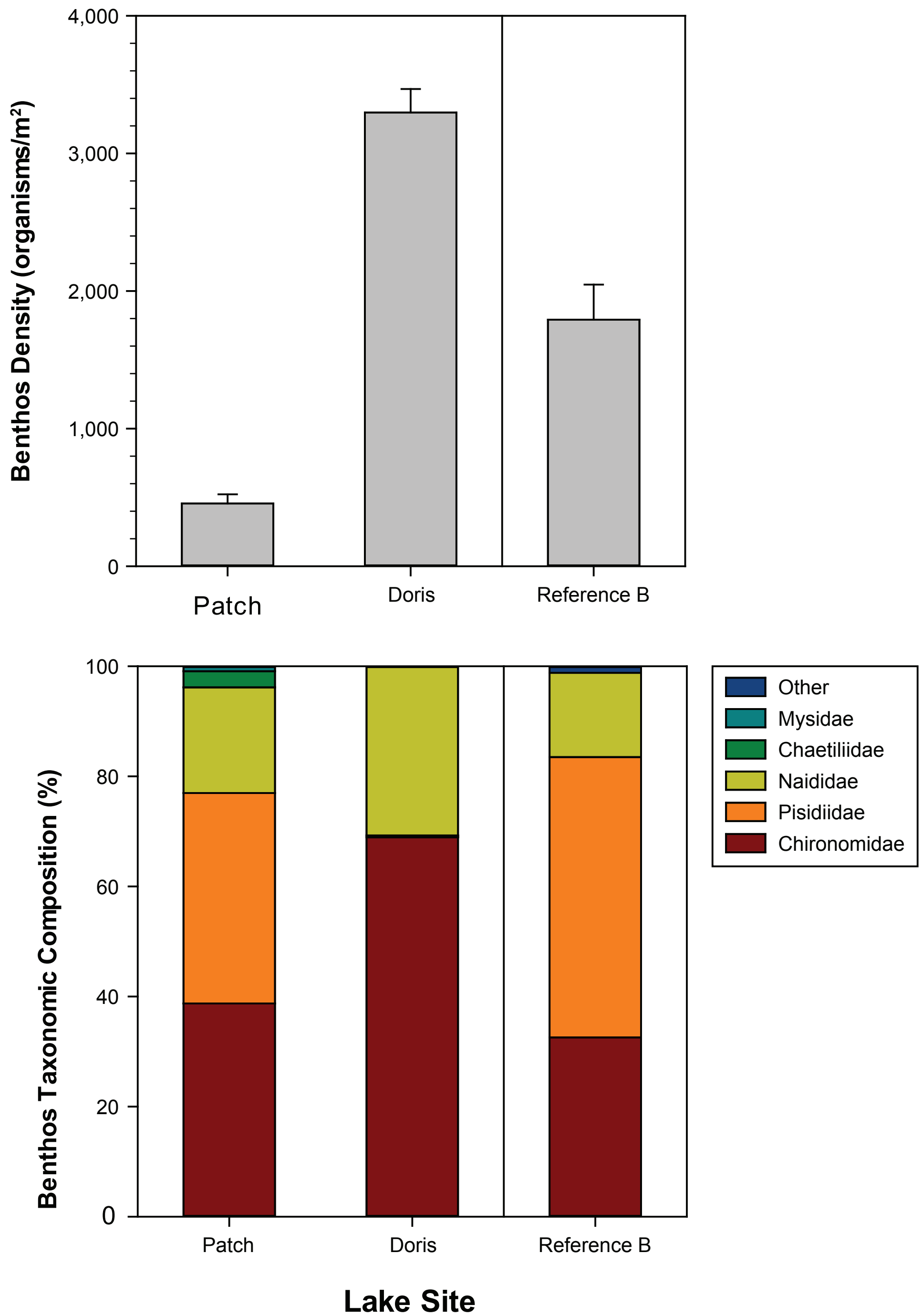
A.7 Benthic Invertebrates

The benthic invertebrate taxonomy data collected in August 2019 from the AEMP sites are presented in this section. Community descriptors including total benthic invertebrate density, family richness, Simpson's evenness index, and the Bray-Curtis similarity index were calculated from the taxonomic data, according to the methods described in Environment Canada (Environment Canada 2012). Details of these calculations are provided in Section A.1-8.

Figure A.7-1 presents the average density and taxonomic composition of the lake benthos communities. Figure A.7-2 presents the average family richness, Simpson's evenness index, and Bray-Curtis index. Annex A.7-1 provides the full lake benthos taxonomy dataset, and Annex A.7-2 presents a summary of the calculated community descriptors.

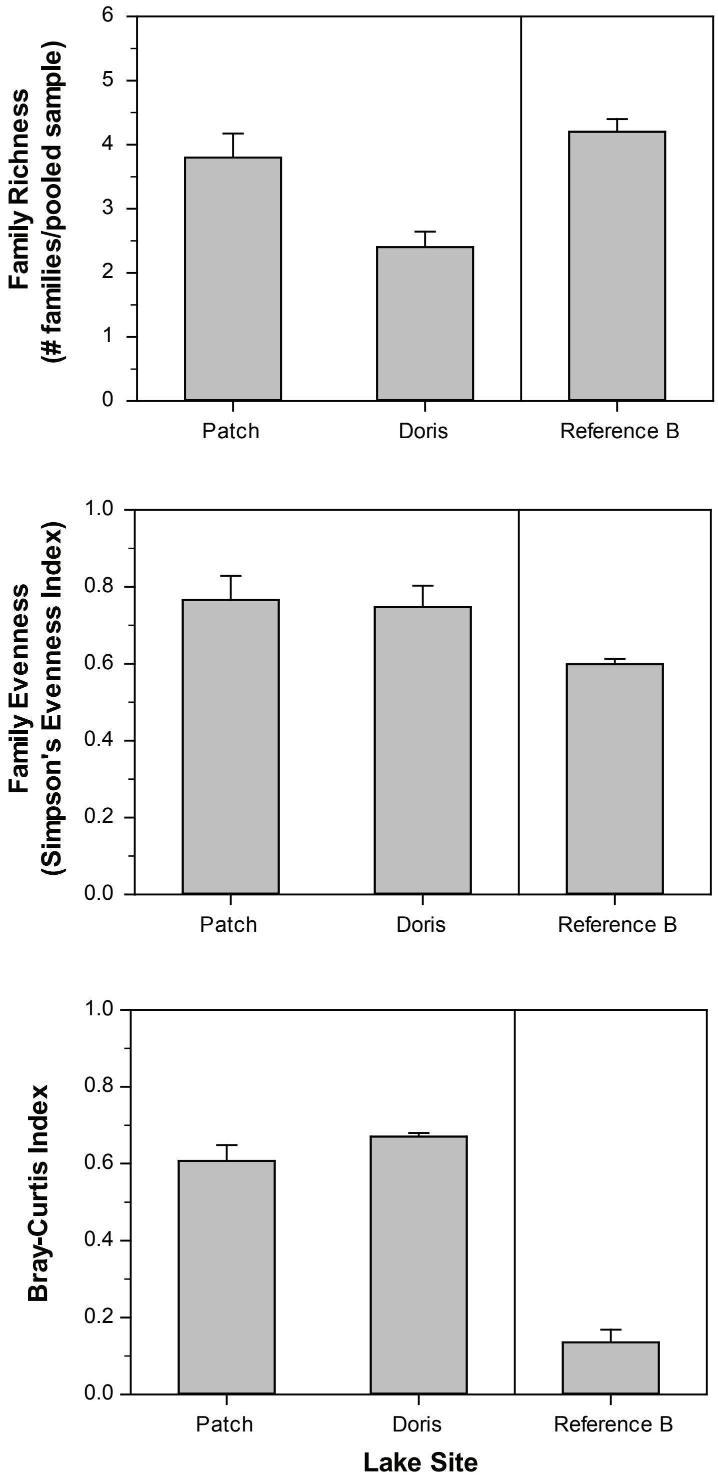
A.7.1 Quality Assurance/Quality Control Data

A re-sorting of randomly selected sample residues was conducted by the taxonomist on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. The 95% minimum sorting efficiency was attained. Results of this QA/QC procedure are provided in Annex A.7-3.



Notes: Error bars represent the standard error of the mean of replicates.
Stacked bars represent the mean of replicate samples.

Figure A.7-1: Lake Benthos Density and Taxonomic Composition, Hope Bay Project, August 2019



Notes: Error bars represent the standard error of the mean of replicates.

Figure A.7-2: Lake Benthos Richness, Evenness, and Bray-Curtis Index, Hope Bay Project, August 2019

Annex A.7-1: Benthic Invertebrate Taxonomy Data, Hope Bay Project, 2019

Major Group	Family	Subfamily	Tribe	Lake	Patch Lake					Doris Lake North					Reference Lake B				
				Sampling Date:	18-Aug-19					16-Aug-19					17-Aug-19				
				Sampling Depth:	8.4	8.1	8.3	8.0	8.4	13.8	13.8	13.9	13.9	13.9	10.3	10.5	10.5	10.5	10.5
				Genus	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5
Nematoda*	-	-	-	-	0	0	0	0	0	0	0	0	0	0	8	26	31	14	15
Oligochaeta	Lumbriculidae	-	-	-	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1
	Naididae	Tubificinae	-	-	7	6	3	2	10	86	81	82	43	53	19	23	47	5	9
Pelecypoda	Pisidiidae	-	-	(i/d)	1	1	1	2	0	1	0	2	0	0	23	22	19	19	4
		-	-	Sphaerium	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
		-	-	Pisidium	11	6	8	14	14	1	0	0	0	0	46	52	42	33	35
Hydracarina	Lebertiidae	-	-	*Lebertia*	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	Oxidae	-	-	*Oxus*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Copepoda – Cyclopoida*	-	-	-	-	1	3	3	3	0	0	0	0	0	0	0	0	0	1	0
Ostracoda*	-	-	-	-	0	6	11	7	1	0	1	1	0	0	4	5	1	3	1
Cladocera*	Bosminidae	-	-	Bosmina	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Daphnidae	-	-	Daphnia	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Malacostraca	Mysidae	-	-	*Mysis relicta*	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Isopoda	Chaetiliidae	-	-	*Saduria entomon*	2	0	1	0	2	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae	-	-	*(pupa)*	0	0	0	0	0	3	7	6	4	9	0	4	4	2	1
		Tanypodinae	Pentaneurini	Thienemannimyia group	0	0	4	1	1	0	0	0	0	0	0	0	0	1	0
			Procladiini	Procladius	2	0	7	8	11	0	0	0	1	1	3	3	1	4	0
		Diamesinae	Protanypini	*Protanypus*	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0
		Prodiamesinae	-	*Monodiamesa*	2	0	2	1	2	0	0	0	0	0	0	0	0	0	0
		Orthocladiinae	Orthocladini	*Cricotopus / Orthocladius*	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
				Heterotrissocladius	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Psectrocladius	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
				Zalutschia	0	0	0	0	0	0	0	0	0	0	9	3	10	6	8
		Chironominae	Chironomini	*Chironomus*	0	0	0	0	0	173	143	122	153	142	0	0	0	0	0
				Stictochironomus	1	0	0	2	2	0	0	0	0	0	0	0	0	0	0
			Tanytarsini	*Corynocera*	0	0	0	0	0	0	0	0	0	0	0	1	3	2	1
				Paratanytarsus	0	0	0	0	0	0	0	0	0	0	4	7	17	5	2
				Tanytarsus	2	1	2	3	1	0	0	0	0	0	24	18	25	14	11
Total #					**30**	**27**	**42**	**43**	**47**	**264**	**233**	**213**	**201**	**205**	**144**	**166**	**205**	**112**	**89**
Total # minus excluded groups					**29**	**18**	**28**	**33**	**46**	**264**	**231**	**212**	**201**	**205**	**131**	**135**	**172**	**94**	**73**

Notes:
Data represent raw counts of the number of organisms in each replicate.
i/d = immature or damaged
** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses:*
- *Copepods and cladocerans were excluded because they are generally planktonic.*
- *Nematodes and ostracods were excluded because they are meiofauna and are not adequately sampled using a 500 µm sieve bucket.*

Annex A.7-2: Summary of Calculated Benthic Invertebrate Community Descriptors, Hope Bay Project, 2019

Lake	Replicate	Total Density (#/m^2)	Family Richness	Simpson's Evenness Index	Bray-Curtis Index
Patch Lake	1	430	4	0.806	0.630
	2	267	3	0.982	0.733
	3	415	4	0.620	0.628
	4	489	3	0.748	0.560
	5	681	5	0.674	0.485
	Mean	456	3.8	0.766	0.607
	SE	67	0.37	0.063	0.041
Doris Lake North	1	3,911	3	0.605	0.701
	2	3,422	2	0.918	0.684
	3	3,141	3	0.648	0.653
	4	2,978	2	0.753	0.654
	5	3,037	2	0.811	0.658
	Mean	3,298	2.4	0.747	0.670
	SE	171	0.24	0.056	0.009
Reference Lake B	1	1,941	4	0.618	0.065
	2	2,000	4	0.624	0.071
	3	2,548	5	0.605	0.190
	4	1,393	4	0.544	0.118
	5	1,081	4	0.603	0.232
	Mean	1,793	4.2	0.599	0.135
	SE	255	0.20	0.014	0.033

Note: SE = Standard error of the mean

Annex A.7-3: Results of Benthic Invertebrate QA/QC Sorting Efficiencies, Hope Bay Project, 2019

Sample ID	Number from First Sort	1st QAQC Re-sort # Found	Initial Sort Efficiency (%)	Re-sort Required?	2nd QAQC Re-sort # Found	Final Efficiency (%)
Patch Lake, Rep#3	42	0	100	No	-	100
Doris Lake North, Rep#2	233	4	98.3	No	-	98.3

Notes:
If the efficiency is 95% or better nothing further is done and the QA/QC invertebrates are not added to the data.
If the efficiency is less than 95%, the QA/QC invertebrates are added to the sample, it is re-sorted, and a second 20% QA/QC is performed.
*% Sorting Efficiency = [1- {# in QA/QC re-sort/(# sorted originally + # in QA/QC re-sort)}]*100*

A.8 References

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APPENDIX B 2019 HYDROLOGY COMPLIANCE MONITORING SUMMARY

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Memo

To	Oliver Curran, Vice President, Environmental Affairs, TMAC Resources Inc. (TMAC); Shelly Potter, Manager, Environment (TMAC)
From	Cameron Evans and Eri Ratnawati
Cc	Nicole Bishop
Date	March 20, 2020
Reference	0510704-0003
Subject	2019 Doris Hydrology Compliance Monitoring Summary

1. INTRODUCTION

This memorandum provides a summary of the hydrology compliance monitoring program performed for the Hope Bay Project (the Project) in 2019. Compliance requirements for hydrometric monitoring, listed below, are set out in the Project Certificate (NIRB No. 003, amended September 23, 2016), the Type A and B Water Licence (NWB Licence No. 2AM-DOH1335 Type A, amended December 7, 2018, and NWB Licence No. 2BE-HOP1222 Type B, renewed June 31, 2012), and the Hope Bay Project Aquatic Effects Monitoring Plan (AEMP).

The Fisheries Authorization NU-02-0117.3 does not explicitly state a monitoring requirement of Roberts Lake outflow. However, monitoring outflows of this lake is necessary, as it is considered a critical component for evaluating the success of the Roberts Lake Outflow Fish Habitat Compensation Monitoring Program. Monitoring of Roberts Lake also provides a control with which to compare the AEMP monitored lakes.

The Type A Water Licence (No. 2AM DOH1335) sets out the following requirements applying to aquatic effects monitoring:

- Part I. Item 3: The Licensee shall undertake the Monitoring Program provided in Tables 1, 2, and 3 of Schedule I. Table 3 outlines the requirement for monitoring Doris Outflow (TL-2) during Operations upon commencement of mining in or beneath the Doris Lake Talik and monitoring Doris Lake (ST-12) water levels during Operations and Closure.

The Type B Water Licence (No. 2BE-HOP1222) sets out the following requirements:

- Part J. Item 9: The Licensee shall monitor water levels in Windy Lake during open water, in order to verify that additional water withdrawal for dust suppression activities does not result in drawdown beyond naturally occurring levels.

The New Project Certificate (NIRB No. 009) sets out the following requirements:

- New Term and Condition 10: the Proponent shall:
    a. monitor the effects of project activities and infrastructure on surface water quality conditions;

b. ensure the monitoring data is sufficient to compare the impact predictions made for the Project with actual monitoring results;

c. ensure that the sampling locations and frequency of monitoring is consistent with and reflects the requirements of the Aquatic Effects Monitoring Plan, and Water Management Plan; and

d. on an annual basis, compare monitoring results with the impact assessment predictions in the FEIS and will identify any significant discrepancies between impact predictions and monitoring results

The Project Aquatic Effects Monitoring Plan prescribes monitoring requirements based on project development phases. In 2019, the Doris development was in the operations phase and Madrid North was in the construction and operations phase, which triggered water level monitoring at Glenn and Imniagut lakes, as well as water level and outflow monitoring at Doris, Little Roberts, Ogama, Patch, PO, and Windy lakes. Tables 3.1-1 and 3.2-1 of the AEMP (TMAC 2018) outline these requirements.

Construction of Madrid South has not yet begun, which would trigger water level monitoring at Wolverine Lake. However, two years of monitoring at Wolverine Lake was planned to start in 2019 to provide concurrent baseline data with the lakes triggered by Madrid North (prior to the start of predicted effects to surface water quantity).

The following section consists of 2019 monitoring data and results. These results are based on the comparison of 2019 monitoring data with past monitoring data and the predicted project effects from the Madrid-Boston Project Final Environmental Impact Statement (FEIS; TMAC 2017).

2. MONITORING STATIONS

The 2019 compliance monitoring program consisted of 11 hydrometric monitoring stations, as presented in Table 2-1, Table 2-2 and Figure 2-1. Water level surveys and manual discharge measurements were conducted at these stations throughout the open water season. Hydrometric stations monitored either Lake Level, Lake Outflow (discharge) or both. Most hydrometric stations are operated seasonally (during the open water season); however, Doris Lake-2 and Roberts Hydro-2 are operated year round.

Seasonal stations consist of an INW PT2X vented pressure transducer placed on the lake or streambed in a weighted assembly, recording water level readings every 15 minutes. The Doris Lake-2 station consists of two Solinst Leveloggers, unvented pressure transducers, installed at depths of approximately 7 metres to monitor lake level year round. The Roberts Hydro-2 station consists of one Levelogger installed at approximately 2 m depth. The Leveloggers are coupled with a Solinst Barologger, located at Doris Camp, to compensate for changes in atmospheric pressure.

Water level surveys were performed using an engineer’s level and stadia rod using a minimum of three local benchmarks at each station. All benchmarks are tied to geodetic elevation. Manual discharge measurements were performed using the velocity area method with an OTT MF Pro electromagnetic current meter. The Doris North Project 2013 Hydrology Compliance Monitoring Report (ERM 2014) describes the details of the standard methods used for installation of hydrometric stations, development of stage-discharge rating equations, and daily flow hydrographs for the Project.

Table 2-1: Station Types

Station	Station Type	Monitoring Period	New or Continued
Windy Outflow	Discharge and Water Level	Seasonal	New[1]
Glenn Lake	Lake Level Only	Seasonal	New
Wolverine Lake	Lake Level Only	Seasonal	New
Imniagut Lake	Lake Level Only	Seasonal	New
Patch Outflow	Discharge and Water Level	Seasonal	Continued
PO Outflow	Discharge and Water Level	Seasonal	Continued
Ogama Outflow	Discharge and Water Level	Seasonal	Continued
Doris Lake-2	Lake Level Only	Year Round	Continued
Doris Creek TL-2	Discharge Only	Seasonal	Continued
Roberts Hydro-2	Discharge and Water Level	Year Round	Continued
Little Roberts Outflow	Discharge and Water Level	Seasonal	New

[1]*Replaced the Windy Lake location as lake discharge monitoring is recently required by the AEMP*

Table 2-2: 2019 Station Locations

Station	Easting[1]	Northing[1]	Watershed Area (km^2)	Lake Coverage (%)
Windy Outflow	431404	7554948	13.73	41
Glenn Lake	430410	7562001	20.59	13
Wolverine Lake	434802	7545443	2.50	40
Imniagut Lake	433403	7551421	1.31	12
Patch Outflow	436248	7548973	32.16	23
PO Outflow	436749	7550055	35.30	23
Ogama Outflow	435595	7555262	74.93	18
Doris Lake-2	433547	7558601	90.29	19
Doris Creek TL-2	434059	7559504	90.29	19
Roberts Hydro-2	435231	7562674	97.83	18
Little Roberts Outflow	434548	7562652	194.15	18

[1] *UTM Zone 13W*

3. 2019 ANALYSIS AND RESULTS

Tables 3-1 to 3-8 present the 2019 compliance monitoring results that include stage-discharge measurements, observed lake levels, rating equations, annual runoff, peak and low flows, and monthly runoff. Appendix A and Appendix B present the lake level graphs and the daily flow hydrographs, respectively. Appendix C and Appendix D present the mean daily lake level and the mean daily discharges, respectively.

ERM staff performed fieldwork over two site visits, one from late-June to early July and one in September. TMAC Environmental Staff performed an under-ice water level measurement in April and additional field measurements from July to September.

TMAC conducted under-ice water surface measurements in April at the same time as the under-ice aquatic sampling. Table 3-1 presents the locations and surveyed water level for each monitored lake. These surveyed elevations were taken using an RTK system and have a lower accuracy than the water level surveys made during the open water season. The lower accuracy lead to some discrepancies in the results, such as PO Lake having a higher reported water level than Patch Lake despite being downstream, and Little Roberts Outflow having a reported water level higher than all open water season water levels.

Table 3-1: Summary of 2019 Under-Ice Lake Level Surveys

Station	Date	Water Surface Elevation (masl)	Northing[1]	Easting[1]
Windy Outflow	4/15/2019	18.318	7553269	431651
Glenn Lake	4/6/2019	9.527	7560333	430189
Wolverine Lake	4/18/2019	32.351	7545883	434721
Imniagut Lake	4/15/2019	27.249	7551479	433562
Patch Outflow	4/15/2019	26.287	7550148	434809
PO Outflow	4/15/2019	26.307	7549391	436569
Ogama Outflow	4/15/2019	24.058	7553504	436150
Doris Lake-2	4/15/2019	21.760	7558527	433640
Little Roberts Outflow	4/15/2019	6.155	7562827	434658

[1] *UTM Zone 13W*

ERM and TMAC personnel conducted open water season water level and discharge measurements from June to September. Table 3-2 shows high water levels due to a very high freshet which prevented discharge measurements from being made at Doris Creek (TL-2) until June 30, and at Little Roberts Outflow until August 10. During the QA/QC process, some measurements were discarded and were not included in further analysis.

Table 3-2: Summary of 2019 Stage and Discharge Measurements

Station	Date	Stage (m)	Discharge (m^3/s)	Measurement Made By
Windy Outflow	6/24/2019	18.52	n/a[3]	ERM
	6/26/2019	18.518	0.638	ERM
	6/29/2019	18.497	0.601	ERM
	7/3/2019	18.482	0.539	ERM
	7/26/2019	18.395	0.208	TMAC
	8/11/2019	18.368	n/a[4]	TMAC
	8/24/2019	18.368	0.115	TMAC
	9/5/2019	18.319	n/a[3]	TMAC
	9/17/2019	18.302	0.081	ERM
	9/20/2019	18.298	0.069	ERM
Glenn Lake	6/24/2019	10.001	n/a[1]	ERM
	6/27/2019	9.971	n/a[1]	ERM
	6/29/2019	9.94	n/a[1]	ERM
	8/8/2019	9.695	n/a[1]	TMAC
	8/22/2019	9.664	n/a[1]	TMAC
	9/5/2019	9.653	n/a[1]	TMAC
	9/18/2019	9.605	n/a[1]	ERM
	9/22/2019	9.588	n/a[1]	ERM
Wolverine Lake	6/23/2019	32.537	n/a[1]	ERM
	6/28/2019	32.514	n/a[1]	ERM
	8/8/2019	32.425	n/a[1]	TMAC
	8/21/2019	32.433	n/a[1]	TMAC
	9/5/2019	32.44	n/a[1]	TMAC
	9/17/2019	32.435	n/a[1]	ERM
	9/20/2019	32.421	n/a[1]	ERM
Imniagut Lake	6/23/2019	27.435	n/a[1]	ERM
	6/26/2019	27.43	n/a[1]	ERM
	7/2/2019	27.4	n/a[1]	ERM
	8/8/2019	27.317	n/a[1]	TMAC
	8/24/2019	27.34	n/a[1]	TMAC
	9/5/2019	27.285	n/a[1]	TMAC
	9/17/2019	27.272	n/a[1]	ERM
	9/20/2019	27.27	n/a[1]	ERM

Station	Date	Stage (m)	Discharge (m^3/s)	Measurement Made By
Patch Outflow	6/22/2019	26.781	2.122	ERM
	6/28/2019	26.689	1.673	ERM
	7/26/2019	26.41	0.381	TMAC
	8/9/2019	26.374	0.257	TMAC
	8/21/2019	26.362	0.222	TMAC
	9/6/2019	26.347	0.237	TMAC
	9/19/2019	26.308	0.225	ERM
	9/20/2019	26.315	0.227	ERM
PO Outflow	6/28/2019	26.569	1.843	ERM
	7/2/2019	26.519	n/a[4]	ERM
	7/25/2019	26.337	0.227	TMAC
	8/9/2019	26.286	0.231	TMAC
	8/21/2019	26.291	0.224	TMAC
	9/6/2019	26.269	0.215	TMAC
	9/19/2019	26.219	0.315	ERM
Ogama Outflow	6/22/2019	24.798	n/a[3]	ERM
	6/26/2019	24.71	4.292	ERM
	6/29/2019	24.63	3.303	ERM
	7/25/2019	24.316	0.832	TMAC
	8/21/2019	24.248	0.574	TMAC
	9/6/2019	24.259	0.572	TMAC
	9/18/2019	24.219	0.518	ERM
	9/21/2019	24.225	0.549	ERM
Doris Lake-2	6/27/2019	22.5	n/a[1]	ERM
	6/30/2019	22.41	n/a[1]	ERM
	7/2/2019	22.37	n/a[1]	ERM
	7/11/2019	22.24	n/a[1]	TMAC
	7/27/2019	22.03	n/a[1]	TMAC
	8/8/2019	21.93	n/a[1]	TMAC
	8/20/2019	21.9	n/a[1]	TMAC
	9/8/2019	21.89	n/a[1]	TMAC
	9/19/2019	21.86	n/a[1]	ERM
	9/22/2019	21.85	n/a[1]	ERM

Station	Date	Stage (m)	Discharge (m^3/s)	Measurement Made By
Doris Creek (TL-2)	6/21/2019	22.493	n/a[2]	ERM
	6/27/2019	22.397	n/a[2]	ERM
	6/30/2019	22.306	4.581	ERM
	7/2/2019	22.262	4.275	ERM
	7/13/2019	22.126	2.689	TMAC
	7/25/2019	21.984	1.284	TMAC
	8/12/2019	21.819	0.691	TMAC
	8/20/2019	21.822	0.69	TMAC
	9/7/2019	21.793	0.661	TMAC
	9/18/2019	21.773	0.591	ERM
	9/22/2019	21.77	0.543	ERM
Roberts Hydro-2	6/27/2019	6.872	6.268	ERM
	7/1/2019	6.755	4.084	ERM
	7/14/2019	6.633	2.369	TMAC
	7/27/2019	6.472	1.002	TMAC
	8/10/2019	6.409	0.6	TMAC
	8/22/2019	6.414	0.659	TMAC
	9/7/2019	6.405	0.54	TMAC
	9/18/2019	6.372	0.485	ERM
	9/21/2019	6.369	0.477	ERM
Little Roberts Outflow	6/24/2019	5.607	n/a[2]	ERM
	6/29/2019	5.441	n/a[2]	ERM
	8/10/2019	4.771	1.416	TMAC
	8/22/2019	4.752	1.414	TMAC
	9/7/2019	4.739	1.33	TMAC
	9/18/2019	4.693	1.156	ERM
	9/22/2019	4.681	1.106	ERM

[1] *Lake Level only at this station*

[2] *Water too deep to perform discharge measurement*

[3] *Not measured due to time constraints*

[4] *Measurement discarded due to poor data quality*

Seasonal stations were re-installed in late-June and were demobilized in late-September. Discharge at TL-2 was modelled using linear regression with the Doris Lake-2 year round monitoring station for open water periods that were not recorded by the seasonal station. Discharge during the open water season that was not monitored at the other stations was modelled using a linear regression with TL-2. For the periods where ice was known or suspected to have impacted flow, discharge was estimated using exponential growth/decay curves.

For the open water period outside of the observed data, lake levels were back calculated using the station rating curves for the periods when discharge had been modeled. For stations with no discharge monitoring, lake level was modeled using a linear regression with Doris Lake-2. For the periods where ice was known or suspected to have impacted flow, lake level was estimated using exponential growth/decay curves, stabilizing at the level surveyed during the April water level survey. In cases where the winter water level survey appeared significantly too high or low in relation to the open water surveys, lake level was assumed to stabilize on the last day of modeled data.

Year round stations operated from January 1 to December 31, however the last data download at Roberts Hydro-2 was performed on September 21. Discharge and lake level data were modelled and estimated in the same way as the seasonal stations.

Discharge at Little Roberts Outflow was modelled by combining the discharge from TL-2 and Roberts Hydro-2, and then scaling up by watershed size. Discharge was modelled during the high flow period as the rating curve for Little Roberts Outflow was not established for high flow and it was not possible to perform a discharge measurement until August 10.

Table 3-3 and Table 3-4 present the estimated discharge and the lake level, respectively. Flow was predicted to have started on June 13, based on site photos taken every 3 to 5 days, and ended on November 8 based on the Doris Lake water level no longer dropping. The lake outflows are estimated to have been free of snow or ice starting June 17, based on site photos, and have ice formation impact outflow on October 13 based on ice cover forming across Doris Lake.

Table 3-3: 2019 Observed, Modelled and Estimated Discharge

Station	Observed	Modelled	Estimated
Windy Outflow	Jun 24 – Sep 20	Jun 17 – Jun 23 Sept 21 – Oct 13	Jun 13 – 16 Oct 14 – Nov 8
Patch Outflow	Jun 22 – Sep 20	Jun 17 – Jun 21 Sept 21 – Oct 13	Jun 13 – 16 Oct 14 – Nov 8
PO Outflow	Jun 22 – Sep 21	Jun 17 – Jun 21 Sept 22 – Oct 13	Jun 13 – 16 Oct 14 – Nov 8
Ogama Outflow	Jun 23 – Sep 21	Jun 17 – Jun 22 Sept 22 – Oct 13	Jun 13 – 16 Oct 14 – Nov 8
Doris Creek TL-2	Jun 21 – Sep 22	Jun 17 – 20 Sep 23 – Oct 13	Jun 13 – 16 Oct 14 – Nov 8
Roberts Hydro-2	Jun 17 – Sep 21	Sept 22 – Oct 13	Oct 14 – Nov 8
Little Roberts Outflow	Aug 10 – Sep 22	Jun 17 – Aug 11 Sep 23 – Oct 13	Jun 13 – 16 Oct 14 – Nov 8

Table 3-4: 2019 Observed, Modelled and Estimated Lake Levels

Station	Observed	Modelled	Estimated
Windy Outflow	Jun 24 – Sep 20	Jun 17 – Jun 23 Sept 21 – Oct 13	Jan 1 – Jun 16 Oct 14 – Dec 31
Glenn Lake	Jun 23 – Sep 22	Jun 17 – Jun 22 Sep 23 – Oct 6	Jan 1 – Jun 16 Oct 7 – Dec 31
Wolverine Lake	Jun 23 – Sep 20	Jun 17 – Jun 24	Jan 1 – Jun 16 Sep 21 – Dec 31
Imniagut Lake	Jun 23 – Sep 20	Jun 17 – Jun 22	Jan 1 – Jun 16 Sep 21 – Dec 31
Patch Outflow	Jun 22 – Sep 20	Jun 17 – Jun 23 Sep 20 - 25	Jan 1 – Jun 16 Sep 26 – Dec 31
PO Outflow	Jun 22 – Sep 21	Jun 17 – Jun 21 Sept 22 – Oct 13	Jan 1 – Jun 16 Oct 14 – Dec 31
Ogama Outflow	Jun 23 – Sep 21	Jun 17 – Jun 22 Sept 22 – Oct 13	Jan 1 – Jun 16 Oct 14 – Dec 31
Doris Lake-2	Jan 1 – Dec 31	n/a	n/a
Roberts Hydro-2	Jan 1 – Sep 21	Sept 22 – Oct 13	Oct 14 – Dec 31
Little Roberts Outflow	Jun 24 – Jul 24 Aug 10 – Sep 22	Jun 1 – Jun 23 Sep 23 – Oct 13	Jan 1 – Jun 16 Jul 25 – Aug 9 Oct 14 – Dec 31

Table 3-5 presents monthly mean, maximum and minimum lake levels, along with the maximum water level fluctuation during the open water season, and over the full calendar year. These monthly statistics include observed, modelled and estimated data.

Table 3-6 presents the stage-discharge rating curves from the seven hydrometric stations that record discharges. Rating curves are empirical equations unique to each monitoring station that convert stage data recorded by the monitoring station to discharge and are developed using concurrent manual measurements of stage (water level) and discharge. Measurements dating back to 2017 were used in the development of the rating curves. Measurements made prior to 2017 did not align with measurements that are more recent and were excluded from the rating development process. This adjustment is common as erosion and aggradation of the channel changes the stage discharge relationship over time.

Table 3-5: Summary of 2019 Lake Levels

Station	Parameter	2019 Monthly Lake Level1 (m)												Lake Level Fluctuation2	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jun-Sep	Annual
Windy Outflow	Mean	18.209	18.209	18.209	18.209	18.209	18.363	18.441	18.350	18.298	18.221	18.209	18.209	0.270	0.319
	Max	18.209	18.209	18.209	18.209	18.209	18.528	18.489	18.375	18.331	18.249	18.209	18.209		
	Min	18.209	18.209	18.209	18.209	18.209	18.209	18.378	18.334	18.258	18.209	18.209	18.209		
Glenn Lake	Mean	9.527	9.527	9.527	9.527	9.527	9.753	9.838	9.693	9.611	9.528	9.527	9.527	0.468	0.487
	Max	9.527	9.527	9.527	9.527	9.527	10.014	9.926	9.724	9.676	9.536	9.527	9.527		
	Min	9.527	9.527	9.527	9.527	9.527	9.527	9.731	9.672	9.546	9.527	9.527	9.527		
Wolverine Lake	Mean	32.351	32.351	32.351	32.351	32.351	32.436	32.476	32.435	32.433	32.390	32.353	32.351	0.119	0.185
	Max	32.351	32.351	32.351	32.351	32.351	32.536	32.510	32.455	32.449	32.416	32.363	32.351		
	Min	32.351	32.351	32.351	32.351	32.351	32.351	32.421	32.417	32.417	32.365	32.351	32.351		
Imniagut Lake	Mean	27.249	27.249	27.249	27.249	27.249	27.337	27.382	27.325	27.273	27.259	27.249	27.249	0.179	0.192
	Max	27.249	27.249	27.249	27.249	27.249	27.441	27.424	27.344	27.305	27.266	27.252	27.249		
	Min	27.249	27.249	27.249	27.249	27.249	27.249	27.326	27.313	27.262	27.253	27.249	27.249		
Patch Outflow	Mean	26.287	26.287	26.287	26.287	26.287	26.502	26.517	26.368	26.320	26.286	26.287	26.287	0.492	0.492
	Max	26.287	26.287	26.287	26.287	26.287	26.778	26.650	26.381	26.370	26.287	26.287	26.287		
	Min	26.287	26.287	26.287	26.287	26.287	26.287	26.388	26.358	26.286	26.286	26.287	26.287		
PO Outflow	Mean	26.120	26.120	26.120	26.120	26.120	26.362	26.416	26.298	26.229	26.133	26.120	26.120	0.503	0.551
	Max	26.120	26.120	26.120	26.120	26.120	26.671	26.532	26.335	26.305	26.158	26.121	26.120		
	Min	26.120	26.120	26.120	26.120	26.120	26.120	26.279	26.266	26.168	26.122	26.120	26.120		

Station	Parameter	2019 Monthly Lake Level1 (m)												Lake Level Fluctuation2	
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jun-Sep	Annual
Ogama Outflow	Mean	24.058	24.058	24.058	24.058	24.058	24.377	24.416	24.251	24.223	24.101	24.059	24.058	0.630	0.726
	Max	24.058	24.058	24.058	24.058	24.058	24.784	24.584	24.294	24.281	24.141	24.069	24.058		
	Min	24.058	24.058	24.058	24.058	24.058	24.058	24.255	24.223	24.154	24.070	24.058	24.058		
Doris Lake-2	Mean	21.705	21.698	21.690	21.703	21.699	22.118	22.173	21.916	21.866	21.789	21.740	21.742	0.779	0.921
	Max	21.714	21.706	21.699	21.710	21.706	22.600	22.389	21.965	21.908	21.814	21.752	21.750		
	Min	21.694	21.687	21.679	21.689	21.696	21.702	21.975	21.896	21.821	21.751	21.731	21.728		
Roberts Hydro – 2	Mean	6.125	6.125	6.124	6.143	6.145	6.537	6.583	6.419	6.376	6.222	6.133	6.130	0.600	0.784
	Max	6.131	6.132	6.133	6.151	6.150	6.900	6.756	6.447	6.435	6.285	6.156	6.130		
	Min	6.116	6.116	6.116	6.129	6.142	6.145	6.429	6.403	6.300	6.160	6.130	6.130		
Little Roberts Outflow	Mean	4.501	4.501	4.501	4.501	4.501	5.019	5.036	4.775	4.704	4.594	4.504	4.501	0.969	1.113
	Max	4.501	4.501	4.501	4.501	4.501	5.614	5.355	4.813	4.777	4.636	4.530	4.501		
	Min	4.501	4.501	4.501	4.501	4.501	4.501	4.819	4.745	4.645	4.534	4.501	4.501		

[1] *Water levels include observed, modelled and estimated data*

[2] *Change in lake level refers to the difference between the highest June and lowest July to September lake levels*

Table 3-6: 2019 Stage-Discharge Rating Equations for Madrid Hydrometric Stations

Station	Rating Equation[1] Q = C (h-a)b	Number of Measurements Used[2]	Root Mean Square – Error (m^3/s)
Windy Outflow	$Q = 7.096\ (h - 18.15)^{2.401}$	6	7.8
Patch Outflow	$Q = 2.975\ (h - 26.105)^{1.706}$; $h < 26.395$ $Q = 5.706\ (h - 26.155)^{1.936}$; $h > 26.395$	12	8.5
PO Outflow	$Q = 2.703\ (h - 25.9)^{1.897}$; $h < 26.27$ $Q = 5.839\ (h - 26)^{2.029}$; $h > 26.27$	7	4.8
Ogama Outflow	$Q = 3.966\ (h - 23.855)^{2.065}$; $h < 24.31$ $Q = 8.145\ (h - 23.95)^{2.296}$; $h > 24.31$	11	4.3
Doris Creek TL-2	$Q = 5.068\ (h - 21.511)^{1.665}$; $h < 22.00$ $Q = 8.545\ (h - 21.611)^{1.815}$; $h > 22.00$	18	9.3
Roberts Outflow- 2	$Q = 7.125\ (h - 6.104)^{2.042}$; $h < 6.49$ $Q = 13.281\ (h - 6.168)^{2.265}$; $h > 6.49$	12	7.3
Little Roberts Outflow	$Q = 2.756\ (h - 4.02)^{2.206}$	5	1.8

[1] *Equation $Q = C(h - a)^b$: Q is the discharge (m^3/s), C and b are dimensionless coefficients, h is the stage (m), and a is the approximate stage at zero flow (m).*

[2] *The 2019 stage-discharge rating equations were developed using measurements from 2017 to 2019 where available*

Table 3-7 presents the hydrologic indices such as runoff, peak flows and 7-day low flows. Table 3-8 presents the monthly runoff distributions from the seven hydrometric stations that record discharges. Annual runoff is the volume of streamflow over the year normalized by drainage area and reported as depth and is useful index for comparing the hydrologic responses of basins of different sizes. Estimates of annual runoff were calculated from the available data and interpolated using the equation:

$$Ro = \frac{(Q * t)}{A}$$

where: runoff (Ro; units = mm) is calculated as streamflow (Q; units = m3/s) multiplied by time (t; units = seconds) divided by basin area (A; units = km^2).

Peak daily flows are the highest mean daily flow during the year and typically occur during freshet. The lowest seven-day averaged flow during the open water season typically occurs during late summer or early fall. Annual low flows are zero and are not reported as the streams freeze solid in winter. Breaking runoff down by month shows the majority of flow occurs during and shortly after freshet, with much less water flowing during late summer and fall. This flow distribution is typical of arctic streams.

Table 3-7: Summary of 2019 Annual Runoff, Peak Flows and Low Flows

Station	Annual Runoff (mm)	Annual Peak Daily Flows[1]		7 – Day Low Flows[2]	
		Peak Flow (m^3/s)	Date	7- Day Low Flow (m^3/s)	Date
Windy Outflow	174	0.69	June 21	0.07	Sept 20
Patch Outflow	189	2.28	June 22	0.21	Sept 20
PO Outflow	222	2.60	June 22	0.31	Sept 21
Ogama Outflow	167	5.37	June 21	0.49	Sept 19
Doris Creek TL-2	191	6.90	June 21	0.52	Sept 22
Roberts Outflow- 2	156	6.55	June 20	0.48	Sept 21
Little Roberts Outflow	175	13.58	June 21	1.14	Sept 22

[1] *Peak flows refer to peak daily discharges in 2019 and are based on estimated and observed data.*

[2] *7-day low flows are based on observed data only.*

Table 3-8: Summary of 2019 Monthly Runoff Distributions

Station	2019 Monthly Runoff (mm)							
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Windy Outflow	0	56	73	29	14	2	0	0
Patch Outflow	0	72	69	26	17	5	0	0
PO Outflow	0	73	77	38	25	9	0	0
Ogama Outflow	0	69	54	21	18	6	0	0
Doris Creek TL-2	0	76	70	23	16	6	0	0
Roberts Outflow- 2	0	68	53	19	13	3	0	0
Little Roberts Outflow	0	72	61	21	16	6	0	0

4. DISCUSSION

4.1 Precipitation

Table 4-1 presents the precipitation at the Hope Bay meteorological station for the 2019 hydrologic year (October 2018 to September 2019). A total of 234 mm of precipitation fell during the 2019 hydrologic year; however, due to freeze up starting earlier than usual in 2018, most of the September 2018 precipitation fell as snow and some portion of that will have contributed to streamflow in the 2018 open water season. Some portion of the September snow will instead be stored over the winter and report as streamflow during the 2019 open water season. Including September 2018 snowfall in the 2019 hydrologic year results in a precipitation depth of 277 mm, though the true contribution is likely in between.

Table 4-1: Doris Hydrometric Station Precipitation October 2018 – September 2019

Month	Total Rainfall (mm)	Total Snowfall (SWE, mm)	Total Precipitation (mm)
Oct-18	0.0	9.9	9.9
Nov-18	0.0	13.0	13.0
Dec-18	0.0	15.9	15.9
Jan-19	0.0	9.8	9.8
Feb-19	0.0	7.1	7.1
Mar-19	0.0	14.0	14.0
Apr-19	0.0	17.8	17.8
May-19	0.0	13.6	13.6
Jun-19	36.1	10.9	47.0
Jul-19	32.3	0.0	32.3
Aug-19	37.8	0.0	37.8
Sep-19	12.3	3.0	15.3
Total	118.5	115	233.5
Total Precipitation Including September 2018 Snowfall			**276.7**

Source: Nunami Stantec 2019-2020

Table 4-2 presents the precipitation return periods used in the Climate and Hydrological Parameters Summary Report, Package P5-2 of the Hope Bay FEIS (SRK 2017). It indicates that 234 mm of precipitation corresponds to a slightly wetter than average year with a return period less than 5 years, while 277 mm corresponds to a 20 year wet year. The 2019 hydrologic year falls between these two return periods.

Table 4-2: Hope Bay Extreme Precipitation Depths

Return Period	Annual Precipitation (mm)
200 Wet	324
100 Wet	311
50 Wet	297
25 Wet	282
20 Wet	277
10 Wet	261
5 Wet	243
Average (MAP)	210
2 Wet	210

Return Period	Annual Precipitation (mm)
3 Dry	195
5 Dry	182
10 Dry	168
20 Dry	158
25 Dry	155
50 Dry	147
100 Dry	140
200 Dry	134

Source: Package P5-2 (Table 6) of the Hope Bay FEIS (SRK 2017)

Note: Annual precipitation values are based on calendar year totals. While the hydrologic year is October to September, total precipitation statistics will be comparable when using a large data set.

4.2 Runoff

A portion of the precipitation is converted to runoff, which enters the lakes and streams, resulting in streamflow. Table 4-3 presents the comparison of the 2019 runoff with historical baseline data collected between 2004 and 2015, as well as the 2018 monitoring data. Runoff in 2019 was much higher than in 2018 and is notably higher than the historical averages. For stations where the historical average runoff is close to the FEIS predicted average (TL-2 and Ogama Outflow), the 2019 runoff was close but below predicted runoff for a 20 year wet year. For stations where the historical average runoff is much higher than the FEIS predicted average (Little Roberts Outflow, Patch Outflow, PO Outflow and Windy Outflow), the 2019 runoff was much higher than the predicted runoff for a 20 year wet year.

Table 4-3: Comparison of 2019 Runoff with Historical Averages and Predicted Values

Station	Monitored Runoff (mm)			FEIS Predicted Runoff[1]	
	2018	2019	2004-2015 Average[1]	Predicted Average Runoff	Predicted 20y Wet Runoff
Windy Outflow	n/a	174	130	58	119
Patch Outflow	111	189	112	77	137
PO Outflow	128	222	153	80	143
Ogama Outflow	93	167	117	100	199
Doris Creek TL-2	129	191	110	101	213
Roberts Outflow- 2	111	156	112	n/a	n/a
Little Roberts Outflow	n/a	175	93	161	347

[1] Data Source: Annex V5-S1 (Table 1.2-5, 1.5-7 to 1.5-12) of the Hope Bay FEIS (TMAC 2017)

n/a: Discharge not monitored at this location in 2018

4.3 Outflows

Table 4-4 presents the impact to the 2019 annual outflow predicted by the FEIS. Effects to Doris Lake are predicted due to direct water withdrawal and mine dewatering activities that could cause the Doris Lake water level drawdown. This water level drawdown could result in downstream effects to Little Roberts Outflow. Effects to Windy Lake are predicted due to the withdrawal of water from Windy Lake.

Drawdown to the Doris Lake water level was not detected in 2019. The 2019 hydrologic year experienced a wetter than normal year, as shown in Table 4-1 and Table 4-2, with corresponding higher than average runoff values, as shown in Table 4-3. Drawdown due to mine dewatering would be expected to reduce water levels in Doris Lake during the winter when there are no inflows to the lake; however, water levels remain stable during the winter, as shown in Table 3-5. Since there is no effects observed in Doris Lake; therefore, there is no downstream effects to Little Roberts Lake either.

Water withdrawal from Windy Lake did not cause a detectable impact in 2019. The 2019 hydrologic year experienced a wetter than normal year, as shown in Table 4-1 and Table 4-2, with corresponding higher than average runoff values, as shown in Table 4-3.
In 2019, no detectable impact caused by the Hope Bay project were observed to lake levels or lake outflow rates as part of the compliance monitoring.

Table 4-4: Predicted Impact due to Annual Outflow from Monitored Lakes

Station	FEIS Predicted Impact[1] to Annual Flow in 2019 Under Average Climate Conditions (% Change)
Windy Outflow	-6.7
Patch Outflow	0
PO Outflow	0
Ogama Outflow	0
Doris Creek TL-2	-13.4
Little Roberts Outflow	-7.8

[1] *Project Phase "Existing and Permitted Projects"*

Source: Annex V5-S1 (Table 1.2-5, 1.5-7 to 1.5-12) of the Hope Bay FEIS (TMAC 2017)

5. CLOSING

We trust that the monitoring summaries are sufficient for your needs. Please contact us if you have any questions.

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APPENDIX A LAKE LEVELS GRAPHS

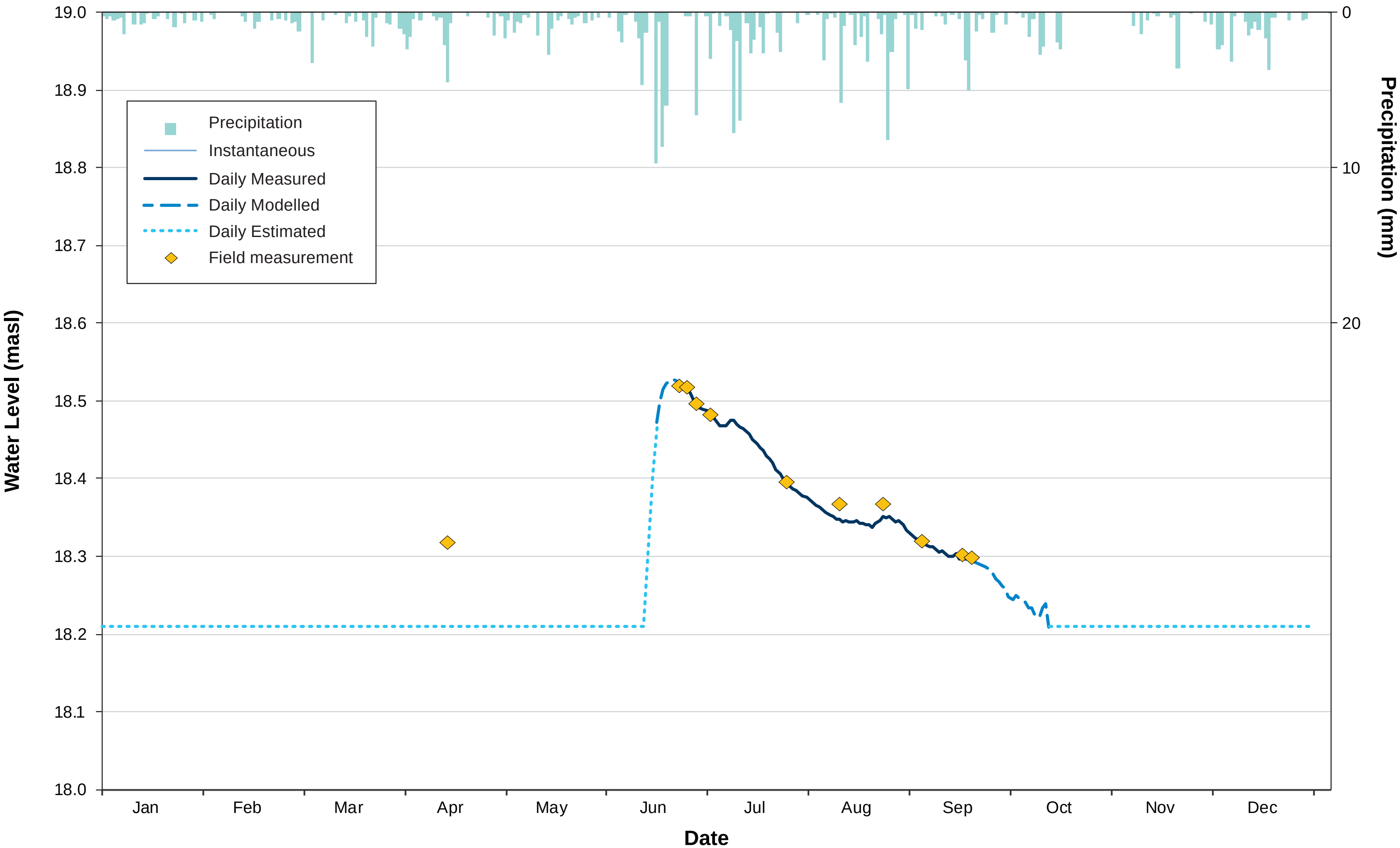

Figure A1: 2019 Mean Daily Lake Level for Monitoring Station Windy Outflow

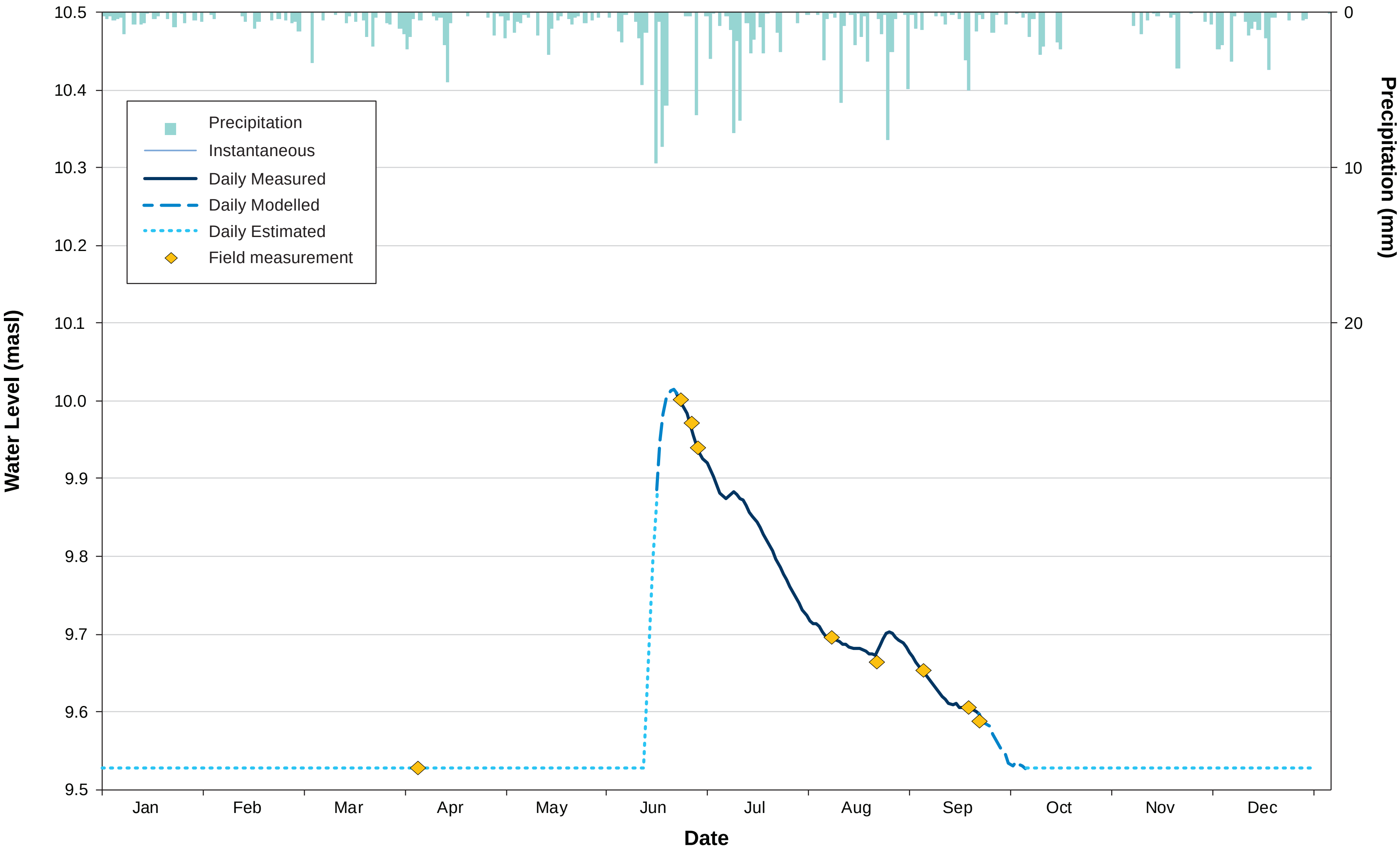

Figure A2: 2019 Mean Daily Lake Level for Monitoring Station Glenn Lake

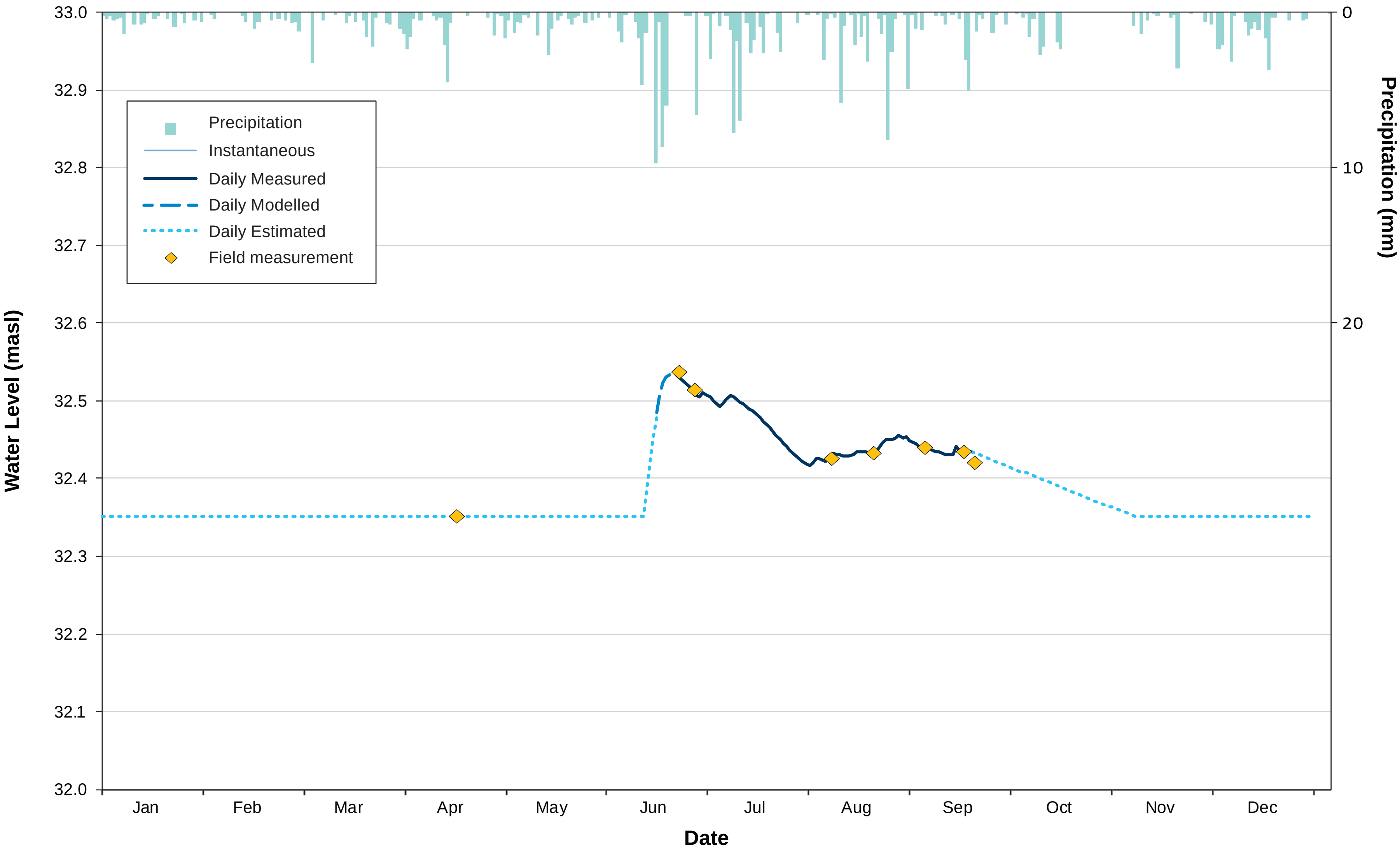

Figure A3: 2019 Mean Daily Lake Level for Monitoring Station Wolverine Lake

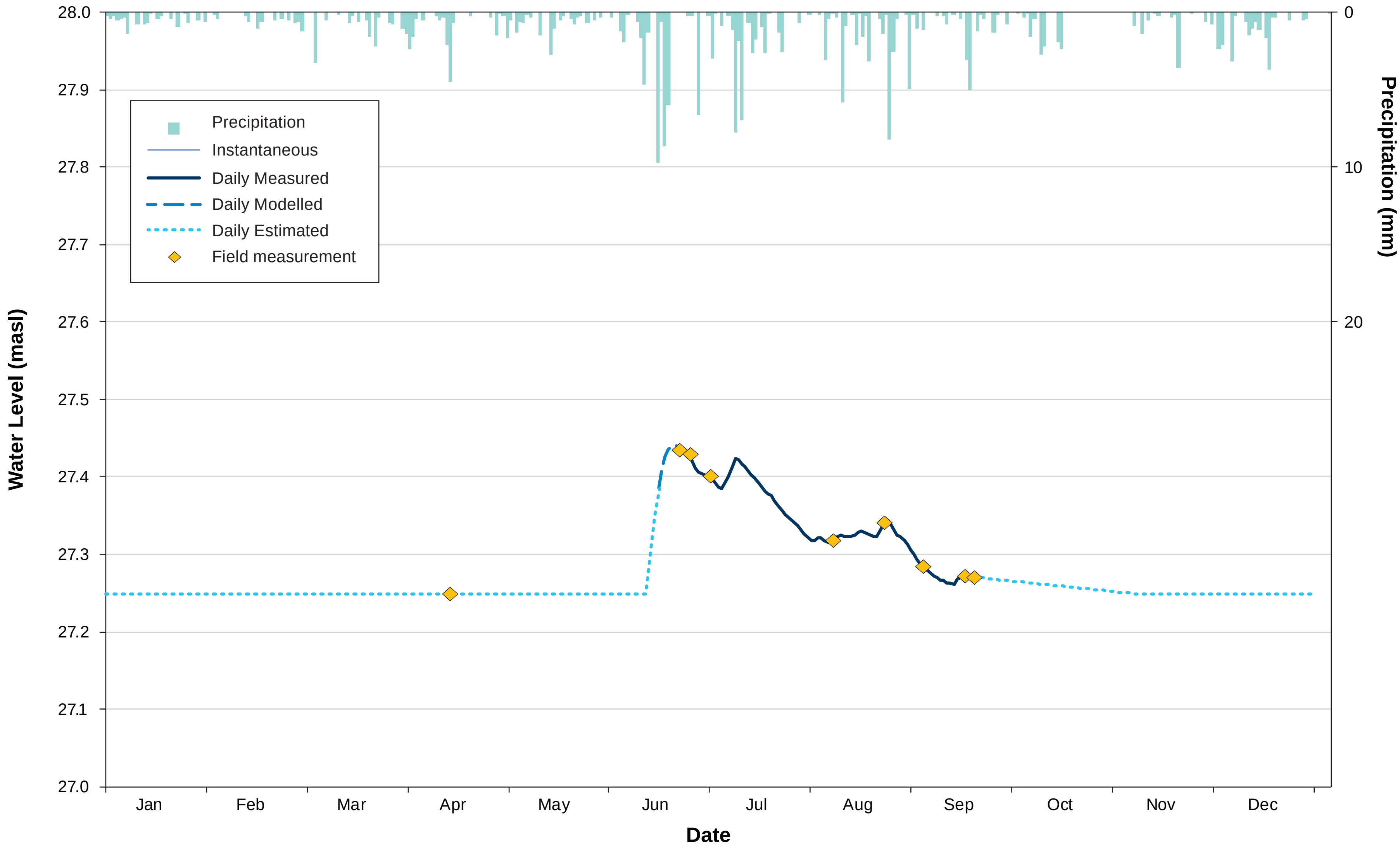

Figure A4: 2019 Mean Daily Lake Level for Monitoring Station Imniagut Lake

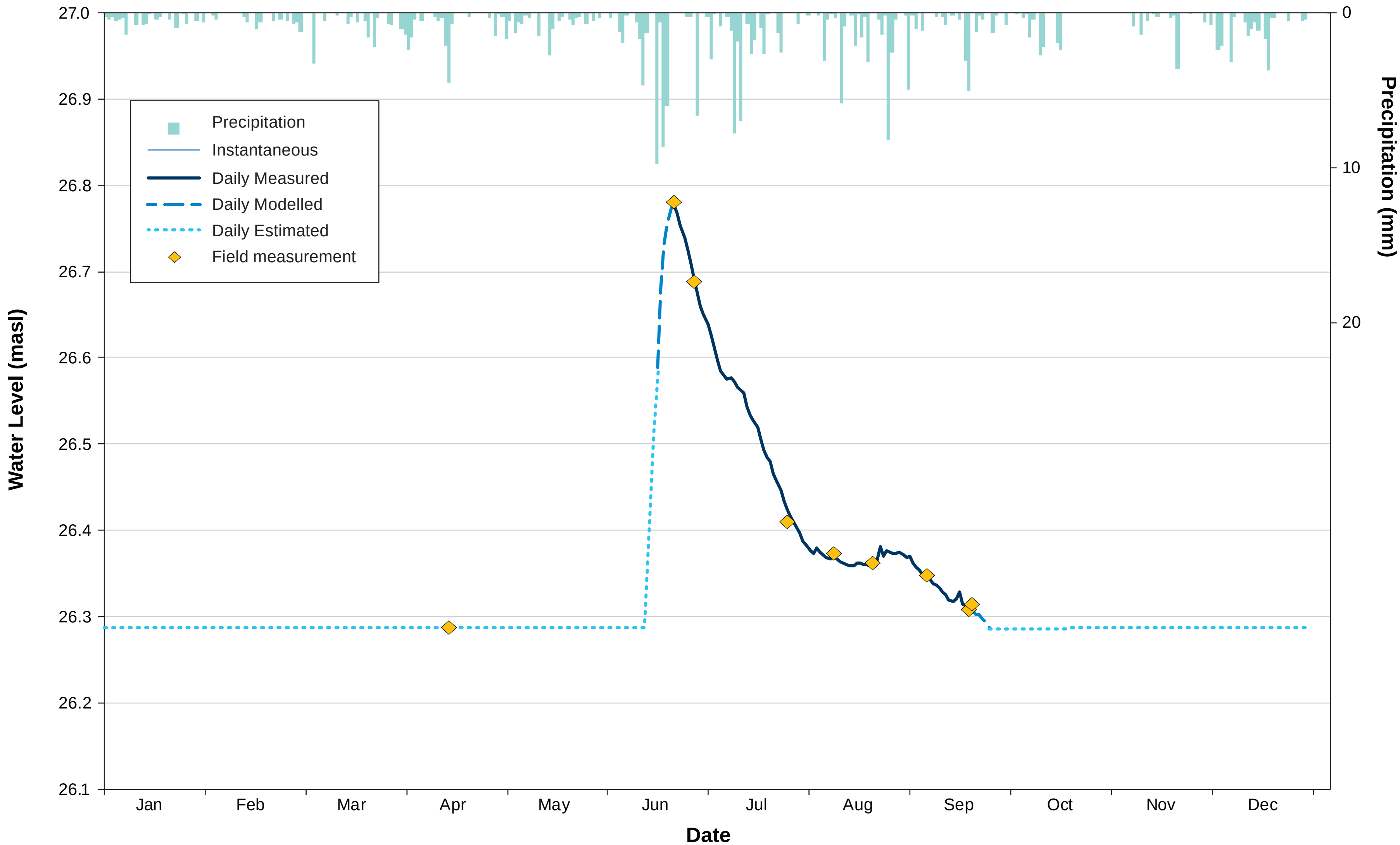

Figure A5: 2019 Mean Daily Lake Level for Monitoring Station Patch Outflow

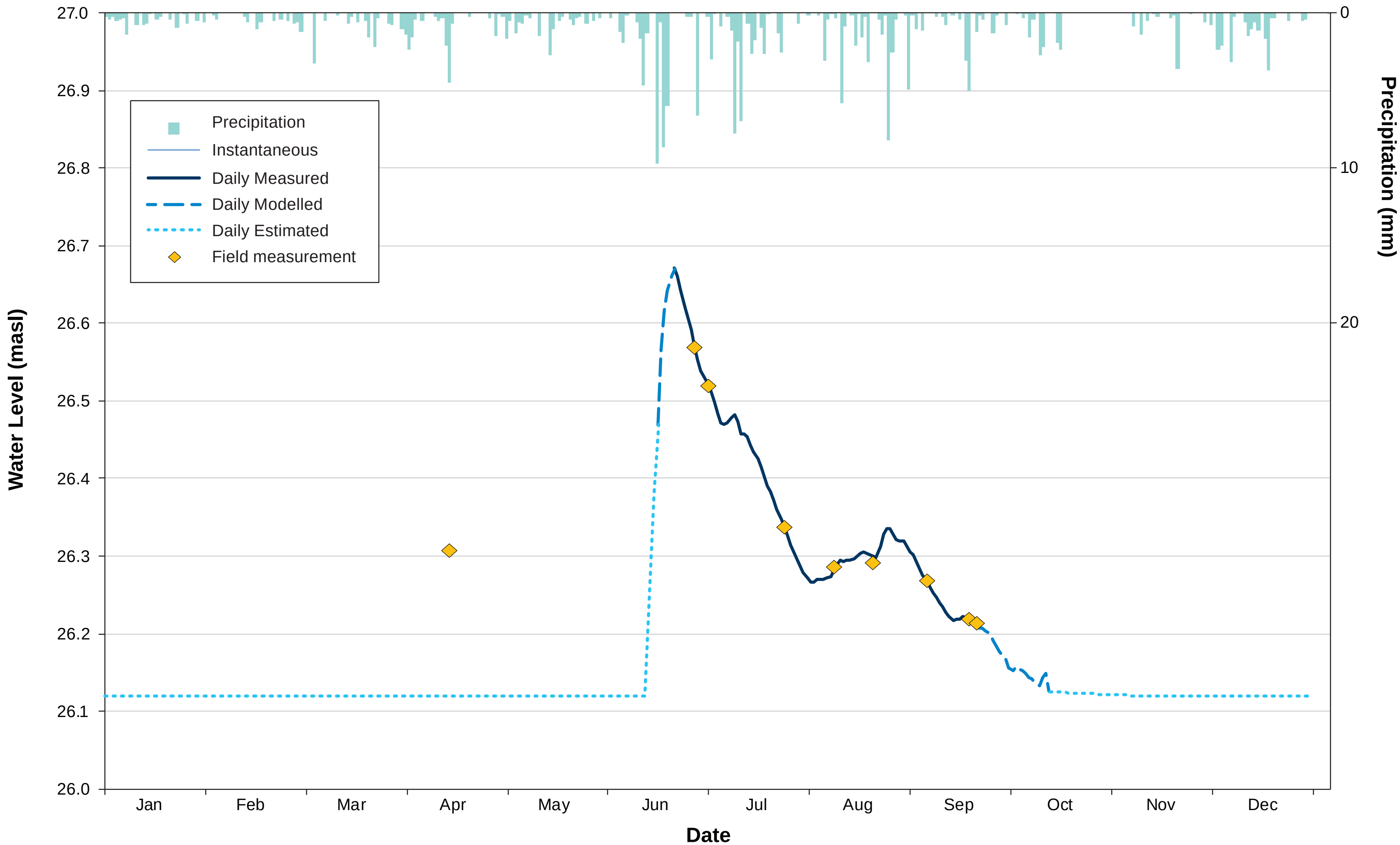

Figure A6: 2019 Mean Daily Lake Level for Monitoring Station PO Outflow

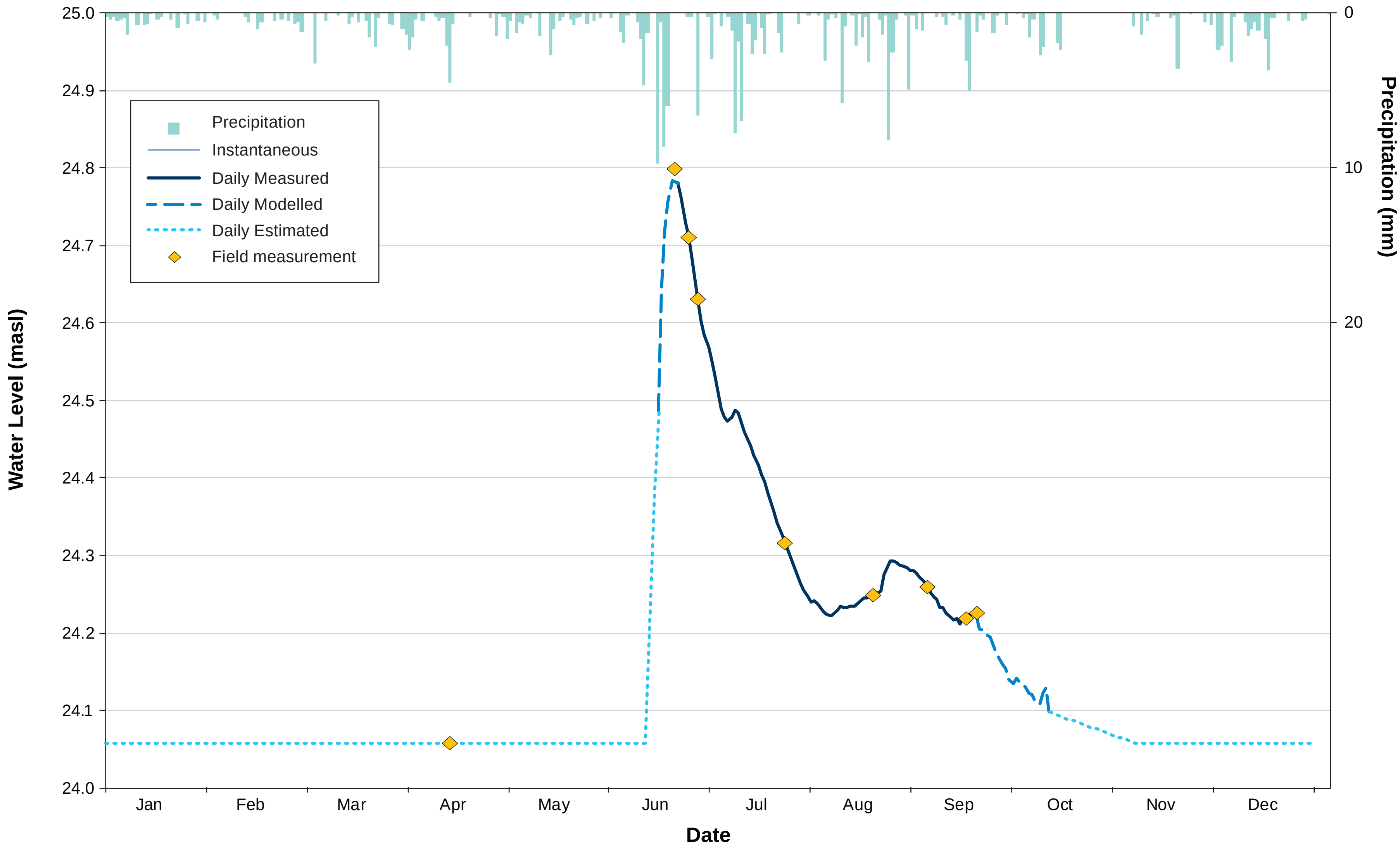

Figure A7: 2019 Mean Daily Lake Level for Monitoring Station Ogama Outflow

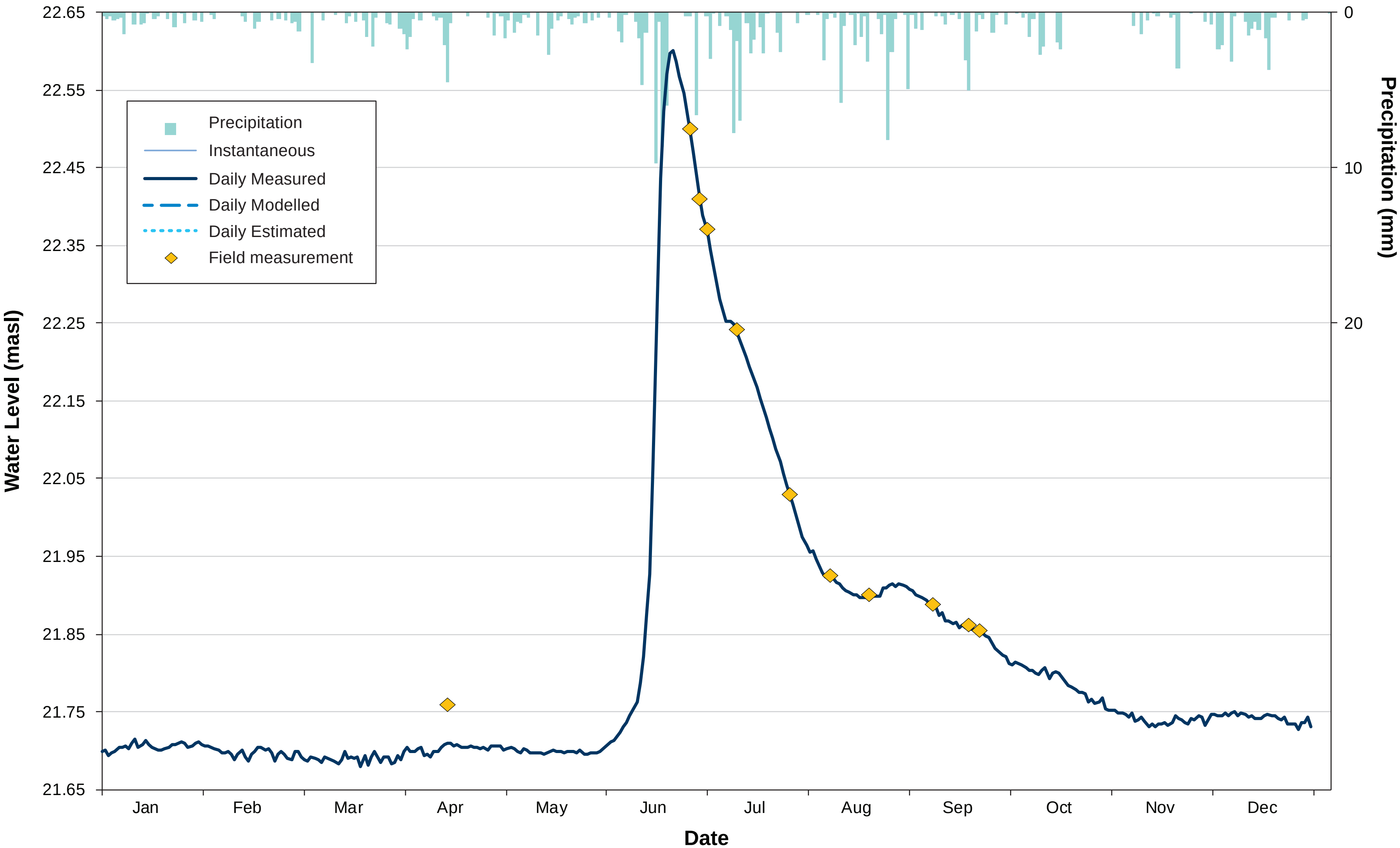

Figure A8: 2019 Mean Daily Lake Level for Monitoring Station Doris Lake-2

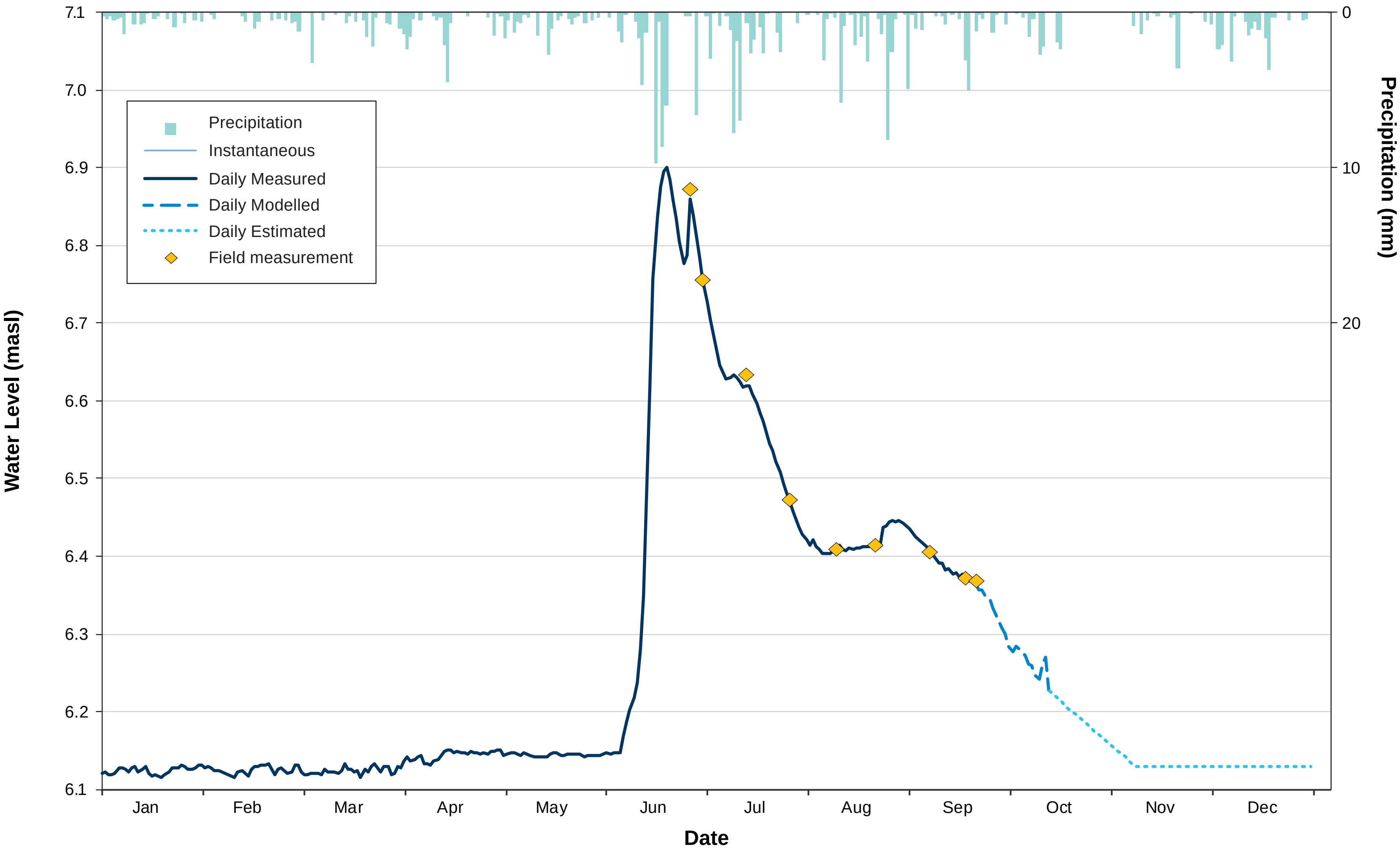

Figure A9: 2019 Mean Daily Lake Level for Monitoring Station Roberts Hydro-2

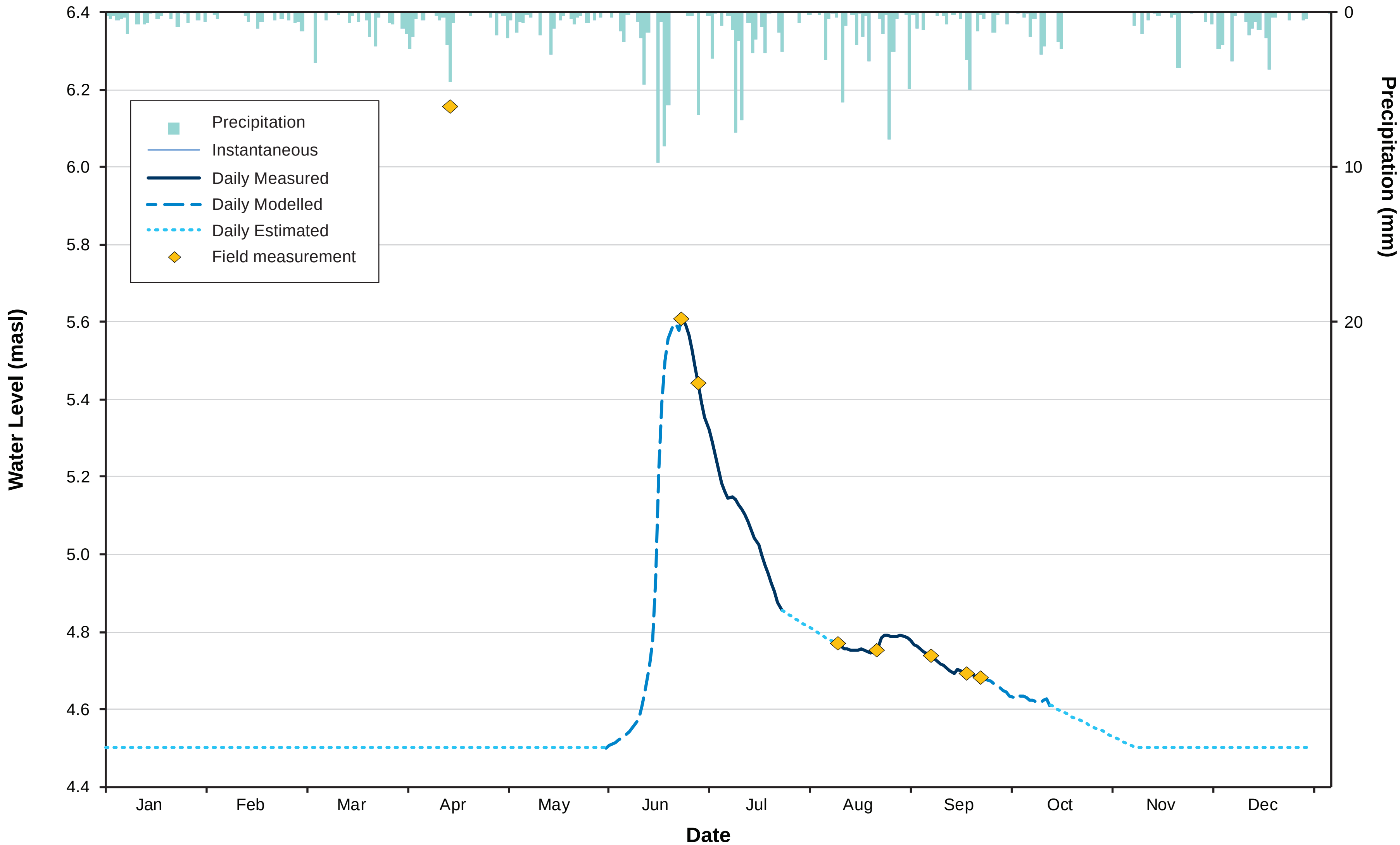

Figure A10: 2019 Mean Daily Lake Level for Monitoring Station Little Roberts Outflow

APPENDIX B HYDROGRAPHS

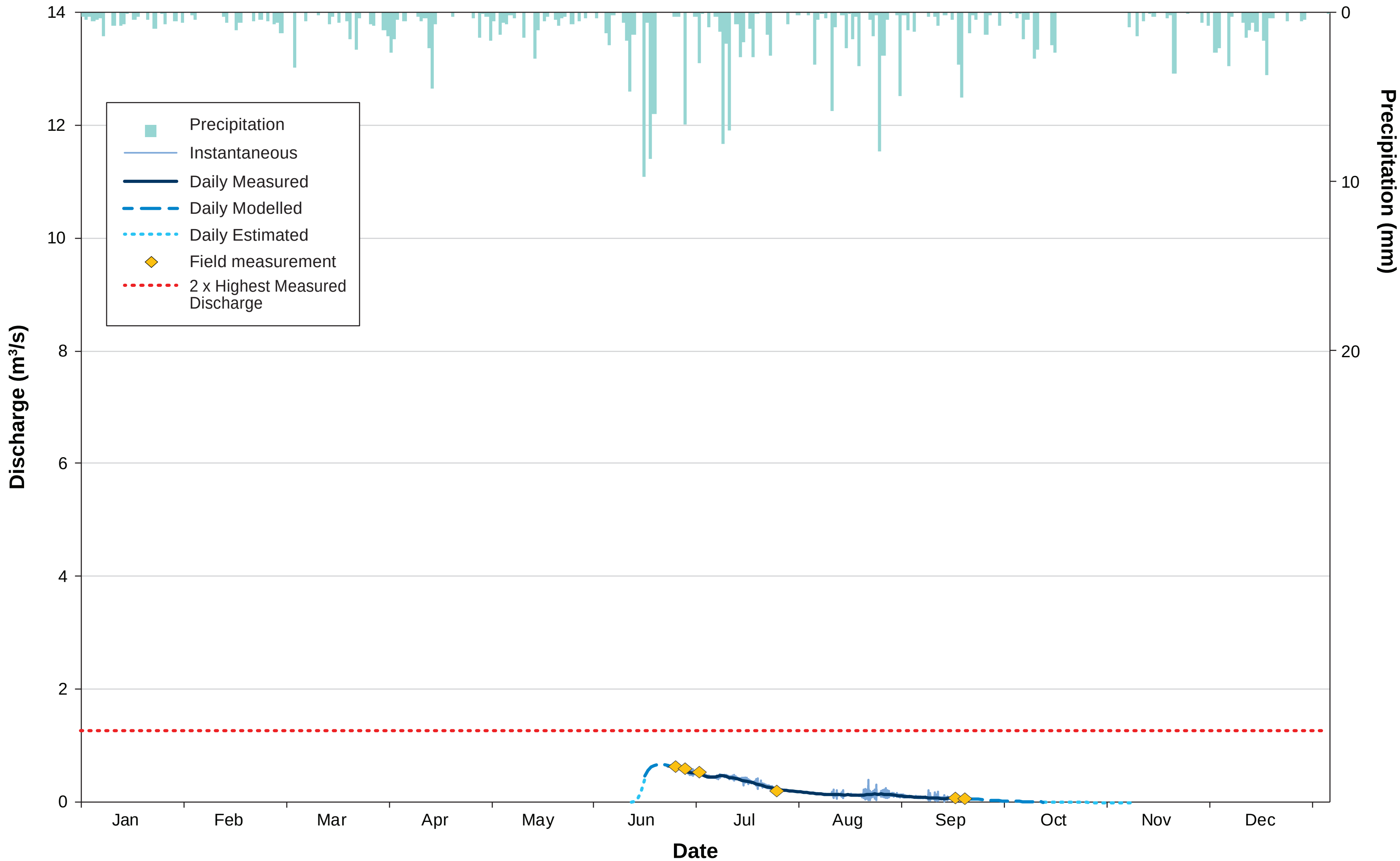

Figure B1: 2019 Mean Daily Hydrograph at Monitoring Station Windy Outflow

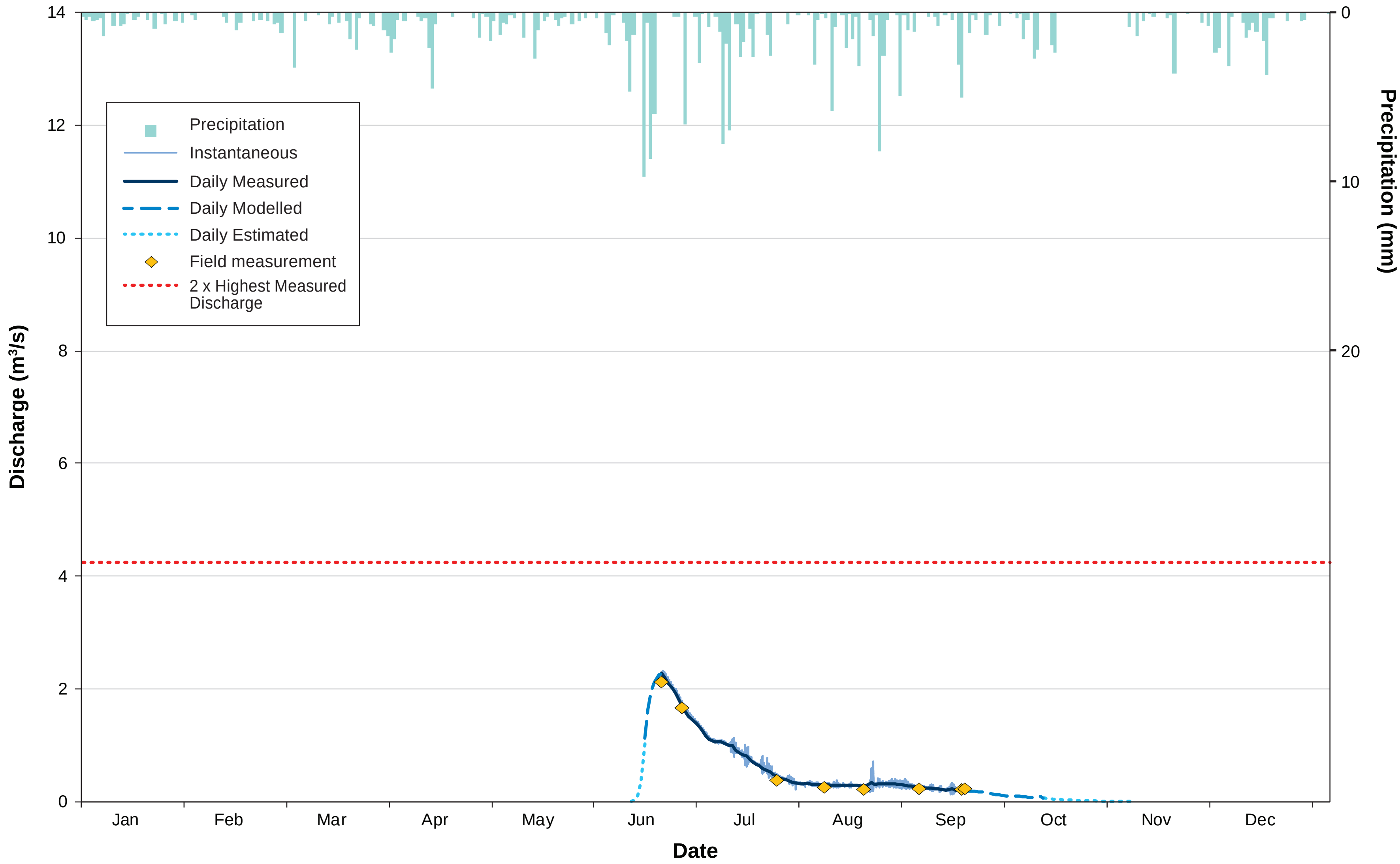

Figure B2: 2019 Mean Daily Hydrograph at Monitoring Station Patch Outflow

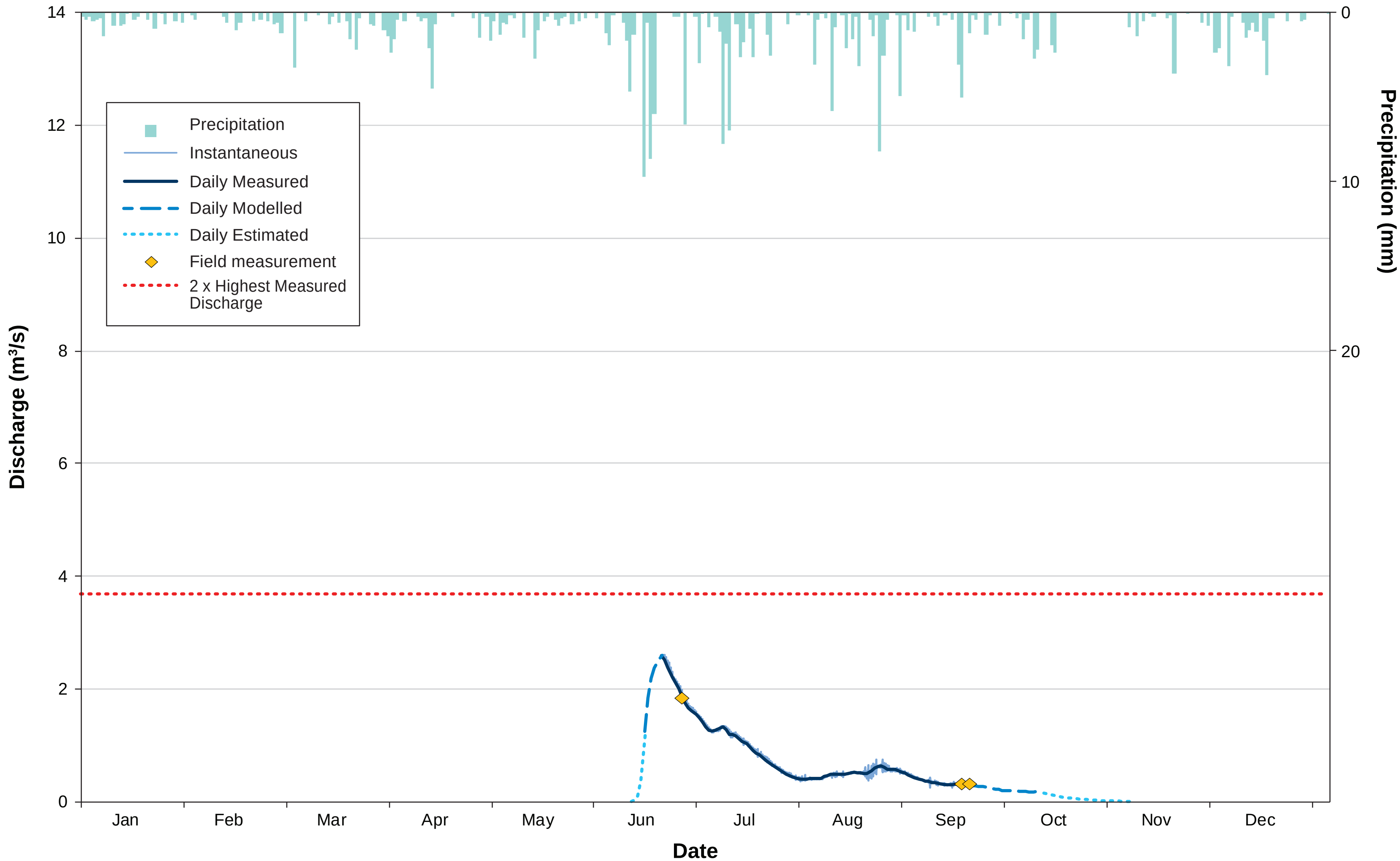

Figure B3: 2019 Mean Daily Hydrograph at Monitoring Station PO Outflow

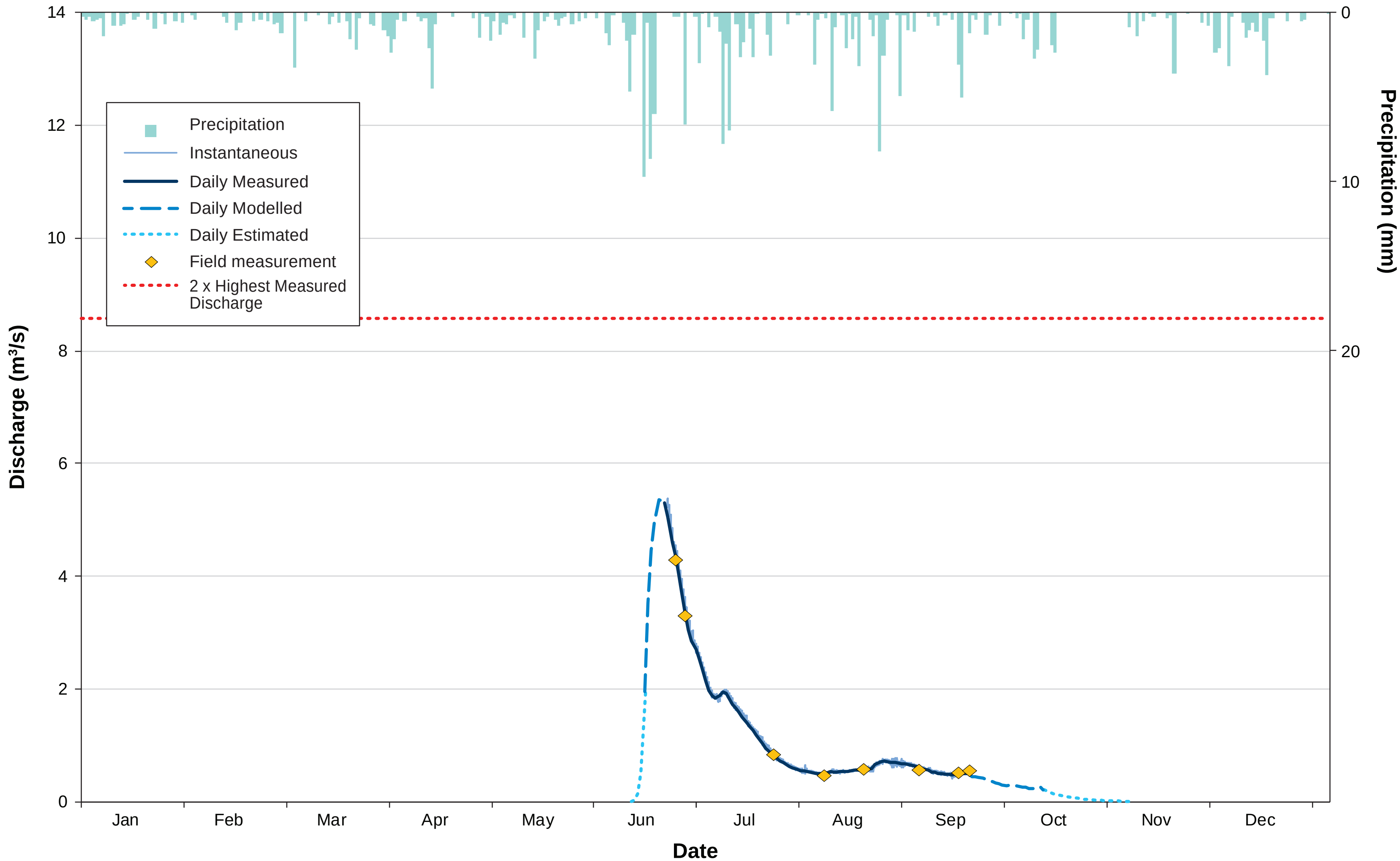

Figure B4: 2019 Mean Daily Hydrograph at Monitoring Station Ogama Outflow

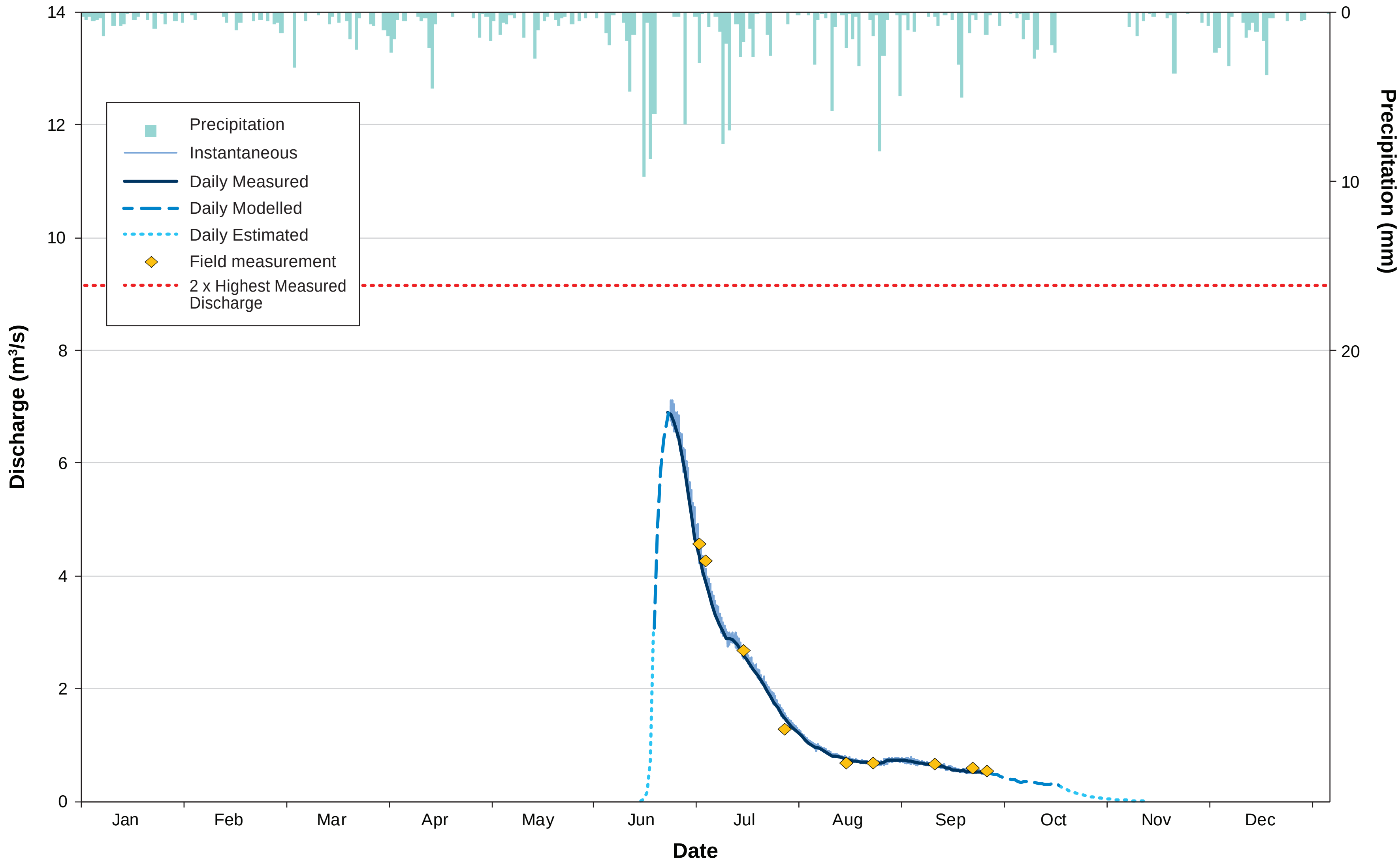

Figure B5: 2019 Mean Daily Hydrograph at Monitoring Station TL-2

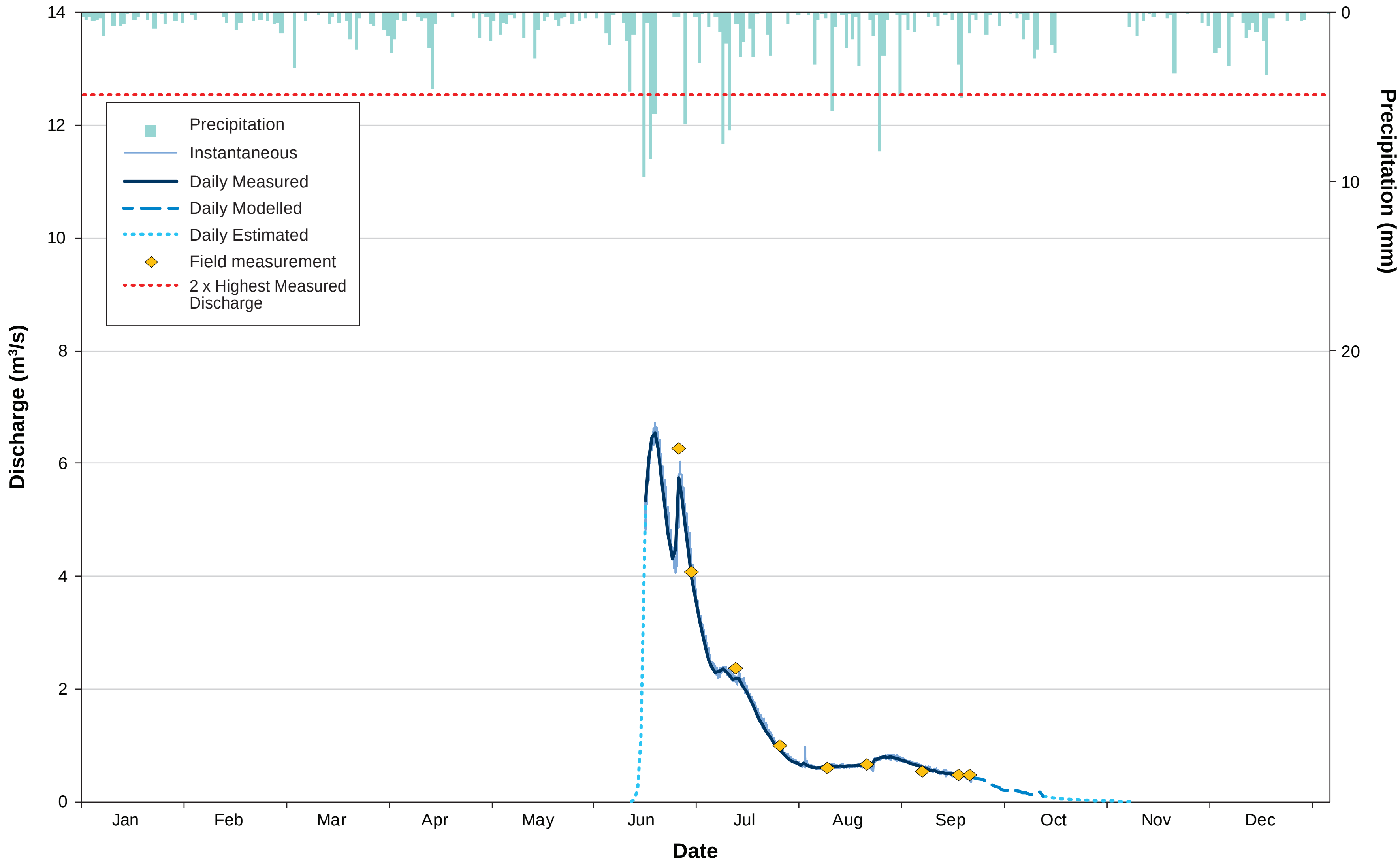

Figure B6: 2019 Mean Daily Hydrograph at Monitoring Station Roberts Hydro-2

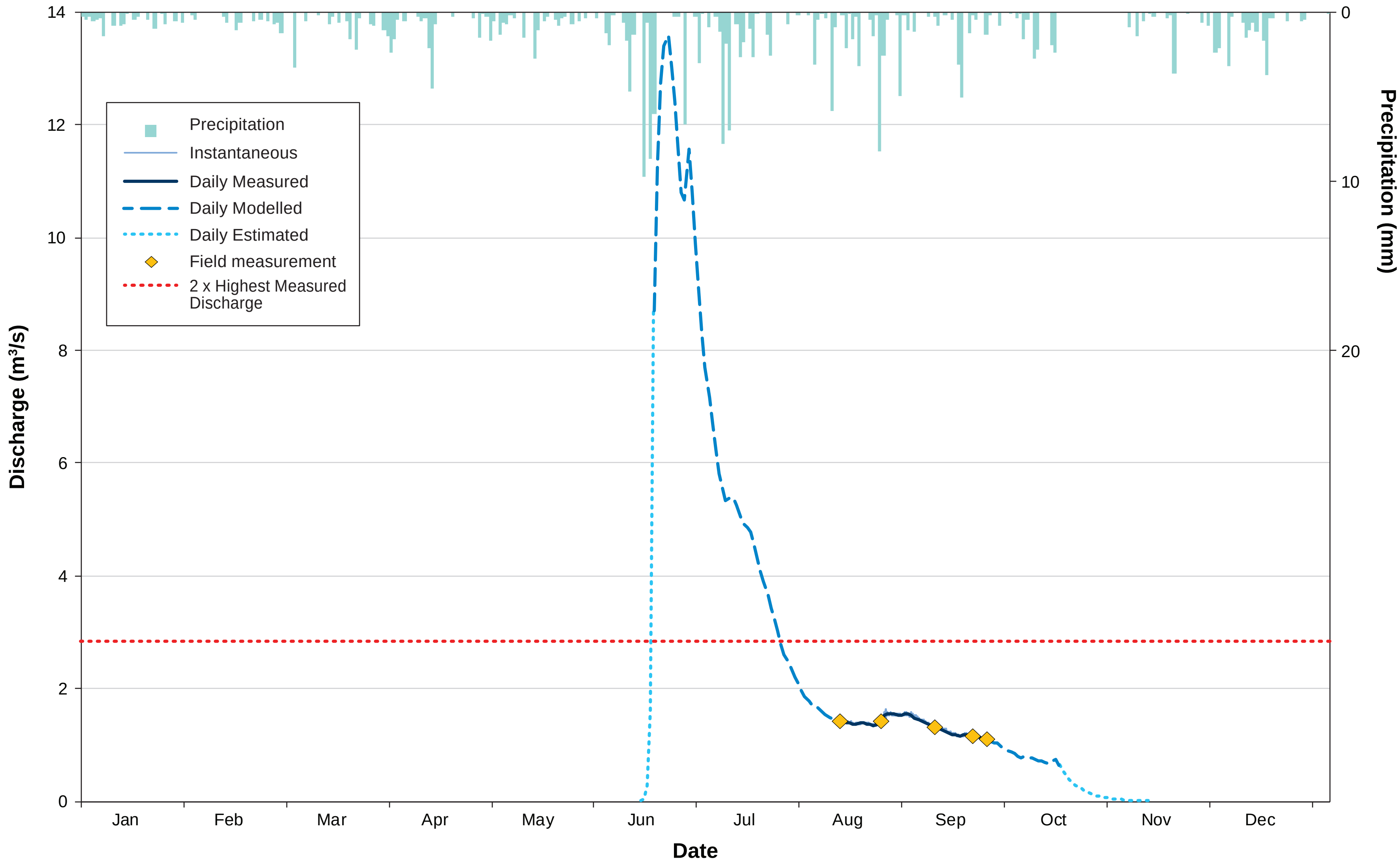

Figure B7: 2019 Mean Daily Hydrograph at Monitoring Station Little Roberts Outflow

APPENDIX C MEAN DAILY LAKE LEVEL TABLES

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Windy Outflow, 2019

Drainage Area = 13.73 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.489	18.375	18.331	*18.248*	*18.209*	*18.209*
2	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.488	18.372	18.327	*18.244*	*18.209*	*18.209*
3	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.485	18.369	18.322	*18.249*	*18.209*	*18.209*
4	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.479	18.366	18.321	*18.246*	*18.209*	*18.209*
5	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.473	18.363	18.319	*18.245*	*18.209*	*18.209*
6	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.468	18.360	18.315	*18.241*	*18.209*	*18.209*
7	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.469	18.357	18.312	*18.235*	*18.209*	*18.209*
8	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.468	18.354	18.312	*18.233*	*18.209*	*18.209*
9	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.475	18.351	18.309	*18.225*	*18.209*	*18.209*
10	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.474	18.348	18.305	*18.221*	*18.209*	*18.209*
11	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.470	18.347	18.307	*18.234*	*18.209*	*18.209*
12	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.466	18.345	18.303	*18.240*	*18.209*	*18.209*
13	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.465	18.346	18.300	*18.209*	*18.209*	*18.209*
14	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.275*	18.461	18.345	18.300	*18.209*	*18.209*	*18.209*
15	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.340*	18.458	18.344	18.303	*18.209*	*18.209*	*18.209*
16	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.406*	18.450	18.345	18.297	*18.209*	*18.209*	*18.209*
17	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.472*	18.446	18.343	18.299	*18.209*	*18.209*	*18.209*
18	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.499*	18.440	18.342	18.297	*18.209*	*18.209*	*18.209*
19	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.514*	18.436	18.340	18.296	*18.209*	*18.209*	*18.209*
20	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.522*	18.429	18.341	18.293	*18.209*	*18.209*	*18.209*
21	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.528*	18.425	18.338	*18.292*	*18.209*	*18.209*	*18.209*
22	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.528*	18.420	18.342	*18.290*	*18.209*	*18.209*	*18.209*
23	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	*18.526*	18.412	18.345	*18.289*	*18.209*	*18.209*	*18.209*
24	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.522	18.406	18.352	*18.286*	*18.209*	*18.209*	*18.209*
25	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.518	18.399	18.350	*18.284*	*18.209*	*18.209*	*18.209*
26	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.514	18.394	18.351	*18.278*	*18.209*	*18.209*	*18.209*
27	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.510	18.390	18.348	*18.272*	*18.209*	*18.209*	*18.209*
28	*18.209*	*18.209*	*18.209*	*18.209*	*18.209*	18.502	18.387	18.345	*18.267*	*18.209*	*18.209*	*18.209*
29	*18.209*		*18.209*	*18.209*	*18.209*	18.495	18.384	18.345	*18.262*	*18.209*	*18.209*	*18.209*
30	*18.209*		*18.209*	*18.209*	*18.209*	18.491	18.381	18.341	*18.258*	*18.209*	*18.209*	*18.209*
31	*18.209*		*18.209*		*18.209*		18.378	18.334		*18.209*		*18.209*
Mean	18.209	18.209	18.209	18.209	18.209	18.363	18.441	18.350	18.298	18.221	18.209	18.209
Max	18.209	18.209	18.209	18.209	18.209	18.528	18.489	18.375	18.331	18.249	18.209	18.209
Min	18.209	18.209	18.209	18.209	18.209	18.209	18.378	18.334	18.258	18.209	18.209	18.209

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Glenn Lake, 2019

Drainage Area = 20.59 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.926	9.724	9.676	*9.535*	*9.527*	*9.527*
2	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.920	9.717	9.671	*9.530*	*9.527*	*9.527*
3	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.912	9.713	9.664	*9.536*	*9.527*	*9.527*
4	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.902	9.714	9.658	*9.533*	*9.527*	*9.527*
5	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.892	9.709	9.653	*9.531*	*9.527*	*9.527*
6	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.881	9.703	9.647	*9.527*	*9.527*	*9.527*
7	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.878	9.697	9.640	*9.527*	*9.527*	*9.527*
8	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.875	9.692	9.635	*9.527*	*9.527*	*9.527*
9	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.879	9.693	9.631	*9.527*	*9.527*	*9.527*
10	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.883	9.692	9.624	*9.527*	*9.527*	*9.527*
11	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.880	9.690	9.620	*9.527*	*9.527*	*9.527*
12	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.875	9.688	9.615	*9.527*	*9.527*	*9.527*
13	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.872	9.686	9.611	*9.527*	*9.527*	*9.527*
14	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.616*	9.865	9.683	9.609	*9.527*	*9.527*	*9.527*
15	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.705*	9.858	9.682	9.610	*9.527*	*9.527*	*9.527*
16	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.795*	9.852	9.682	9.606	*9.527*	*9.527*	*9.527*
17	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.887*	9.845	9.682	9.606	*9.527*	*9.527*	*9.527*
18	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.947*	9.837	9.680	9.605	*9.527*	*9.527*	*9.527*
19	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*9.983*	9.828	9.678	9.605	*9.527*	*9.527*	*9.527*
20	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*10.002*	9.821	9.675	9.603	*9.527*	*9.527*	*9.527*
21	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*10.013*	9.815	9.674	9.600	*9.527*	*9.527*	*9.527*
22	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	*10.014*	9.808	9.672	9.598	*9.527*	*9.527*	*9.527*
23	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	10.010	9.797	9.686	*9.590*	*9.527*	*9.527*	*9.527*
24	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	10.002	9.786	9.694	*9.585*	*9.527*	*9.527*	*9.527*
25	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.991	9.777	9.701	*9.582*	*9.527*	*9.527*	*9.527*
26	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.984	9.769	9.703	*9.572*	*9.527*	*9.527*	*9.527*
27	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.970	9.761	9.701	*9.563*	*9.527*	*9.527*	*9.527*
28	*9.527*	*9.527*	*9.527*	*9.527*	*9.527*	9.956	9.755	9.696	*9.557*	*9.527*	*9.527*	*9.527*
29	*9.527*		*9.527*	*9.527*	*9.527*	9.943	9.747	9.693	*9.550*	*9.527*	*9.527*	*9.527*
30	*9.527*		*9.527*	*9.527*	*9.527*	9.933	9.739	9.688	*9.546*	*9.527*	*9.527*	*9.527*
31	*9.527*		*9.527*		*9.527*		9.731	9.684		*9.527*		*9.527*
Mean	9.527	9.527	9.527	9.527	9.527	9.753	9.838	9.693	9.611	9.528	9.527	9.527
Max	9.527	9.527	9.527	9.527	9.527	10.014	9.926	9.724	9.676	9.536	9.527	9.527
Min	9.527	9.527	9.527	9.527	9.527	9.527	9.731	9.672	9.546	9.527	9.527	9.527

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Wolverine Lake, 2019

Drainage Area = 2.50 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.510	32.418	32.449	*32.416*	*32.363*	*32.351*
2	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.507	32.417	32.446	*32.414*	*32.361*	*32.351*
3	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.505	32.420	32.445	*32.412*	*32.359*	*32.351*
4	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.500	32.426	32.442	*32.410*	*32.358*	*32.351*
5	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.496	32.426	32.441	*32.409*	*32.356*	*32.351*
6	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.493	32.425	32.440	*32.407*	*32.354*	*32.351*
7	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.497	32.423	32.438	*32.405*	*32.353*	*32.351*
8	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.501	32.427	32.436	*32.404*	*32.351*	*32.351*
9	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.508	32.433	32.434	*32.402*	*32.351*	*32.351*
10	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.505	32.431	32.434	*32.400*	*32.351*	*32.351*
11	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.502	32.430	32.432	*32.399*	*32.351*	*32.351*
12	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.499	32.429	32.431	*32.397*	*32.351*	*32.351*
13	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.496	32.429	32.430	*32.395*	*32.351*	*32.351*
14	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.384*	32.493	32.429	32.430	*32.393*	*32.351*	*32.351*
15	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.418*	32.489	32.430	32.441	*32.392*	*32.351*	*32.351*
16	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.451*	32.487	32.435	32.436	*32.390*	*32.351*	*32.351*
17	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.485*	32.483	32.435	32.433	*32.388*	*32.351*	*32.351*
18	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.509*	32.478	32.435	32.434	*32.387*	*32.351*	*32.351*
19	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.523*	32.473	32.434	32.435	*32.385*	*32.351*	*32.351*
20	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.531*	32.470	32.433	32.434	*32.383*	*32.351*	*32.351*
21	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.535*	32.467	32.432	*32.433*	*32.382*	*32.351*	*32.351*
22	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	*32.536*	32.461	32.433	*32.431*	*32.380*	*32.351*	*32.351*
23	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.534	32.456	32.442	*32.429*	*32.378*	*32.351*	*32.351*
24	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.530	32.450	32.446	*32.427*	*32.376*	*32.351*	*32.351*
25	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.524	32.445	32.450	*32.426*	*32.375*	*32.351*	*32.351*
26	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.522	32.441	32.450	*32.424*	*32.373*	*32.351*	*32.351*
27	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.518	32.436	32.451	*32.422*	*32.371*	*32.351*	*32.351*
28	*32.351*	*32.351*	*32.351*	*32.351*	*32.351*	32.512	32.432	32.453	*32.421*	*32.370*	*32.351*	*32.351*
29	*32.351*		*32.351*	*32.351*	*32.351*	32.507	32.429	32.455	*32.419*	*32.368*	*32.351*	*32.351*
30	*32.351*		*32.351*	*32.351*	*32.351*	32.506	32.426	32.453	*32.417*	*32.366*	*32.351*	*32.351*
31	*32.351*		*32.351*		*32.351*		32.421	32.453		*32.365*		*32.351*
Mean	32.351	32.351	32.351	32.351	32.351	32.436	32.476	32.435	32.433	32.390	32.353	32.351
Max	32.351	32.351	32.351	32.351	32.351	32.536	32.510	32.455	32.449	32.416	32.363	32.351
Min	32.351	32.351	32.351	32.351	32.351	32.351	32.421	32.417	32.417	32.365	32.351	32.351

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Imniagut Lake, 2019

Drainage Area = 1.31 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.402	27.321	27.305	*27.266*	*27.252*	*27.249*
2	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.400	27.318	27.300	*27.265*	*27.252*	*27.249*
3	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.397	27.318	27.294	*27.265*	*27.251*	*27.249*
4	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.391	27.322	27.288	*27.265*	*27.251*	*27.249*
5	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.386	27.321	27.283	*27.264*	*27.250*	*27.249*
6	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.385	27.318	27.279	*27.264*	*27.250*	*27.249*
7	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.392	27.316	27.275	*27.263*	*27.249*	*27.249*
8	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.399	27.315	27.272	*27.263*	*27.249*	*27.249*
9	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.414	27.322	27.270	*27.262*	*27.249*	*27.249*
10	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.424	27.323	27.267	*27.262*	*27.249*	*27.249*
11	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.422	27.324	27.266	*27.261*	*27.249*	*27.249*
12	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.416	27.323	27.264	*27.261*	*27.249*	*27.249*
13	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.413	27.324	27.262	*27.261*	*27.249*	*27.249*
14	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.283*	27.408	27.323	27.262	*27.260*	*27.249*	*27.249*
15	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.317*	27.403	27.325	27.269	*27.260*	*27.249*	*27.249*
16	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.351*	27.399	27.328	27.269	*27.259*	*27.249*	*27.249*
17	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.385*	27.392	27.329	27.271	*27.259*	*27.249*	*27.249*
18	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.411*	27.386	27.329	27.272	*27.258*	*27.249*	*27.249*
19	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.427*	27.382	27.327	27.272	*27.258*	*27.249*	*27.249*
20	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.435*	27.378	27.324	27.271	*27.257*	*27.249*	*27.249*
21	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.440*	27.375	27.323	*27.270*	*27.257*	*27.249*	*27.249*
22	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	*27.441*	27.369	27.323	*27.270*	*27.257*	*27.249*	*27.249*
23	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.438	27.364	27.334	*27.269*	*27.256*	*27.249*	*27.249*
24	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.437	27.357	27.344	*27.269*	*27.256*	*27.249*	*27.249*
25	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.431	27.352	27.344	*27.269*	*27.255*	*27.249*	*27.249*
26	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.428	27.348	27.339	*27.268*	*27.255*	*27.249*	*27.249*
27	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.420	27.345	27.333	*27.268*	*27.254*	*27.249*	*27.249*
28	*27.249*	*27.249*	*27.249*	*27.249*	*27.249*	27.411	27.340	27.325	*27.267*	*27.254*	*27.249*	*27.249*
29	*27.249*		*27.249*	*27.249*	*27.249*	27.407	27.336	27.323	*27.267*	*27.253*	*27.249*	*27.249*
30	*27.249*		*27.249*	*27.249*	*27.249*	27.404	27.331	27.318	*27.266*	*27.253*	*27.249*	*27.249*
31	*27.249*		*27.249*		*27.249*		27.326	27.313		*27.253*		*27.249*
Mean	27.249	27.249	27.249	27.249	27.249	27.337	27.382	27.325	27.273	27.259	27.249	27.249
Max	27.249	27.249	27.249	27.249	27.249	27.441	27.424	27.344	27.305	27.266	27.252	27.249
Min	27.249	27.249	27.249	27.249	27.249	27.249	27.326	27.313	27.262	27.253	27.249	27.249

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Patch Outflow, 2019

Drainage Area = 32.16 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.650	26.381	26.370	*26.286*	*26.287*	*26.287*
2	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.639	26.376	26.362	*26.286*	*26.287*	*26.287*
3	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.626	26.373	26.357	*26.286*	*26.287*	*26.287*
4	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.612	26.379	26.354	*26.286*	*26.287*	*26.287*
5	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.597	26.375	26.349	*26.286*	*26.287*	*26.287*
6	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.584	26.371	26.347	*26.286*	*26.287*	*26.287*
7	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.580	26.369	26.343	*26.286*	*26.287*	*26.287*
8	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.576	26.366	26.339	*26.286*	*26.287*	*26.287*
9	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.577	26.369	26.337	*26.286*	*26.287*	*26.287*
10	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.572	26.367	26.333	*26.286*	*26.287*	*26.287*
11	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.566	26.363	26.328	*26.286*	*26.287*	*26.287*
12	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.563	26.363	26.326	*26.286*	*26.287*	*26.287*
13	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.560	26.361	26.319	*26.286*	*26.287*	*26.287*
14	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.362*	26.544	26.360	26.317	*26.286*	*26.287*	*26.287*
15	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.437*	26.535	26.360	26.321	*26.286*	*26.287*	*26.287*
16	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.513*	26.527	26.363	26.329	*26.286*	*26.287*	*26.287*
17	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.588*	26.519	26.363	26.314	*26.286*	*26.287*	*26.287*
18	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.682*	26.505	26.361	26.312	*26.287*	*26.287*	*26.287*
19	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.730*	26.493	26.360	26.311	*26.287*	*26.287*	*26.287*
20	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.755*	26.484	26.358	26.308	*26.287*	*26.287*	*26.287*
21	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	*26.775*	26.479	26.359	*26.303*	*26.287*	*26.287*	*26.287*
22	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.778	26.466	26.360	*26.303*	*26.287*	*26.287*	*26.287*
23	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.768	26.458	26.381	*26.298*	*26.287*	*26.287*	*26.287*
24	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.754	26.447	26.371	*26.295*	*26.287*	*26.287*	*26.287*
25	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.739	26.433	26.376	*26.286*	*26.287*	*26.287*	*26.287*
26	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.726	26.424	26.374	*26.286*	*26.287*	*26.287*	*26.287*
27	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.709	26.416	26.373	*26.286*	*26.287*	*26.287*	*26.287*
28	*26.287*	*26.287*	*26.287*	*26.287*	*26.287*	26.691	26.409	26.374	*26.286*	*26.287*	*26.287*	*26.287*
29	*26.287*		*26.287*	*26.287*	*26.287*	26.675	26.404	26.375	*26.286*	*26.287*	*26.287*	*26.287*
30	*26.287*		*26.287*	*26.287*	*26.287*	26.660	26.396	26.372	*26.286*	*26.287*	*26.287*	*26.287*
31	*26.287*		*26.287*		*26.287*		26.388	26.368		*26.287*		*26.287*
Mean	26.287	26.287	26.287	26.287	26.287	26.502	26.517	26.368	26.320	26.286	26.287	26.287
Max	26.287	26.287	26.287	26.287	26.287	26.778	26.650	26.381	26.370	26.287	26.287	26.287
Min	26.287	26.287	26.287	26.287	26.287	26.287	26.388	26.358	26.286	26.286	26.287	26.287

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station PO Outflow, 2019

Drainage Area = 35.30 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.532	26.273	26.305	*26.157*	*26.121*	*26.120*
2	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.522	26.267	26.301	*26.152*	*26.121*	*26.120*
3	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.510	26.266	26.293	*26.158*	*26.121*	*26.120*
4	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.497	26.270	26.285	*26.155*	*26.121*	*26.120*
5	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.484	26.271	26.276	*26.153*	*26.121*	*26.120*
6	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.472	26.271	26.267	*26.149*	*26.120*	*26.120*
7	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.470	26.271	26.259	*26.144*	*26.120*	*26.120*
8	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.472	26.274	26.252	*26.142*	*26.120*	*26.120*
9	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.479	26.283	26.247	*26.136*	*26.120*	*26.120*
10	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.483	26.289	26.240	*26.133*	*26.120*	*26.120*
11	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.474	26.294	26.235	*26.143*	*26.120*	*26.120*
12	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.458	26.294	26.227	*26.148*	*26.120*	*26.120*
13	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.458	26.294	26.222	*26.125*	*26.120*	*26.120*
14	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.207*	26.454	26.295	26.218	*26.125*	*26.120*	*26.120*
15	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.294*	26.444	26.296	26.219	*26.125*	*26.120*	*26.120*
16	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.382*	26.434	26.299	26.218	*26.125*	*26.120*	*26.120*
17	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.469*	26.426	26.303	26.222	*26.125*	*26.120*	*26.120*
18	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.566*	26.415	26.305	26.220	*26.124*	*26.120*	*26.120*
19	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.616*	26.402	26.304	26.219	*26.124*	*26.120*	*26.120*
20	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.642*	26.391	26.301	26.217	*26.124*	*26.120*	*26.120*
21	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	*26.662*	26.383	26.300	26.215	*26.124*	*26.120*	*26.120*
22	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.671	26.373	26.299	*26.208*	*26.124*	*26.120*	*26.120*
23	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.661	26.361	26.312	*26.207*	*26.123*	*26.120*	*26.120*
24	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.643	26.347	26.328	*26.203*	*26.123*	*26.120*	*26.120*
25	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.620	26.337	26.335	*26.200*	*26.123*	*26.120*	*26.120*
26	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.606	26.327	26.335	*26.191*	*26.123*	*26.120*	*26.120*
27	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.592	26.315	26.328	*26.184*	*26.122*	*26.120*	*26.120*
28	*26.120*	*26.120*	*26.120*	*26.120*	*26.120*	26.571	26.305	26.321	*26.178*	*26.122*	*26.120*	*26.120*
29	*26.120*		*26.120*	*26.120*	*26.120*	26.553	26.297	26.319	*26.172*	*26.122*	*26.120*	*26.120*
30	*26.120*		*26.120*	*26.120*	*26.120*	26.539	26.288	26.319	*26.168*	*26.122*	*26.120*	*26.120*
31	*26.120*		*26.120*		*26.120*		26.279	26.312		*26.122*		*26.120*
Mean	26.120	26.120	26.120	26.120	26.120	26.362	26.416	26.298	26.229	26.133	26.120	26.120
Max	26.120	26.120	26.120	26.120	26.120	26.671	26.532	26.335	26.305	26.158	26.121	26.120
Min	26.120	26.120	26.120	26.120	26.120	26.120	26.279	26.266	26.168	26.122	26.120	26.120

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Ogama Outflow, 2019

Drainage Area = 74.93 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.584	24.248	24.281	*24.140*	*24.069*	*24.058*
2	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.568	24.241	24.281	*24.134*	*24.067*	*24.058*
3	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.552	24.242	24.276	*24.141*	*24.066*	*24.058*
4	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.531	24.238	24.272	*24.137*	*24.064*	*24.058*
5	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.510	24.233	24.268	*24.135*	*24.063*	*24.058*
6	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.489	24.228	24.260	*24.130*	*24.061*	*24.058*
7	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.479	24.224	24.252	*24.123*	*24.060*	*24.058*
8	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.474	24.223	24.247	*24.121*	*24.058*	*24.058*
9	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.479	24.227	24.243	*24.112*	*24.058*	*24.058*
10	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.487	24.229	24.233	*24.108*	*24.058*	*24.058*
11	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.484	24.235	24.233	*24.122*	*24.058*	*24.058*
12	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.472	24.233	24.225	*24.129*	*24.058*	*24.058*
13	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.459	24.234	24.223	*24.098*	*24.058*	*24.058*
14	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.164*	24.451	24.235	24.218	*24.096*	*24.058*	*24.058*
15	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.271*	24.441	24.235	24.218	*24.095*	*24.058*	*24.058*
16	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.379*	24.430	24.238	24.212	*24.093*	*24.058*	*24.058*
17	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.487*	24.416	24.241	24.220	*24.092*	*24.058*	*24.058*
18	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.644*	24.405	24.245	24.222	*24.090*	*24.058*	*24.058*
19	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.719*	24.395	24.246	24.223	*24.089*	*24.058*	*24.058*
20	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.755*	24.382	24.246	24.224	*24.087*	*24.058*	*24.058*
21	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.784*	24.370	24.248	24.223	*24.086*	*24.058*	*24.058*
22	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	*24.782*	24.356	24.250	*24.205*	*24.084*	*24.058*	*24.058*
23	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.780	24.343	24.254	*24.204*	*24.083*	*24.058*	*24.058*
24	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.763	24.329	24.275	*24.199*	*24.081*	*24.058*	*24.058*
25	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.730	24.318	24.285	*24.195*	*24.079*	*24.058*	*24.058*
26	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.712	24.307	24.293	*24.184*	*24.078*	*24.058*	*24.058*
27	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.686	24.296	24.294	*24.174*	*24.076*	*24.058*	*24.058*
28	*24.058*	*24.058*	*24.058*	*24.058*	*24.058*	24.657	24.286	24.291	*24.167*	*24.075*	*24.058*	*24.058*
29	*24.058*		*24.058*	*24.058*	*24.058*	24.629	24.276	24.287	*24.159*	*24.073*	*24.058*	*24.058*
30	*24.058*		*24.058*	*24.058*	*24.058*	24.602	24.266	24.286	*24.154*	*24.072*	*24.058*	*24.058*
31	*24.058*		*24.058*		*24.058*		24.255	24.284		*24.070*		*24.058*
Mean	24.058	24.058	24.058	24.058	24.058	24.377	24.416	24.251	24.223	24.101	24.059	24.058
Max	24.058	24.058	24.058	24.058	24.058	24.784	24.584	24.294	24.281	24.141	24.069	24.058
Min	24.058	24.058	24.058	24.058	24.058	24.058	24.255	24.223	24.154	24.070	24.058	24.058

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Doris Lake, 2019

Drainage Area = 90.29 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	21.699	21.706	21.699	21.689	21.706	21.702	22.389	21.965	21.908	21.813	21.752	21.747
2	21.700	21.705	21.692	21.699	21.701	21.706	22.369	21.955	21.906	21.810	21.751	21.747
3	21.694	21.704	21.689	21.705	21.703	21.711	22.345	21.956	21.901	21.814	21.748	21.745
4	21.697	21.702	21.687	21.699	21.704	21.714	22.323	21.946	21.898	21.812	21.748	21.745
5	21.700	21.701	21.691	21.698	21.703	21.718	22.301	21.937	21.896	21.810	21.746	21.749
6	21.704	21.697	21.690	21.703	21.700	21.725	22.281	21.930	21.894	21.808	21.744	21.745
7	21.704	21.696	21.689	21.704	21.698	21.730	22.267	21.924	21.888	21.804	21.748	21.748
8	21.705	21.698	21.685	21.695	21.703	21.736	22.253	21.922	21.887	21.803	21.738	21.750
9	21.703	21.696	21.693	21.695	21.702	21.745	22.252	21.922	21.885	21.799	21.740	21.745
10	21.710	21.689	21.690	21.691	21.697	21.755	22.249	21.917	21.875	21.797	21.742	21.749
11	21.714	21.696	21.689	21.698	21.697	21.762	22.239	21.915	21.877	21.804	21.737	21.746
12	21.705	21.700	21.687	21.699	21.698	21.787	22.227	21.909	21.868	21.807	21.731	21.743
13	21.708	21.693	21.684	21.705	21.697	21.820	22.218	21.906	21.867	21.792	21.734	21.745
14	21.712	21.687	21.689	21.708	21.696	21.877	22.206	21.904	21.864	21.800	21.732	21.742
15	21.707	21.696	21.698	21.710	21.697	21.927	22.195	21.901	21.866	21.801	21.735	21.742
16	21.704	21.698	21.691	21.709	21.699	22.062	22.184	21.900	21.858	21.799	21.734	21.741
17	21.703	21.704	21.691	21.707	21.701	22.290	22.168	21.898	21.861	21.794	21.737	21.744
18	21.701	21.705	21.690	21.708	21.699	22.437	22.154	21.898	21.859	21.789	21.733	21.747
19	21.700	21.701	21.691	21.705	21.699	22.524	22.142	21.896	21.857	21.785	21.736	21.744
20	21.703	21.703	21.679	21.704	21.696	22.571	22.129	21.896	21.856	21.783	21.745	21.745
21	21.704	21.698	21.693	21.704	21.698	22.596	22.115	21.899	21.856	21.779	21.741	21.741
22	21.708	21.687	21.682	21.707	21.699	22.600	22.102	21.899	21.854	21.775	21.739	21.739
23	21.708	21.696	21.692	21.704	21.699	22.587	22.088	21.898	21.851	21.775	21.737	21.744
24	21.709	21.699	21.699	21.705	21.698	22.568	22.071	21.909	21.847	21.773	21.735	21.734
25	21.712	21.695	21.693	21.702	21.700	22.546	22.056	21.909	21.845	21.763	21.741	21.735
26	21.709	21.690	21.685	21.705	21.696	22.521	22.043	21.914	21.838	21.767	21.740	21.735
27	21.703	21.688	21.692	21.701	21.696	22.497	22.030	21.914	21.832	21.762	21.745	21.728
28	21.705	21.699	21.692	21.706	21.697	22.469	22.017	21.911	21.828	21.763	21.743	21.737
29	21.709		21.683	21.707	21.696	22.442	22.003	21.915	21.823	21.768	21.733	21.736
30	21.711		21.685	21.707	21.698	22.413	21.988	21.913	21.821	21.754	21.740	21.744
31	21.708		21.694		21.699		21.975	21.911		21.751		21.731
Mean	21.705	21.698	21.690	21.703	21.699	22.118	22.173	21.916	21.866	21.789	21.740	21.742
Max	21.714	21.706	21.699	21.710	21.706	22.600	22.389	21.965	21.908	21.814	21.752	21.750
Min	21.694	21.687	21.679	21.689	21.696	21.702	21.975	21.896	21.821	21.751	21.731	21.728

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Roberts Hydro-2, 2019

Drainage Area = 97.83 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*6.121*	*6.128*	*6.131*	*6.129*	*6.150*	*6.145*	6.756	6.421	6.435	*6.284*	*6.156*	*6.130*
2	*6.122*	*6.129*	*6.122*	*6.137*	*6.144*	*6.147*	6.727	6.414	6.431	*6.277*	*6.152*	*6.130*
3	*6.120*	*6.127*	*6.119*	*6.143*	*6.145*	*6.146*	6.704	6.421	6.425	*6.285*	*6.149*	*6.130*
4	*6.119*	*6.125*	*6.119*	*6.137*	*6.147*	*6.147*	6.685	6.413	6.421	*6.281*	*6.145*	*6.130*
5	*6.122*	*6.124*	*6.121*	*6.139*	*6.147*	*6.147*	6.666	6.408	6.418	*6.278*	*6.141*	*6.130*
6	*6.127*	*6.122*	*6.121*	*6.143*	*6.145*	*6.147*	6.647	6.404	6.412	*6.271*	*6.137*	*6.130*
7	*6.127*	*6.121*	*6.121*	*6.143*	*6.144*	*6.168*	6.636	6.403	6.406	*6.262*	*6.134*	*6.130*
8	*6.127*	*6.119*	*6.120*	*6.134*	*6.147*	*6.187*	6.628	6.404	6.402	*6.259*	*6.130*	*6.130*
9	*6.122*	*6.117*	*6.125*	*6.133*	*6.146*	*6.201*	6.631	6.407	6.397	*6.248*	*6.130*	*6.130*
10	*6.127*	*6.116*	*6.122*	*6.131*	*6.143*	*6.218*	6.634	6.410	6.391	*6.242*	*6.130*	*6.130*
11	*6.129*	*6.123*	*6.123*	*6.137*	*6.143*	*6.238*	6.630	6.415	6.391	*6.261*	*6.130*	*6.130*
12	*6.122*	*6.124*	*6.123*	*6.138*	*6.143*	*6.280*	6.625	6.409	6.383	*6.270*	*6.130*	*6.130*
13	*6.126*	*6.121*	*6.120*	*6.144*	*6.142*	*6.349*	6.618	6.408	6.384	*6.227*	*6.130*	*6.130*
14	*6.129*	*6.117*	*6.124*	*6.149*	*6.142*	*6.481*	6.619	6.410	6.378	*6.223*	*6.130*	*6.130*
15	*6.122*	*6.126*	*6.133*	*6.151*	*6.143*	*6.613*	6.619	6.409	6.378	*6.219*	*6.130*	*6.130*
16	*6.118*	*6.129*	*6.126*	*6.150*	*6.145*	*6.757*	6.608	6.410	6.373	*6.216*	*6.130*	*6.130*
17	*6.118*	*6.130*	*6.127*	*6.148*	*6.147*	6.837	6.597	6.411	6.378	*6.212*	*6.130*	*6.130*
18	*6.118*	*6.132*	*6.123*	*6.148*	*6.146*	6.876	6.584	6.412	6.373	*6.208*	*6.130*	*6.130*
19	*6.116*	*6.131*	*6.125*	*6.148*	*6.145*	6.896	6.573	6.413	6.369	*6.204*	*6.130*	*6.130*
20	*6.120*	*6.132*	*6.116*	*6.147*	*6.144*	6.900	6.559	6.413	6.368	*6.201*	*6.130*	*6.130*
21	*6.123*	*6.125*	*6.127*	*6.146*	*6.146*	6.885	6.545	6.414	6.366	*6.197*	*6.130*	*6.130*
22	*6.128*	*6.119*	*6.122*	*6.148*	*6.146*	6.858	6.535	6.415	*6.357*	*6.193*	*6.130*	*6.130*
23	*6.127*	*6.126*	*6.129*	*6.147*	*6.146*	6.834	6.521	6.413	*6.356*	*6.190*	*6.130*	*6.130*
24	*6.128*	*6.129*	*6.133*	*6.147*	*6.145*	6.805	6.508	6.436	*6.351*	*6.186*	*6.130*	*6.130*
25	*6.131*	*6.124*	*6.127*	*6.145*	*6.145*	6.776	6.494	6.439	*6.347*	*6.182*	*6.130*	*6.130*
26	*6.129*	*6.120*	*6.122*	*6.147*	*6.142*	6.787	6.482	6.445	*6.335*	*6.178*	*6.130*	*6.130*
27	*6.127*	*6.123*	*6.129*	*6.145*	*6.143*	6.859	6.472	6.446	*6.324*	*6.175*	*6.130*	*6.130*
28	*6.126*	*6.132*	*6.129*	*6.150*	*6.143*	6.839	6.459	6.445	*6.315*	*6.171*	*6.130*	*6.130*
29	*6.128*		*6.119*	*6.150*	*6.143*	6.812	6.448	6.447	*6.306*	*6.167*	*6.130*	*6.130*
30	*6.131*		*6.121*	*6.150*	*6.143*	6.786	6.437	6.443	*6.300*	*6.163*	*6.130*	*6.130*
31	*6.131*		*6.130*		*6.144*		6.429	6.439		*6.160*		*6.130*
Mean	6.125	6.125	6.124	6.143	6.145	6.537	6.583	6.419	6.376	6.222	6.133	6.130
Max	6.131	6.132	6.133	6.151	6.150	6.900	6.756	6.447	6.435	6.285	6.156	6.130
Min	6.116	6.116	6.116	6.129	6.142	6.145	6.429	6.403	6.300	6.160	6.130	6.130

Note: Estimated and modelled values are italicized

Appendix C: Mean Daily Lake Water Levels

Summary of Mean Daily Water Level (m) at Hydrometric Station Little Roberts Outflow, 2019

Drainage Area = 6.03 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	5.355	*4.813*	4.777	*4.635*	*4.530*	*4.501*
2	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.505*	5.324	*4.808*	4.768	*4.632*	*4.526*	*4.501*
3	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.511*	5.290	*4.803*	4.762	*4.636*	*4.522*	*4.501*
4	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.515*	5.254	*4.798*	4.755	*4.634*	*4.517*	*4.501*
5	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.520*	5.219	*4.792*	4.749	*4.633*	*4.513*	*4.501*
6	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.528*	5.185	*4.787*	4.743	*4.629*	*4.509*	*4.501*
7	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.535*	5.164	*4.782*	4.736	*4.625*	*4.505*	*4.501*
8	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.541*	5.145	*4.777*	4.730	*4.624*	*4.501*	*4.501*
9	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.553*	5.149	*4.771*	4.726	*4.619*	*4.501*	*4.501*
10	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.565*	5.143	4.766	4.717	*4.616*	*4.501*	*4.501*
11	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.573*	5.129	4.763	4.712	*4.624*	*4.501*	*4.501*
12	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.604*	5.116	4.758	4.706	*4.628*	*4.501*	*4.501*
13	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.644*	5.102	4.755	4.699	*4.611*	*4.501*	*4.501*
14	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.713*	5.084	4.752	4.694	*4.606*	*4.501*	*4.501*
15	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.774*	5.063	4.752	4.702	*4.602*	*4.501*	*4.501*
16	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*4.939*	5.043	4.754	4.699	*4.598*	*4.501*	*4.501*
17	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*5.216*	5.024	4.755	4.696	*4.593*	*4.501*	*4.501*
18	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*5.396*	4.998	4.752	4.694	*4.589*	*4.501*	*4.501*
19	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*5.501*	4.973	4.748	4.692	*4.585*	*4.501*	*4.501*
20	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*5.559*	4.949	4.745	4.688	*4.581*	*4.501*	*4.501*
21	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*5.590*	4.927	4.749	4.682	*4.576*	*4.501*	*4.501*
22	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*5.594*	4.903	4.750	4.677	*4.572*	*4.501*	*4.501*
23	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	*5.579*	4.878	4.784	*4.682*	*4.568*	*4.501*	*4.501*
24	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	5.614	4.856	4.792	*4.678*	*4.564*	*4.501*	*4.501*
25	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	5.590	*4.850*	4.790	*4.675*	*4.559*	*4.501*	*4.501*
26	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	5.565	*4.845*	4.789	*4.666*	*4.555*	*4.501*	*4.501*
27	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	5.528	*4.840*	4.789	*4.659*	*4.551*	*4.501*	*4.501*
28	*4.501*	*4.501*	*4.501*	*4.501*	*4.501*	5.481	*4.835*	4.787	*4.654*	*4.547*	*4.501*	*4.501*
29	*4.501*		*4.501*	*4.501*	*4.501*	5.440	*4.829*	4.793	*4.648*	*4.543*	*4.501*	*4.501*
30	*4.501*		*4.501*	*4.501*	*4.501*	5.392	*4.824*	4.789	*4.645*	*4.538*	*4.501*	*4.501*
31	*4.501*		*4.501*		*4.501*		*4.819*	4.784		*4.534*		*4.501*
Mean	4.501	4.501	4.501	4.501	4.501	5.019	5.036	4.775	4.704	4.594	4.504	4.501
Max	4.501	4.501	4.501	4.501	4.501	5.614	5.355	4.813	4.777	4.636	4.530	4.501
Min	4.501	4.501	4.501	4.501	4.501	4.501	4.819	4.745	4.645	4.534	4.501	4.501

Note: Estimated and modelled values are italicized

APPENDIX D MEAN DAILY DISCHARGE TABLES

Appendix D: Mean Daily Discharge Tables

Summary of Daily Discharge [Q, m^3/s] at Hydrometric Station Windy Outflow, 2019

Drainage Area = 13.73 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	0.529	0.198	0.117	*0.027*	*0.002*	-
2	-	-	-	-	-	-	0.525	0.192	0.111	*0.024*	*0.002*	-
3	-	-	-	-	-	-	0.512	0.186	0.104	*0.028*	*0.001*	-
4	-	-	-	-	-	-	0.491	0.179	0.102	*0.026*	*0.001*	-
5	-	-	-	-	-	-	0.469	0.173	0.100	*0.025*	*0.001*	-
6	-	-	-	-	-	-	0.452	0.168	0.094	*0.022*	*0.001*	-
7	-	-	-	-	-	-	0.455	0.162	0.090	*0.019*	*0.001*	-
8	-	-	-	-	-	-	0.452	0.156	0.090	*0.018*	*0.001*	-
9	-	-	-	-	-	-	0.476	0.151	0.088	*0.014*	-	-
10	-	-	-	-	-	-	0.475	0.145	0.080	*0.012*	-	-
11	-	-	-	-	-	-	0.461	0.145	0.086	*0.019*	-	-
12	-	-	-	-	-	-	0.448	0.140	0.078	*0.022*	-	-
13	-	-	-	-	-	*0.010*	0.443	0.142	0.075	*0.008*	-	-
14	-	-	-	-	-	*0.026*	0.428	0.141	0.075	*0.007*	-	-
15	-	-	-	-	-	*0.068*	0.420	0.138	0.079	*0.007*	-	-
16	-	-	-	-	-	*0.179*	0.395	0.141	0.072	*0.006*	-	-
17	-	-	-	-	-	*0.467*	0.380	0.137	0.073	*0.006*	-	-
18	-	-	-	-	-	*0.568*	0.365	0.135	0.071	*0.005*	-	-
19	-	-	-	-	-	*0.628*	0.350	0.132	0.070	*0.005*	-	-
20	-	-	-	-	-	*0.660*	0.332	0.134	0.067	*0.005*	-	-
21	-	-	-	-	-	*0.686*	0.321	0.130	*0.065*	*0.004*	-	-
22	-	-	-	-	-	*0.685*	0.306	0.140	*0.063*	*0.004*	-	-
23	-	-	-	-	-	*0.677*	0.283	0.142	*0.062*	*0.004*	-	-
24	-	-	-	-	-	0.659	0.269	0.155	*0.059*	*0.003*	-	-
25	-	-	-	-	-	0.643	0.253	0.149	*0.057*	*0.003*	-	-
26	-	-	-	-	-	0.627	0.239	0.152	*0.051*	*0.003*	-	-
27	-	-	-	-	-	0.611	0.232	0.146	*0.045*	*0.003*	-	-
28	-	-	-	-	-	0.578	0.225	0.141	*0.041*	*0.002*	-	-
29	-		-	-	-	0.550	0.218	0.141	*0.037*	*0.002*	-	-
30	-		-	-	-	0.535	0.211	0.133	*0.034*	*0.002*	-	-
31	-		-		-		0.205	0.122		*0.002*		-
Mean	0.000	0.000	0.000	0.000	0.000	0.492	0.375	0.150	0.075	0.011	0.001	0.000
Max	0.000	0.000	0.000	0.000	0.000	0.686	0.529	0.198	0.117	0.028	0.002	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.010	0.205	0.122	0.034	0.002	0.001	0.000

Note: Estimated and modelled values are italicized

Values in red denote high uncertainty based on extrapolation of the rating curve beyond 2 times the greatest measured discharge.

Appendix D: Mean Daily Discharge Tables

Summary of Daily Discharge [Q, m^3/s] at Hydrometric Station Patch Outflow, 2019

Drainage Area = 32.16 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	1.464	0.331	0.309	*0.110*	*0.010*	-
2	-	-	-	-	-	-	1.398	0.321	0.293	*0.104*	*0.009*	-
3	-	-	-	-	-	-	1.330	0.315	0.283	*0.111*	*0.008*	-
4	-	-	-	-	-	-	1.254	0.327	0.278	*0.107*	*0.007*	-
5	-	-	-	-	-	-	1.177	0.319	0.269	*0.105*	*0.007*	-
6	-	-	-	-	-	-	1.110	0.312	0.264	*0.099*	*0.006*	-
7	-	-	-	-	-	-	1.090	0.306	0.257	*0.092*	*0.006*	-
8	-	-	-	-	-	-	1.066	0.302	0.249	*0.090*	*0.005*	-
9	-	-	-	-	-	-	1.072	0.307	0.247	*0.082*	-	-
10	-	-	-	-	-	-	1.050	0.304	0.240	*0.078*	-	-
11	-	-	-	-	-	-	1.019	0.296	0.230	*0.092*	-	-
12	-	-	-	-	-	-	1.004	0.295	0.227	*0.098*	-	-
13	-	-	-	-	-	*0.010*	0.993	0.291	0.215	*0.068*	-	-
14	-	-	-	-	-	*0.033*	0.917	0.288	0.211	*0.062*	-	-
15	-	-	-	-	-	*0.106*	0.875	0.288	0.219	*0.056*	-	-
16	-	-	-	-	-	*0.347*	0.843	0.294	0.234	*0.051*	-	-
17	-	-	-	-	-	*1.130*	0.808	0.295	0.207	*0.046*	-	-
18	-	-	-	-	-	*1.650*	0.747	0.291	0.203	*0.041*	-	-
19	-	-	-	-	-	*1.957*	0.697	0.289	0.200	*0.037*	-	-
20	-	-	-	-	-	*2.123*	0.663	0.286	0.195	*0.034*	-	-
21	-	-	-	-	-	*2.260*	0.646	0.286	*0.193*	*0.031*	-	-
22	-	-	-	-	-	2.284	0.596	0.289	*0.188*	*0.028*	-	-
23	-	-	-	-	-	2.209	0.568	0.345	*0.187*	*0.025*	-	-
24	-	-	-	-	-	2.112	0.527	0.310	*0.180*	*0.023*	-	-
25	-	-	-	-	-	2.012	0.479	0.322	*0.175*	*0.020*	-	-
26	-	-	-	-	-	1.925	0.449	0.317	*0.161*	*0.019*	-	-
27	-	-	-	-	-	1.821	0.423	0.315	*0.149*	*0.017*	-	-
28	-	-	-	-	-	1.706	0.403	0.316	*0.140*	*0.015*	-	-
29	-		-	-	-	1.611	0.387	0.320	*0.131*	*0.014*	-	-
30	-		-	-	-	1.522	0.366	0.314	*0.125*	*0.012*	-	-
31	-		-		-		0.346	0.306		*0.011*		-
Mean	0.000	0.000	0.000	0.000	0.000	1.490	0.831	0.306	0.215	0.057	0.007	0.000
Max	0.000	0.000	0.000	0.000	0.000	2.284	1.464	0.345	0.309	0.111	0.010	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.010	0.346	0.286	0.125	0.011	0.005	0.000

Note: Estimated and modelled values are italicized

Values in red denote high uncertainty based on extrapolation of the rating curve beyond 2 times the greatest measured discharge.

Appendix D: Mean Daily Discharge Tables

Summary of Daily Discharge [Q, m^3/s] at Hydrometric Station PO Outflow, 2019

Drainage Area = 35.30 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	1.623	0.418	0.527	*0.205*	*0.021*	-
2	-	-	-	-	-	-	1.560	0.404	0.512	*0.198*	*0.019*	-
3	-	-	-	-	-	-	1.491	0.403	0.484	*0.206*	*0.017*	-
4	-	-	-	-	-	-	1.416	0.411	0.457	*0.202*	*0.015*	-
5	-	-	-	-	-	-	1.339	0.412	0.429	*0.200*	*0.014*	-
6	-	-	-	-	-	-	1.272	0.413	0.405	*0.194*	*0.012*	-
7	-	-	-	-	-	-	1.260	0.414	0.388	*0.186*	*0.011*	-
8	-	-	-	-	-	-	1.274	0.421	0.373	*0.183*	*0.010*	-
9	-	-	-	-	-	-	1.313	0.450	0.363	*0.174*	-	-
10	-	-	-	-	-	-	1.334	0.470	0.349	*0.170*	-	-
11	-	-	-	-	-	-	1.284	0.487	0.340	*0.185*	-	-
12	-	-	-	-	-	-	1.196	0.487	0.325	*0.192*	-	-
13	-	-	-	-	-	*0.010*	1.198	0.489	0.315	*0.160*	-	-
14	-	-	-	-	-	*0.033*	1.178	0.492	0.307	*0.144*	-	-
15	-	-	-	-	-	*0.112*	1.123	0.493	0.310	*0.129*	-	-
16	-	-	-	-	-	*0.376*	1.074	0.505	0.308	*0.116*	-	-
17	-	-	-	-	-	*1.258*	1.034	0.520	0.314	*0.104*	-	-
18	-	-	-	-	-	*1.843*	0.979	0.525	0.312	*0.094*	-	-
19	-	-	-	-	-	*2.188*	0.918	0.521	0.310	*0.084*	-	-
20	-	-	-	-	-	*2.374*	0.869	0.511	0.307	*0.076*	-	-
21	-	-	-	-	-	*2.527*	0.833	0.508	0.302	*0.068*	-	-
22	-	-	-	-	-	2.598	0.790	0.504	*0.289*	*0.061*	-	-
23	-	-	-	-	-	2.520	0.738	0.553	*0.288*	*0.055*	-	-
24	-	-	-	-	-	2.381	0.683	0.607	*0.281*	*0.050*	-	-
25	-	-	-	-	-	2.215	0.645	0.634	*0.275*	*0.045*	-	-
26	-	-	-	-	-	2.113	0.606	0.637	*0.260*	*0.040*	-	-
27	-	-	-	-	-	2.019	0.560	0.609	*0.248*	*0.036*	-	-
28	-	-	-	-	-	1.874	0.527	0.583	*0.238*	*0.032*	-	-
29	-		-	-	-	1.755	0.497	0.576	*0.228*	*0.029*	-	-
30	-		-	-	-	1.669	0.467	0.574	*0.222*	*0.026*	-	-
31	-		-		-		0.440	0.552		*0.023*		-
Mean	0.000	0.000	0.000	0.000	0.000	1.659	1.017	0.503	0.335	0.118	0.015	0.000
Max	0.000	0.000	0.000	0.000	0.000	2.598	1.623	0.637	0.527	0.206	0.021	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.010	0.440	0.403	0.222	0.023	0.010	0.000

Note: Estimated and modelled values are italicized

Values in red denote high uncertainty based on extrapolation of the rating curve beyond 2 times the greatest measured discharge.

Appendix D: Mean Daily Discharge Tables

Summary of Daily Discharge [Q, m^3/s] at Hydrometric Station Ogama Outflow, 2019

Drainage Area = 74.93 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	2.860	0.576	0.680	*0.297*	*0.023*	-
2	-	-	-	-	-	-	2.702	0.555	0.680	*0.284*	*0.020*	-
3	-	-	-	-	-	-	2.538	0.560	0.665	*0.299*	*0.018*	-
4	-	-	-	-	-	-	2.344	0.545	0.652	*0.291*	*0.016*	-
5	-	-	-	-	-	-	2.152	0.532	0.637	*0.287*	*0.014*	-
6	-	-	-	-	-	-	1.974	0.518	0.615	*0.276*	*0.013*	-
7	-	-	-	-	-	-	1.888	0.507	0.589	*0.261*	*0.011*	-
8	-	-	-	-	-	-	1.843	0.503	0.575	*0.257*	*0.010*	-
9	-	-	-	-	-	-	1.885	0.514	0.561	*0.240*	-	-
10	-	-	-	-	-	-	1.954	0.520	0.533	*0.233*	-	-
11	-	-	-	-	-	-	1.925	0.536	0.531	*0.260*	-	-
12	-	-	-	-	-	-	1.828	0.533	0.509	*0.273*	-	-
13	-	-	-	-	-	*0.010*	1.726	0.534	0.503	*0.213*	-	-
14	-	-	-	-	-	*0.037*	1.667	0.539	0.488	*0.190*	-	-
15	-	-	-	-	-	*0.140*	1.594	0.538	0.490	*0.169*	-	-
16	-	-	-	-	-	*0.522*	1.510	0.546	0.474	*0.150*	-	-
17	-	-	-	-	-	*1.952*	1.410	0.557	0.495	*0.133*	-	-
18	-	-	-	-	-	*3.525*	1.336	0.568	0.500	*0.119*	-	-
19	-	-	-	-	-	*4.452*	1.268	0.570	0.505	*0.105*	-	-
20	-	-	-	-	-	*4.954*	1.185	0.571	0.506	*0.094*	-	-
21	-	-	-	-	-	*5.366*	1.111	0.575	0.503	*0.083*	-	-
22	-	-	-	-	-	*5.336*	1.030	0.584	*0.453*	*0.074*	-	-
23	-	-	-	-	-	5.309	0.955	0.596	*0.451*	*0.066*	-	-
24	-	-	-	-	-	5.056	0.876	0.662	*0.437*	*0.058*	-	-
25	-	-	-	-	-	4.606	0.819	0.693	*0.427*	*0.052*	-	-
26	-	-	-	-	-	4.365	0.771	0.720	*0.399*	*0.046*	-	-
27	-	-	-	-	-	4.034	0.732	0.723	*0.376*	*0.041*	-	-
28	-	-	-	-	-	3.680	0.696	0.713	*0.357*	*0.037*	-	-
29	-		-	-	-	3.345	0.663	0.702	*0.339*	*0.032*	-	-
30	-		-	-	-	3.054	0.631	0.698	*0.328*	*0.029*	-	-
31	-		-		-		0.599	0.690		*0.026*		-
Mean	0.000	0.000	0.000	0.000	0.000	3.319	1.499	0.586	0.509	0.160	0.016	0.000
Max	0.000	0.000	0.000	0.000	0.000	5.366	2.860	0.723	0.680	0.299	0.023	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.010	0.599	0.503	0.328	0.026	0.010	0.000

Note: Estimated and modelled values are italicized

Values in red denote high uncertainty based on extrapolation of the rating curve beyond 2 times the greatest measured discharge.

Appendix D: Mean Daily Discharge Tables

Summary of Daily Discharge [Q, m^3/s] at Hydrometric Station Doris Creek TL-2, 2019

Drainage Area = 90.29 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	4.097	1.047	0.693	*0.357*	*0.025*	-
2	-	-	-	-	-	-	3.901	0.997	0.688	*0.346*	*0.022*	-
3	-	-	-	-	-	-	3.706	0.960	0.680	*0.359*	*0.019*	-
4	-	-	-	-	-	-	3.498	0.947	0.669	*0.352*	*0.017*	-
5	-	-	-	-	-	-	3.313	0.912	0.662	*0.348*	*0.015*	-
6	-	-	-	-	-	-	3.129	0.874	0.652	*0.338*	*0.013*	-
7	-	-	-	-	-	-	3.014	0.839	0.636	*0.324*	*0.011*	-
8	-	-	-	-	-	-	2.890	0.814	0.628	*0.321*	*0.010*	-
9	-	-	-	-	-	-	2.895	0.813	0.623	*0.305*	-	-
10	-	-	-	-	-	-	2.871	0.791	0.592	*0.299*	-	-
11	-	-	-	-	-	-	2.786	0.779	0.593	*0.324*	-	-
12	-	-	-	-	-	-	2.698	0.755	0.567	*0.336*	-	-
13	-	-	-	-	-	*0.010*	2.600	0.735	0.557	*0.281*	-	-
14	-	-	-	-	-	*0.042*	2.522	0.726	0.546	*0.247*	-	-
15	-	-	-	-	-	*0.176*	2.433	0.714	0.555	*0.217*	-	-
16	-	-	-	-	-	*0.736*	2.346	0.709	0.533	*0.191*	-	-
17	-	-	-	-	-	*3.084*	2.236	0.703	0.536	*0.168*	-	-
18	-	-	-	-	-	*4.844*	2.149	0.694	0.532	*0.148*	-	-
19	-	-	-	-	-	*5.881*	2.057	0.684	0.527	*0.130*	-	-
20	-	-	-	-	-	*6.443*	1.965	0.680	0.520	*0.114*	-	-
21	-	-	-	-	-	6.904	1.869	0.685	0.510	*0.101*	-	-
22	-	-	-	-	-	6.870	1.768	0.680	0.500	*0.089*	-	-
23	-	-	-	-	-	6.735	1.664	0.708	*0.499*	*0.078*	-	-
24	-	-	-	-	-	6.444	1.552	0.731	*0.486*	*0.069*	-	-
25	-	-	-	-	-	6.142	1.476	0.732	*0.477*	*0.060*	-	-
26	-	-	-	-	-	5.842	1.413	0.746	*0.451*	*0.053*	-	-
27	-	-	-	-	-	5.459	1.345	0.742	*0.430*	*0.047*	-	-
28	-	-	-	-	-	5.085	1.286	0.733	*0.413*	*0.041*	-	-
29	-		-	-	-	4.688	1.222	0.732	*0.396*	*0.036*	-	-
30	-		-	-	-	4.356	1.154	0.721	*0.386*	*0.032*	-	-
31	-		-		-		1.092	0.712		*0.028*		-
Mean	0.000	0.000	0.000	0.000	0.000	4.430	2.353	0.777	0.551	0.198	0.016	0.000
Max	0.000	0.000	0.000	0.000	0.000	6.904	4.097	1.047	0.693	0.359	0.025	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.010	1.092	0.680	0.386	0.028	0.010	0.000

Note: Estimated and modelled values are italicized

Values in red denote high uncertainty based on extrapolation of the rating curve beyond 2 times the greatest measured discharge.

Appendix D: Mean Daily Discharge Tables

Summary of Daily Discharge [Q, m^3/s] at Hydrometric Station Roberts Hydro-2, 2019

Drainage Area = 97.83 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	3.988	0.684	0.743	*0.214*	*0.019*	-
2	-	-	-	-	-	-	3.553	0.653	0.725	*0.197*	*0.017*	-
3	-	-	-	-	-	-	3.242	0.685	0.701	*0.217*	*0.016*	-
4	-	-	-	-	-	-	2.978	0.648	0.681	*0.206*	*0.014*	-
5	-	-	-	-	-	-	2.738	0.627	0.669	*0.200*	*0.013*	-
6	-	-	-	-	-	-	2.504	0.612	0.644	*0.185*	*0.012*	-
7	-	-	-	-	-	-	2.383	0.605	0.616	*0.164*	*0.011*	-
8	-	-	-	-	-	-	2.293	0.611	0.603	*0.159*	*0.010*	-
9	-	-	-	-	-	-	2.317	0.624	0.583	*0.136*	-	-
10	-	-	-	-	-	-	2.359	0.634	0.555	*0.125*	-	-
11	-	-	-	-	-	-	2.316	0.654	0.555	*0.163*	-	-
12	-	-	-	-	-	-	2.252	0.630	0.524	*0.181*	-	-
13	-	-	-	-	-	0.010	2.181	0.626	0.528	*0.099*	-	-
14	-	-	-	-	-	0.048	2.193	0.636	0.505	*0.090*	-	-
15	-	-	-	-	-	0.231	2.187	0.631	0.507	*0.083*	-	-
16	-	-	-	-	-	1.112	2.072	0.636	0.487	*0.076*	-	-
17	-	-	-	-	-	5.349	1.953	0.637	0.505	*0.069*	-	-
18	-	-	-	-	-	6.078	1.826	0.645	0.487	*0.064*	-	-
19	-	-	-	-	-	6.463	1.716	0.648	0.471	*0.058*	-	-
20	-	-	-	-	-	6.549	1.581	0.647	0.469	*0.053*	-	-
21	-	-	-	-	-	6.259	1.458	0.653	0.462	*0.049*	-	-
22	-	-	-	-	-	5.740	1.375	0.658	*0.431*	*0.045*	-	-
23	-	-	-	-	-	5.297	1.259	0.648	*0.428*	*0.041*	-	-
24	-	-	-	-	-	4.788	1.151	0.752	*0.408*	*0.037*	-	-
25	-	-	-	-	-	4.312	1.053	0.764	*0.395*	*0.034*	-	-
26	-	-	-	-	-	4.485	0.976	0.791	*0.356*	*0.031*	-	-
27	-	-	-	-	-	5.756	0.923	0.797	*0.324*	*0.029*	-	-
28	-	-	-	-	-	5.389	0.859	0.792	*0.298*	*0.026*	-	-
29	-		-	-	-	4.906	0.804	0.800	*0.273*	*0.024*	-	-
30	-		-	-	-	4.461	0.755	0.781	*0.257*	*0.022*	-	-
31	-		-		-		0.717	0.763		*0.020*		-
Mean	0.000	0.000	0.000	0.000	0.000	4.291	1.934	0.677	0.506	0.100	0.014	0.000
Max	0.000	0.000	0.000	0.000	0.000	6.549	3.988	0.800	0.743	0.217	0.019	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.010	0.717	0.605	0.257	0.020	0.010	0.000

Note: Estimated and modelled values are italicized

Values in red denote high uncertainty based on extrapolation of the rating curve beyond 2 times the greatest measured discharge.

Appendix D: Mean Daily Discharge Tables

Summary of Daily Discharge [Q, m^3/s] at Hydrometric Station Little Roberts Outflow, 2019

Drainage Area = 6.03 km^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	*8.344*	*1.786*	1.489	*0.794*	*0.031*	-
2	-	-	-	-	-	-	*7.693*	*1.703*	1.452	*0.772*	*0.026*	-
3	-	-	-	-	-	-	*7.170*	*1.698*	1.427	*0.798*	*0.022*	-
4	-	-	-	-	-	-	*6.683*	*1.646*	1.398	*0.784*	*0.019*	-
5	-	-	-	-	-	-	*6.244*	*1.588*	1.371	*0.776*	*0.016*	-
6	-	-	-	-	-	-	*5.814*	*1.533*	1.348	*0.756*	*0.014*	-
7	-	-	-	-	-	-	*5.571*	*1.490*	1.320	*0.729*	*0.012*	-
8	-	-	-	-	-	-	*5.349*	*1.470*	1.295	*0.722*	*0.010*	-
9	-	-	-	-	-	-	*5.380*	*1.483*	1.279	*0.692*	-	-
10	-	-	-	-	-	-	*5.397*	1.445	1.243	*0.679*	-	-
11	-	-	-	-	-	-	*5.266*	1.431	1.225	*0.728*	-	-
12	-	-	-	-	-	-	*5.109*	1.409	1.199	*0.752*	-	-
13	-	-	-	-	-	*0.010*	*4.935*	1.397	1.173	*0.644*	-	-
14	-	-	-	-	-	*0.054*	*4.865*	1.385	1.155	*0.549*	-	-
15	-	-	-	-	-	*0.295*	*4.768*	1.383	1.185	*0.468*	-	-
16	-	-	-	-	-	*1.602*	*4.560*	1.393	1.175	*0.398*	-	-
17	-	-	-	-	-	*8.704*	*4.324*	1.397	1.164	*0.339*	-	-
18	-	-	-	-	-	*11.272*	*4.102*	1.384	1.155	*0.289*	-	-
19	-	-	-	-	-	*12.741*	*3.894*	1.369	1.148	*0.246*	-	-
20	-	-	-	-	-	*13.409*	*3.660*	1.356	1.133	*0.210*	-	-
21	-	-	-	-	-	*13.584*	*3.434*	1.371	1.111	*0.179*	-	-
22	-	-	-	-	-	*13.014*	*3.244*	1.377	1.090	*0.152*	-	-
23	-	-	-	-	-	*12.418*	*3.017*	1.524	*1.072*	*0.130*	-	-
24	-	-	-	-	-	*11.592*	*2.790*	1.556	*1.046*	*0.111*	-	-
25	-	-	-	-	-	*10.788*	*2.610*	1.549	*1.029*	*0.094*	-	-
26	-	-	-	-	-	*10.659*	*2.466*	1.545	*0.978*	*0.080*	-	-
27	-	-	-	-	-	*11.575*	*2.340*	1.543	*0.936*	*0.068*	-	-
28	-	-	-	-	-	*10.810*	*2.214*	1.536	*0.903*	*0.058*	-	-
29	-		-	-	-	*9.902*	*2.091*	1.562	*0.870*	*0.050*	-	-
30	-		-	-	-	*9.100*	*1.970*	1.544	*0.850*	*0.042*	-	-
31	-		-		-		*1.867*	1.521		*0.036*		-
Mean	0.000	0.000	0.000	0.000	0.000	8.974	4.425	1.496	1.174	0.423	0.019	0.000
Max	0.000	0.000	0.000	0.000	0.000	13.584	8.344	1.786	1.489	0.798	0.031	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.010	1.867	1.356	0.850	0.036	0.010	0.000

Note: Estimated and modelled values are italicized

Values in red denote high uncertainty based on extrapolation of the rating curve beyond 2 times the greatest measured discharge.

APPENDIX C 2019 EVALUATION OF EFFECTS SUPPORTING INFORMATION

February 2020

HOPE BAY PROJECT

2019 Aquatic Effects Monitoring Program Report

Appendix C: 2019 Evaluation of Effects Supporting Information

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Appendix C: 2019 Evaluation of Effects Supporting Information

C.1 Historical Data Selection Rationale for Evaluation of Effects

The tables in this section present a summary of the historical physical limnology (temperature and dissolved oxygen), water quality, sediment quality, phytoplankton biomass, and benthic invertebrate community data collected at the AEMP lake sites, as well as the rationale for the exclusion of certain historical data from the 2019 evaluation of effects.

C.1.1 Temperature and Dissolved Oxygen Profiles

Table C.1-1 presents a summary of the historical temperature and dissolved oxygen profile data collected at AEMP lake sites, and the rationale for the exclusion of certain historical data from the 2019 evaluation of effects. The selection of historical data to include in the temperature and dissolved oxygen evaluation of effects was based on similarity of historical sampling locations to 2019 AEMP sampling locations.

Table C.1-1: Historical Data Selection Rationale for Temperature and Dissolved Oxygen Evaluation of Effects, Hope Bay Project, 2019

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake	1995	August	Data from northern end of the lake	Data from southern end of the lake	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	1996	April, August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	1997	April, July, August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	1998	April	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2000	August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake *(cont'd)*	2003	July, August, September	August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.
	2004	June, July, August, September	June and August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.
	2005	July, August, September	August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.
	2006 to 2008	May, July, August, September	May and August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.
	2009	April, August	Data collected at "Doris" sampling location	Data collected at "Doris South" sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	Annually from 2010 to 2016	April, July, August, September	April and August data collected at "Doris" sampling location	All data collected at "Doris South" sampling location; all July and September data	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.
	2017 and 2018	April, July, August, September	April and August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Patch Lake	1995	August	All	None	
	1996	April, August	All	None	Note: Data were estimated from plots of the profiles.
	1997	April, July	April data	July data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July data were excluded. Note: April data were estimated from plots of the profiles.
	1998	April	All	None	
	2006	June, July, and September	None	All	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2007 and 2008	May, July, August, September	None	All	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2009	April, August	Data collected at “Patch” sampling location	Data collected at “Patch South” sampling location	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2017 and 2018	April, August	All	None	
Windy Lake	1995	August	None	All	Excluded data collected from southern end of Windy Lake, as current AEMP sampling site is at northern end of the lake.
	1996	August	None	All	Excluded data collected from southern end of Windy Lake, as current AEMP sampling site is at northern end of the lake.
	1997	April, July	April data	July data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July data were excluded. Note: April data were estimated from plots of the profiles.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Windy Lake *(cont'd)*	1998	April	All	None	
	2006	June, July, August, September	June and August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.
	2007 and 2008	May, July, August, September	May and August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.
	2009, 2010, 2017, and 2018	April, August	All	None	.
Reference Lake B	2009	May, August	None	All	Excluded data collected from northeastern end of Reference Lake B, as current AEMP sampling site is in the central basin of the lake.
	2010	April, July, August September	August data	April, July, and September data	Excluded data collected from April and July as these were collected from northeastern end of the lake. Data from August were used for the evaluation of effects for open-water temperature and dissolved oxygen, so September data were excluded.
	Annually from 2011 to 2018	April, July, August, September	April and August data	July and September data	Data from August was used for the evaluation of effects for open-water temperature and dissolved oxygen, so July and September data were excluded.

C.1.2 Water Quality

Table C.1-2 presents a summary of the historical water quality data collected at AEMP lake sites, and the rationale for the exclusion of certain historical data from the 2019 evaluation of effects. The selection of historical data to include in the water quality evaluation of effects was based on similarity of historical sampling locations to 2019 AEMP sampling locations and sampling methodology.

Table C.1-2: Historical Data Selection Rationale for Water Quality Evaluation of Effects, Hope Bay Project, 2019

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake	1995	May, June, July, August	Data from northern end of the lake	Data from southern end of the lake, and all shoreline grab samples	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; excluded shoreline grabs, which are not comparable to samples collected from a boat over deep areas of the lake.
	1996	April, August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	1997	April, July, August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	1998	April	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2000	July, August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2003	July, August, September	All	None	
	2004	June, July, August, September	All	None	
	2005	July, August, September	All	None	
	2006 to 2008	May, July, August, September	All	None	

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake *(cont'd)*	2009	April, August	Data collected at “Doris” sampling location	Data collected at “Doris South” sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	Annually from 2010 to 2016	April, July, August, September	Data collected at “Doris” sampling location	Data collected at “Doris South” sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2017 and 2018	April, July, August, September	All	None	
Patch Lake	1995	May, June, July, August	Data from northern end of the lake	Data from southern end of the lake, and all shoreline grab samples	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake; excluded shoreline grabs, which are not comparable to samples collected from a boat over deep areas of the lake.
	1996	April, August	All	None	.
	1997	April, July	All	None	.
	1998	April	All	None	
	2006	June, July, August, September	None	All	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2007 and 2008	May, July, August, September	None	All	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2009	April, August	Data collected at “Patch” sampling location	Data collected at “Patch South” sampling location	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2017 and 2018	April, August	All	None	

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Windy Lake	1995	May, June, July, August	None	All	Excluded data collected from southern end of Windy Lake, as current AEMP sampling site is at northern end of the lake; excluded shoreline grabs, which are not comparable to samples collected from a boat over deep areas of the lake.
	1996	August	None	All	Excluded data collected from southern end of Windy Lake, as current AEMP sampling site is at northern end of the lake.
	1997	April, July	All	None	
	1998	April	All	None	
	1999	July	Samples collected from boat	All shoreline grab samples	Some samples were shoreline grabs, which are not comparable to samples collected from a boat over deep areas of the lake.
	2000	July	All	None	
	2006	June, July, August, September	All	None	
	2007 and 2008	May, July, August, September	All	None	
	2009, 2010, 2017, and 2018	April, August	All	None	.
Reference Lake B	2009	May, August	None	All	Excluded data collected from northeastern end of Reference Lake B, as current AEMP sampling site is in the central basin of the lake.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Graphs and Statistical Analyses	Data Excluded from Graphs and Statistical Analyses	Rationale for Exclusion
Reference Lake B *(cont'd)*	2010	April, July, August September	August and September data	April and July data	Excluded data collected from April and July, as these were collected from northeastern end of the lake. The August and September samples were collected at the current AEMP sampling site.
	Annually from 2011 to 2018	April, July, August, September	All	None	

C.1.3 Sediment Quality

Table C.1-3 presents a summary of the historical sediment quality data collected at AEMP lake sites, and the rationale for the exclusion of certain historical data from the 2019 evaluation of effects. The selection of historical data to include in the sediment quality evaluation of effects was mainly based on the comparability of the depth strata sampled between historical and 2019 samples, and the proximity of historical sampling sites to the 2019 sites.

Table C.1-3: Historical Data Selection Rationale for Sediment Quality Evaluation of Effects, Hope Bay Project, 2019

Sampling Sites	Years Sampled	Month Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake	1996	August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	1997	July	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2009	August	Data from deep site at northern end of lake	Data from shallow sites and sites at southern end of lake	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; excluded shallow sites (<5 m) as the current AEMP site is deep (>10 m).

Sampling Sites	Years Sampled	Month Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake *(cont'd)*	Annually from 2010 to 2016	August	Data collected at "Doris" sampling location	Data collected at "Doris South" sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2017	August	All	None	
Patch Lake	1996	August	None	All	Excluded deep sites (>10 m) as the current AEMP site is a mid-depth site (5 to 10 m).
	1997	July	None	All	Excluded shallow sites (< 5m) as the current AEMP site is a mid-depth site (5 to 10 m).
	2007	August	None	All	Excluded deep and shallow sites as the current AEMP site is a mid-depth site (5 to 10 m); excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2009	August	Data from mid-depth site at northern end of lake	Data from shallow sites and sites at southern end of lake	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake; excluded shallow and deep sites as the current AEMP site is a mid-depth site (5 to 10 m).
	2010	August	None	All	Excluded shallow sites and sites at the southern end of the lake as the current AEMP site is a mid-depth site (5 to 10 m) at the northern end of the lake.
	2017 and 2018	August	All	None	
Reference Lake B	2009	August	None	All	Excluded data collected from northeastern end of Reference Lake B, as current AEMP sampling site is in the central basin of the lake; excluded shallow (< 5m) sites as the current AEMP site is a deep site (> 10 m).

Sampling Sites	Years Sampled	Month Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Reference Lake B *(cont'd)*	2010	August	Data from deep site	Data from shallow site	Excluded shallow (< 5m) sites as the current AEMP site is a deep site (> 10 m).
	Annually from 2011 to 2017	August	All	None	

C.1.4 Phytoplankton Biomass

Table C.1-4 presents a summary of the historical phytoplankton biomass (as chlorophyll *a*) data collected at AEMP lake sites, and the rationale for the exclusion of certain historical data from the 2019 evaluation of effects. The main criteria for the selection of historical biomass data for inclusion in the evaluation of effect were the proximity of historical sampling sites to 2019 AEMP sampling sites, the timing of sample collection, and comparability of sampling methodology.

Table C.1-4: Historical Data Selection Rationale for Phytoplankton Biomass (as Chlorophyll *a*) Evaluation of Effects, Hope Bay Project, 2019

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake	1997	July	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake. Potential issue with sample integrity, as samples were lost and then found and analyzed more than one year after sample collection.
	2000	July	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2003	July, August, September	None	All	Excluded because of methodological differences, as samples consisted of a composite of subsamples collected throughout the euphotic zone (not comparable to discrete surface samples collected in 2019).

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake *(cont'd)*	2006	September	None	All	Methodology not described. Assumed to be a composite sample from throughout euphotic zone.
	2007 and 2008	July, August, September	None	All	Excluded because of methodological differences, as samples consisted of a composite of subsamples collected throughout the euphotic zone (not comparable to discrete surface samples collected in 2019).
	2009	April, August	August data collected at "Doris" sampling location	All April data and August data collected at "Doris South" sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; only open-water season chlorophyll *a* data included in the 2019 evaluation of effects, so excluded historical under-ice data.
	2010 to 2016	April, July, August, September	July, August, September data collected at "Doris" sampling location	April data and all data collected at "Doris South" sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; only open-water season chlorophyll *a* data included in the 2019 evaluation of effects, so excluded historical under-ice data.
	2017 and 2018	August	All	None	
Patch Lake	1997	July	None	All	Potential issue with sample integrity, as samples were lost and then found and analyzed more than one year after sample collection.
	2006	September	None	All	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Patch Lake *(cont'd)*	2007 and 2008	July, August, September	None	All	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake; excluded because of methodological differences, as samples consisted of a composite of subsamples collected throughout the euphotic zone (not comparable to discrete surface samples collected in 2019).
	2009	April, August	August data collected at "Patch" sampling location	All April data and August data collected at "Patch South" sampling location	Excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake; only open-water season chlorophyll *a* data included in the 2019 evaluation of effects, so excluded historical under-ice data.
	2017 and 2018	April, August	August data	April data	Only open-water season chlorophyll *a* data included in the 2019 evaluation of effects, so excluded historical under-ice data.
Reference Lake B	2009	August	None	All	Excluded data collected from northeastern end of Reference Lake B, as current AEMP sampling site is in the central basin of the lake.
	2010	April, July, August, September	August, September data	April, July data	Excluded April and July data collected from northeastern end of Reference Lake B, as current AEMP sampling site is in the central basin of the lake; only open-water season chlorophyll *a* data included in the 2019 evaluation of effects, so excluded historical under-ice data.
	Annually from 2011 to 2016	April, July, August, September	July, August, September data	April data	Only open-water season chlorophyll *a* data included in the 2019 evaluation of effects, so excluded historical under-ice data.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Reference Lake B	2017	April, August	August data	April data	Only open-water season chlorophyll *a* data included in the 2019 evaluation of effects, so excluded historical under-ice data.
	2018	August	All	None	

C.1.5 Benthic Invertebrates

Table C.1-5 presents a summary of the historical benthic invertebrate data collected at AEMP lake sites, and the rationale for the exclusion of certain historical data from the 2019 evaluation of effects. The selection of historical data to include in the benthos evaluation of effects was mainly based on the comparability of the depth strata sampled between historical and 2019 samples, the proximity of historical sampling sites to the 2019 sites, and the similarity of sampling techniques (e.g., single grab samples vs. composite samples).

Table C.1-5: Historical Data Selection Rationale for Benthic Invertebrate Evaluation of Effects, Hope Bay Project, 2019

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake	1996	August	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; unlike current AEMP sampling methodology, samples consisted of single grabs rather than composite samples.
	1997	July, August	None	All	Excluded shallow sites (<5 m) and sites at the southern end of the lake as the current AEMP site is a deep site (>10 m) at the northern end of the lake; unlike current AEMP sampling methodology, samples consisted of single grabs rather than composite samples.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Doris Lake *(cont'd)*	2000	July	None	All	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; unlike current AEMP sampling methodology, samples consisted of single grabs rather than composite samples.
	2009	August	data collected at "Doris" sampling location	data collected at "Doris South" sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake; although three discrete replicate samples were collected at each site in 2009, data from the three replicates were pooled to obtain a single composite sample comparable to the replicates in the 2010 to 2019 dataset.
	2010 to 2016	August	data collected at "Doris" sampling location	data collected at "Doris South" sampling location	Excluded data collected from southern end of Doris Lake, as current AEMP sampling site is at northern end of the lake.
	2017	August	All	None	
Patch Lake	1996	August	None	All	Excluded deep sites (>10 m) as current AEMP site is mid-depth site (5 to 10 m); unlike current AEMP sampling methodology, samples consisted of single grabs rather than composite samples.
	1997	July	None	All	Excluded shallow sites (<5 m) as current AEMP site is mid-depth site (5 to 10 m); unlike current AEMP sampling methodology, samples consisted of single grabs rather than composite samples.

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Patch Lake *(cont'd)*	2007	August	None	All	Excluded deep and shallow sites as current AEMP site is mid-depth site (5 to 10 m); excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake; unlike current AEMP sampling methodology, samples consisted of single grabs rather than composite samples.
	2009	August	data collected at mid-depth site in "Patch" sampling location	data collected at shallow sites or in southern end of Patch Lake	Excluded shallow sites as current AEMP site is mid-depth site (5 to 10 m); excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake; although three discrete replicate samples were collected at each site in 2009, data from the three replicates were pooled to obtain a single composite sample comparable to the replicates in the 2010 to 2019 dataset.
	2010	August	None	All	Excluded shallow sites as current AEMP site is mid-depth site (5 to 10 m); excluded data collected from southern end of Patch Lake, as current AEMP sampling site is at northern end of the lake.
	2017 and 2018	August	All	None	
Reference Lake B	2009	August	None	All	Excluded data collected from northeastern end of Reference Lake B, as current AEMP sampling site is in the central basin of the lake.
	2010	August	data from deep site	data from mid-depth site	Excluded data from mid-depth site (5 to 10 m) as current AEMP site is a deep site (>10 m);
	Annually from 2011 to 2017	August	All	None	

C.2 Statistical Methodology for Evaluation of Effects

The general statistical methodology is described in Sections C.2.1 and C.2.2. Variations in methodology specific to each monitoring component and analysis are described in Sections C.2.3 and C.2.4.

C.2.1 Lakes with ≥ 10 Years of Historical Data (e.g., Doris and Little Roberts)

Regression models were used to assess data from lakes with 10 or more years of historical data available for most variables (e.g., Doris and Little Roberts lakes) and examine any time trends over the monitoring period. Hypothesis tests were conducted to assess time trends for particular variables. If there was a significant change over time, the time trend in the exposure lake was compared to the time trend in the reference lake (Reference Lake B). All the observed and fitted data are presented graphically to support the interpretation of results.

C.2.1.1 Non-detects

If all data in the current assessment year (2019) were below the detection limit, no regression analysis was performed for that variable. If a large amount of data (> 50% of the dataset) from a lake was below the detection limit, the lake was removed from the analyses and inference was based on plots of the observed data. In cases where the reference lake data was removed, it was not possible to make comparisons between exposure and reference lakes, and inference about the exposure lake was based on the within-lake regression analysis and plots of the observed data.

Linear mixed effects (LME) regression or Tobit regression analysis was used to test whether or not there was evidence of time trend at each exposure lake. Tobit regression was used when a moderate amount of data (between 10 and 50%) from a given lake were below the detection limit. For LME models, observations below the analytical detection limit were substituted by half the detection limit. Then, the lake, year (as well as depth and season, if applicable) average was calculated. For Tobit models, the fact that each censored measurement falls between 0 and the detection limit was used to obtain the estimated range for the average in a given lake and year (as well as depth and season, if applicable). This interval was used in the Tobit regression analysis.

C.2.1.2 Linear Mixed Effects (LME) Regression

Model Form

Let y denote a variable of interest, and $y_i(x)$ be an observation from lake *i* in year x. The model fitted to the data have the basic regression model form:

$$y = \text{Lake} + s(\text{Year}) + \text{Lake}*s(\text{Year}),$$

where the mean level of a variable is modelled with separate intercepts and time effects, *s*(Year), in each lake. Separate intercepts allowed for differences in the initial values of the variable between lakes.
Time effects were modelled using natural cubic regression splines to allow for non-linearity. Cubic regression splines are piecewise cubic polynomials joined together at points, called knots, often chosen at quantile points, and continuous up to the second derivative at each knot. Natural cubic splines have the additional constraint that the spline is linear beyond the boundaries of the data. The advantage of using regression splines over linear and quadratic effects is improved flexibility in capturing fluctuations in the data where a quadratic relationship appears inadequate. Regression splines are an extension of linear and quadratic effects where instead of representing an effect x with x and x^2, functions of x, called basis functions, are used.

Mathematically, the regression model can be written as:

$$E[y_i(x)] = \beta_{0i} + \sum_{n=1}^{K} \beta_{ki} h_k(x),$$

where:

- $E[y_i(x)]$ represents the expected mean value of the variable in lake *i* in year *x,*
- β_{0i} represents the intercept for lake *i*,
- β_{ki} represents the basis coefficients for lake *i*, and
- $\{h_k\}$ are known functions called basis functions.

The regression model is linear in the new variables, $h_k(x)$, and usual LME or Tobit approaches for model fitting and inference may be used. The splines are represented as linear combinations of basis functions evaluated at *x* and the number of basis functions is dependent on the number of knots (*K*) chosen. As 10 or more years of data are available, the number of knots chosen was 4 and 5 for variables with 10 years of data and more than 10 years of data, respectively. Plots of the fitted curves were used to assess the adequacy of the number of knots and to avoid over- or under-fitting the data.

Pseudoreplication

For water, sediment, and benthic variables, all observations from the same lake in the same year (as well as the same depth and same season, if applicable) were averaged to obtain a single observation. Since comparisons were made across years and across lakes, averaging the data within one lake (as well as season and depth, if applicable) had little effect on the tests of interest. For phytoplankton biomass, all observations from the same lake on the same date were averaged.

Random Variation

Random sources of variation can affect variable measurements. Potential sources of variability include environmental factors affecting all lakes equally in a given year, sampling variation that affects samples taken from a lake in a single year, and true measurement errors from laboratory analysis. The main sources of variation can be broken down into two components: yearly effects that affect the measurements in all lakes and effects that affect each lake individually. Random effects are included in the LME model to account for these sources of variation. The final model of the average variable value observed in lake *i* in year *x* becomes:

y = Lake + s(Year) + Lake*s(Year) + Year-R + Error-R,

or mathematically:

$$y_i(x) = \beta_{0i} + \sum_{k=1}^{K} \beta_{ki} h_k(x) + \varepsilon_x + \varepsilon_{ix} ,$$

where ε_x and ε_{ix} represent random variables that affect all lakes identically in year *x*, and those that only affects lake *i*, respectively. These random variables are assumed to follow normal distributions with zero mean and variance σ_x^2 and σ_{ix}^2, respectively.

Assessing Model Fit and Outliers

The goodness-of-fit of the regression models was examined through plots of the residuals. Let $\hat{y}_i(x)$ denote the fitted value for lake *i* in year x, defined as:

$$\hat{y}_i(x) = \hat{\beta}_{0i} + \sum_{k=1}^{K} \hat{\beta}_{ki} h_k(x) + \varepsilon_x + \varepsilon_{ix} ,$$

The residual for each observation, denoted e_{ix}, is the difference between the fitted and observed values:

$$e_{ix} = y_i(x) - \widehat{y_i}(x).$$

The residuals estimate the true error or unexplained variation for lake *i* in year *x.* The key assumption is that the true errors are normally distributed with equal variance. That is, the residuals are normally distributed and their variance does not depend on either lake or year. Normal quantile-quantile (Q-Q) plots were used to assess the distribution of residuals for each fitted model. Plots of the residuals by year and against the fitted values were used to assess homogeneity of variance over time and across values of the variable. A common deviation from this assumption is that variance increases as the value of the variable increases since values tend to vary more at larger scales. A natural logarithm transformation was often required to stabilize variance and meet the assumption of approximately normally distributed residuals. Standardized residuals greater than three were identified as outliers and flagged to caution interpretation of results, but not removed from the analysis.

C.2.1.3 Tobit Regression

Model Form

All water quality variables have detection limits below which the laboratory analyses cannot make an accurate measurement. Thus, for some water quality variables the observed value was below the detection limit and only an upper bound could be determined (i.e., censored data). Often values below the detection limit are replaced with half the upper bound and statistical analyses are performed as if the value is actually observed. Results from this type of analysis can be misleading, particularly when the detection limits are not consistent from year to year. For example, if all observations for a given variable in one lake have been below the detection limit in every year but the detection limit for that variable has consistently decreased (perhaps due to improving technology), then the imputed observations will appear to decrease over time. In reality, there is no information to conclude if the value is increasing, decreasing or remaining constant. Further, replacing these values with half of the detection limit ignores any uncertainty in these observations and the analysis will tend to underestimate the standard deviation (SD) of the variables.

A better approach is to use Tobit regression, which properly accounts for the censoring below the detection limit. In a maximum likelihood analysis of a standard regression model (as above) the likelihood contribution of a single observation *y* given the covariates $x_1, \ldots, x_p$ and a single error term $\varepsilon \sim N(0, \sigma^2)$ is:

$$L(y) = \left(2\pi\sigma^2\right)^{-1/2} \exp\left(\frac{-1}{2\sigma^2}\left(y - \sum_{i=1}^{p}\beta_i x_i\right)^2\right),$$

which is simply a normal probability density function of an observation, *y*, with mean $\sum \beta_i x_i$ and variance σ^2.

Now consider the case where *y* is censored and is only known to lie in the interval (*a,b*). Tobit regression replaces the likelihood contribution with the integrated density:

$$L(y) = \int_a^b \exp\left(\frac{-1}{2\sigma^2}\left(y - \sum_{i=1}^{p}\beta_i x_i\right)^2\right)dy = \Phi\left(\frac{b - \sum_{i=1}^{p}\beta_i x_i}{\sigma}\right) - \Phi\left(\frac{a - \sum_{i=1}^{p}\beta_i x_i}{\sigma}\right),$$

where $\Phi(x)$ is the standard normal cumulative distribution function. The likelihood can then be formed by multiplying the appropriate censored or uncensored contributions for each observation and maximum likelihood inference can be conducted to compute variable estimates and their standard errors, and perform hypothesis tests (Tobin 1958).

Pseudoreplication

The same concern with pseudoreplication in the LME regression models exists in the Tobit regression. However, when values were censored it was not possible to average the observations in each lake to obtain a single value for each year or season and a different solution was necessary. Suppose that observations $y_1,...,y_{n1}$ and $y'_1,....,y'_{n2}$ are available from a given lake in a given year where each y_i is known exactly and each y'_i is censored so that y'_i belongs to the interval (a_i, b_i). Given these observations, the sample average, $\bar{y}$, was bounded such that:

$$a = \frac{\sum_{i=1}^{n_1} y_i + \sum_{i=1}^{n_2} a_i}{n_1 + n_2} < \bar{y} < \frac{\sum_{i=1}^{n_1} y_i + \sum_{i=1}^{n_2} b_i}{n_1 + n_2} = b \quad ,$$

and Tobit regression was performed with (a, b) as the censoring interval for the sample mean. If all measurements are known exactly, then $n_2 = 0$ and $a = b = \bar{y}$.

C.2.1.4 Hypothesis Testing

Once the LME or Tobit regression models were fit, hypothesis tests were performed to determine if there was evidence that the mean variable values in the exposure lake (*E*) had changed over time. If there was no evidence of change over time, differences were attributed to random variation. If there was evidence of change over time, the time trend at the exposure lake was compared to the reference lake (*R*) to determine if there was a parallel trend over time at the exposure and reference lakes.

Test 1: Comparison within Exposure Lake

The fitted pattern of means in the exposure lake were compared to a constant value to determine if there was evidence suggesting the mean value of the variable had changed over time.

The hypothesis of this test was:

H_0: $\beta_{kE} = 0$ for k = 1 … K.

H_a: $\beta_{kE} \neq 0$ for at least one k = 1 … K.

Rejection of the null hypothesis provides evidence that the mean variable value in the exposure lake had changed over time and the analysis proceeded with Test 2. If the reference lake was removed from the analysis then plots of the fitted and observed values were used to identify the changes.

Test 2: Comparison to Reference Lake

If there was enough evidence to suggest that the variable changed over time, the fitted patterns of means in the exposure lake were compared to the reference lake.

The hypotheses of these tests were:

H_0: $\beta_{kE} = \beta_{kR}$ for k = 1 … K.

H_a: $\beta_{kE} \neq \beta_{kR}$ for at least one k = 1 … K.

Rejection of the null hypothesis provided evidence that the time trend in the mean variable value in the exposure lake differed from the time trend in the reference lake.

Structure of Tests

All of the hypothesis tests were performed using Wald-type chi-square tests based on the normal approximation for maximum likelihood estimation. Each null hypothesis can be written as a matrix equation with the form, $L'\beta = 0$, where *L'* denotes the vector of regression coefficients. The Wald theory then states that the quantity:

$$X^2 = (L'\hat{\beta})(L'\Sigma L)(\hat{\beta}'L)$$

is approximately distributed as a chi-square with degrees of freedom equal to the row rank of L, where $\hat{\beta}$ is the vector of maximum likelihood estimates and Σ is its estimated variance-covariance matrix. The p-values for the tests are computed from the upper-tail probabilities of this distribution.

Plots of Observed and Fitted Values

Plots of the observed and fitted values were used to visually assess and compare the values within and among lakes, and aid in the interpretation of the hypothesis test results. Observations below the detection limit were plotted at half the detection limit and indicated by a hollow symbol. Different symbols were used to distinguish between observed and yearly averaged values. The fitted values of the mean variable were represented with curves and error bars about the curves represent the 95% confidence intervals for the model estimates of the annual mean.

C.2.2 Lakes with < 10 Years of Historical Data (e.g., Patch and Windy)

C.2.2.1 Statistical Modelling – Before-After Control-Impact Design

A Before-After (BA) analysis was used to compare the mean measurements for all years prior to 2019 to the mean for 2019 in the exposure site. If the change in means was found to be significant, this change was then compared to the change in means at Reference B using a Before-After Control-Impact (BACI) analysis. Each site and evaluated variable was treated independently. Section C.2.4 describes modifications to the general methodology for specific variables.

Non-detects

Observations below analytical detection limits were considered censored. Censored data can potentially bias statistical analyses because of violation of underlying mathematical assumptions. For a particular variable, a site was removed from the analysis if more than 50% of observations for the site were censored.

If more than 10% of observations from a site were censored, data were flagged to caution interpretation of results. If censored data were included in the analyses, the data were assumed to be equal to half the analytical detection limit.

Data Transformations

Initial model assessment was carried out to determine if data transformation was appropriate. The general approach was to compare the normalized residuals and overall model performance for the basic linear model (Equation X) using both untransformed and natural log-transformed data. Plots of standardized residuals, fitted values and normal Q-Q plots were examined to establish the most appropriate choice of transformation. A data transformation was conducted if it produced a more uniform random distribution of residuals and a closer distribution along the 1:1 reference line on the Q-Q plot.

Outliers

The standardized residuals from the model fit were examined and outliers were identified as standardized residuals greater than 3. The outliers (if any) were flagged to caution interpretation of results but not removed from the model.

Model Form – Before-After Design

Regression models were constructed for each exposure site based on a Before-After (BA) design. A model was constructed for each exposure site and season. The models follow the general form given in Equation X.

(X) $y = period$ + Year-R +Error-R

This model identifies variation associated with different components, where:

period describes the differences between the before and after periods,

or mathematically:

$$E[y_p] = \beta_0 + \beta_p$$

where:

- $\mathrm{E}[y_p]$ represents the expected mean value of the variable in period *p*;
- β_0 represents the intercept; and
- β_p represents the expected difference in the variable between the before and after periods.

Model Form – Before-After Control-Impact Design

LME models were constructed for each exposure site based on a BACI. The models follow the general form given below:

$$y = site\ class + period + site\ class{:}\ period.$$

This model identifies variation associated with different components, where:

site class describes the differences between the reference and exposure sites;

period describes the differences between the before and after periods across all sites (reference and exposure); and

site class:period is the interaction term describing reference and exposure site-specific differences between periods (the BACI term).

The *site class:period* term is the key statistical term that describes differential changes to the exposure site during the period of potential mine effects relative to changes at the reference sites.

Let $y_{i\,sc\,p}$ denote observation *i* at site *sc* in period *p*, where period is before or after. The basic regression model specifies:

$$E(y_{i\,sc\,p}) = \beta_0 + \beta_{sc} + \beta_p + \beta_{sc:p}$$

where β_0 is the intercept, β_{sc} is the expected difference between reference and exposure site effects, β_p is the expected period effect, and $\beta_{sc:p}$ is a vector of expected site specific period effects.

Pseudoreplication

All observations from the same site and season were presented in the plots of the observed data and modelled values. However, repeated observations from each lake in each season were collected from similar locations at similar times and the variability between these observations may not reflect the true variation between random replicates from the entire lake in the given season. Analyzing these measurements as independent observations may underestimate the true variability and lead to overly sensitive statistical tests. Thus, LME models were used to incorporate random effects for site and year, and improve error variance modelling.

Random Variation

Random effects were included in the model to control for natural inter-annual variation (*year*) and natural site to site variation. Including random effects for site, year, and the interaction between site and year provided an adjustment for dependence among observations in a given season, at a specific site, and in a given year.

The model can be represented as:

$$E(y_{isp}) = \beta_0 + \beta_{sc} + \beta_p + \beta_{sc:p} + \varepsilon_s + \varepsilon_y + \varepsilon_{s:y}$$

where β_0 is the intercept, β_{sc} is the expected value for site class *sc*, β_p is the expected value for period *p*, $\beta_{sc:p}$ is the expected value for site class *sc* in period *p*, and $\varepsilon_s + \varepsilon_y + \varepsilon_{s:y}$ are the predicted random component for site *s* and year *y*.

C.2.2.2 Hypothesis Testing

Test 1: BA Analysis - Comparison within Exposure Lake

A Project-related effect would be expected to result in a significant difference between the before-after change observed at the exposure site. The period term describes the change from the before period to the after period. For each exposure site, the period effect was assessed using an F-test.

The hypothesis of this test was:

$H_0: \beta_p = 0$

$H_a: \beta_p \neq 0$

If the p-value for this *period* hypothesis test was less than α = 0.05, then it was concluded that a significant difference between the before and after periods was observed in the exposure site and the analysis proceeded to a BACI analysis.

Test 2: BACI Analysis - Comparison of Exposure and Reference Lake

A Project-related effect would be expected to result in a significant difference between the before-after change observed at the exposure sites and the reference sites. The *site class:period* term describes the site class-specific variability in the change from the before period to the after period.

The hypothesis of this test was:

$H_0: \beta_{sc:p} = 0$

$H_a: \beta_{sc:p} \neq 0$

For each exposure site, the overall *site class:period* effect was assessed using an F-test. If the p-value for this *site class:period* hypothesis test was less than $\alpha = 0.05$, then it was concluded that a significant site class-specific difference between the before and after periods was observed.

Confidence Intervals for Contrast Terms

Contrasts were calculated to compare the difference between the change at the exposure site and reference sites. In this approach, any contrast substantially different from zero would represent a differential before/after effect between the exposure site and the reference site currently being contrasted. For the contrasts, 95% confidence intervals were calculated to support the interpretation and, in turn, support the identification of significant site-specific differences. If the confidence interval for a contrast did not cover zero, it was concluded that a significant site-specific difference between the *before* and *after* periods was observed between the exposure site and that particular reference site.

C.2.2.3 Plots of Observed Data and Modelled Values

Plots of the observed data for each site in each year were plotted for each variable to visualize the variation between sites. Symbols show the observed values of the variable for each site in each year. Given sufficient data above detection limit, LME model predictions and approximate 95% confidence intervals were obtained and plotted as vertical lines. Observations below analytical detection limits were substituted with half the analytical detection limit for the calculation of annual site specific means.

C.2.3 Variations in Methodology – Doris Lake

C.2.3.1 Ice Thickness

Ice thickness data were collected in one season, hence the model forms and hypothesis testing procedures followed those outlined in Section C.2.1.2 and C.2.1.4.

C.2.3.2 Water Quality

Water quality samples were collected during the under-ice (April, May, or June) and open-water (July, August, and/or September) seasons at shallow and deep depths. Depth was included in the regression model as a fixed effect and represents the mean difference between surface and deep samples. Season was included in the regression model as an interaction term with lake and time so that separate time trends were estimated for each lake-season group. The regression model for water quality data in lake *i* season *j* was as follows:

y = Lake + Season + Depth + *s*(Year) + Lake*Season + Lake* Season**s*(Year) + Year-R + Error-R,

or mathematically:

$$E[y_{ij}(x)] = \beta_{0ij} + \beta_1 + \sum_{k=2}^{K} \beta_{kij} h_k(x) ,$$

where:

- $E[y_{ij}(x)]$ represents the expected mean value of the variable in lake i, season j, in year x;
- β_{0ij} represents the intercept for lake i in season j;
- β_1 represents the mean difference between deep and surface samples;
- β_{kij} represents the basis coefficients for lake i season j; and
- $\{h_k\}$ are the basis functions.

Hypothesis Testing

Test 1: Comparison within Exposure Lake

For season *j* in exposure lake *E*, the hypothesis tests were:

$H_0: \beta_{kEj} = 0$ for *k* = 1 … *K*.

$H_a: \beta_{kEj} \neq 0$ for at least one *k* = 1 … *K*.

If there was enough evidence to suggest the variable changed across time in the exposure lake in season *j*, the time trend in the exposure lake was compared to the reference lake in season *j* using Test 2.

Test 2: Comparison against Reference Lake

The hypotheses of the tests were:

$H_0: \beta_{kEj} = \beta_{kRj}$ for k = 1 … K.

$H_a: \beta_{kEj} \neq \beta_{kRj}$ for at least one *k* = 1 … *K*.

Rejection of the null hypothesis provided evidence that the change over time in the mean variable value in the exposure lake differed from the time trend in the reference lake in season *j*.

C.2.3.3 Sediment Quality

Sediment quality data were collected in August and deep depths. The regression model for sediment quality data in lake *i* was as follows:

y = Lake + s(Year) + Lake*s(Year) + Year-R + Error-R

or mathematically:

$$E[y_i(x)] = \beta_{0i} + \sum_{k=1}^{K} \beta_{ki} h_k(x) \ ,$$

where:

- $E[y_i(x)]$ represents the expected mean value of the variable in lake *i* in year *x*;
- β_{0i} represents the intercept for lake *i*;
- β_{ki} represents the basis coefficients for lake *i;* and
- $\{h_k\}$ are basis functions.

Hypothesis testing for Doris Lake was undertaken as described in Section C.2.1.4.

C.2.3.4 Phytoplankton Biomass

Phytoplankton biomass data were collected in July, August, and September. Sampling month was included in the regression model as a fixed effect and represented the mean difference between samples collected in different months, while assuming this difference was the same across lakes and time.

*y = Lake + Month + s(Year) + Lake*s(Year) + Year-R + Error-R*

or mathematically:

$$E[y_i(x)] = \beta_{0i} + \alpha_m + \sum_{k=1}^{K} \beta_{ki} h_k(x) \ ,$$

where:

- $E[y_i(x)]$ represents the expected mean value of the variable in lake i in year x;
- β_{0i} represents the intercept for lake i;
- α_m represents the mean difference between month m and reference month m*;
- β_{ki} represents the basis coefficients for lake i; and
- $\{h_k\}$ are basis functions.

All hypothesis testing procedures follow that described in Section C.2.1.4.

C.2.3.5 Benthic Invertebrates

Density

Benthos density data were collected in one season at one depth, hence the model forms and hypothesis testing procedures followed those outlined in Section C.2.1.2 and C.2.1.4.

Family Richness

Family richness is the number of distinct families collected in a sample. A generalized linear mixed effects model (GLMM) was used to model family richness. Generalized linear mixed effects models are an extension of LME where the response, given the covariates, may follow one of several distributions. Count data are often fit using a Poisson distribution, as done here. In a GLMM, instead of modelling the response directly, a link function, in this case, the “log link” (natural logarithm) relates the mean of the response to the linear predictor.

Let $y_i(x)$ be the family richness count for lake *i* in year *x*, then $y_i(x)$ is assumed to follow a Poisson distribution with mean $\mu_i(x)$. The model is written as:

$$\log(\mu_i(x)) = \beta_{0i} + \beta_{1i}x + \varepsilon_x,$$

where,

- $\mu_i(x) = E[y_i(x)]$ represents the expected mean value of the variable in lake *i* in year *x,*
- β_{1i} represents the time effect in lake *i,* and
- ε_x is the random effect that affects all lakes identically in year *x*, and is assumed to follow a normal distribution with variance σ_x^2 .

Hypothesis Testing

Test 1: Comparison within Exposure Lake

The hypothesis of this test was:

$H_0: \beta_{1E} = 0$

$H_a: \beta_{1E} \neq 0$

If there was enough evidence to suggest that the variable values changed across time in lake *E*, the fitted pattern of means in that exposure lake was compared to the reference lake.

Test 2: Comparison against Reference Lake

The hypotheses of this test was:

$H_0: \beta_{1E} = \beta_{1R}$

$H_a: \beta_{1E} \neq \beta_{1R}$

Rejection of the null hypothesis provided evidence that the change over time in the mean variable value in the exposure lake differed from the time trend in the reference lake.

Family Evenness and Bray-Curtis Index

Benthos family evenness and Bray-Curtis index data were collected in one season at one depth, hence the model forms and hypothesis testing procedures followed those outlined in Sections C.2.1.2 and C.2.1.4. However, for the regression analyses, instead of modelling the natural log of the variable value, logit transformations were employed as the data were constrained to lie between 0 and 1. The logit transformation maps data in the interval [0, 1] to the real line so that predicted values are restricted to fall in the interval [0, 1].

C.2.4 Variations in methodology – Patch and Windy Lake

C.2.4.1 Ice Thickness

Ice thickness samples were collected during the under-ice season. Since only one ice thickness sample was available each year, random effects for year were not included in the BA model. The regression models for the BA and BACI water quality data were as follows:

y = *period* + Error-R

or mathematically:

$$E[y_{dp}] = \beta_0 + \beta_{\mathrm{p}} \ ,$$

and

y = site class + *period* + *site class:period* + Year-R + Error-R,

Hypothesis testing procedures followed that outlined in section C.2.2.2.

C.2.4.2 Water Quality

Water quality samples were collected during the under-ice and open-water seasons at shallow and deep depths. Depth was included in the regression model as a fixed effect and represents the mean difference between surface and deep samples. The regression models for the BA and BACI water quality data were as follows:

y = *depth* + *period* + Year-R + Error-R

or mathematically:

$$E[y_{dp}] = \beta_0 + \beta_{\mathrm{d}} + \beta_{\mathrm{p}} \ ,$$

and

y = *depth* + site class + *period* + *site class:period* + Year-R + Error-R, or mathematically:

$$E[y_{dp\,sc}] = \beta_0 + \beta_{\mathrm{d}} + \beta_{\mathrm{sc}} + \beta_{\mathrm{p}} + \beta_{\mathrm{sc:p}} \,,$$

where:

- $\mathrm{E}[y_{dp\,sc}]$ represents the expected mean value of the variable*;*
- β_0 represents the intercept*;*
- β_d represents the expected value for depth *d*;
- β_{sc} represents the expected value for site class *sc*; and
- $\beta_{sc:p}$ represents the expected value for site class *sc* in period *p*.

Hypothesis testing procedures followed that outlined in section C.2.2.2.

C.2.4.3 Sediment Quality

Sediment data were collected in one season at one depth, hence the model form and hypothesis testing procedure followed that outlined in section C.2.2.1 and C.2.2.2.

C.2.4.4 Phytoplankton Biomass

Phytoplankton biomass data were collected in one month at one depth, hence the model form and hypothesis testing procedure followed that outlined in section C.2.2.1 and C.2.2.2.

C.2.4.5 Benthic Invertebrates

Benthos Density

Benthos density data were collected in one season at one depth, hence the model form and hypothesis testing procedure followed that outlined in section C.2.2.1 and C.2.2.2.

Family Diversity and Bray-Curtis Index

Benthos family diversity and Bray-Curtis index data were collected in one season at one depth, hence the model form and hypothesis testing procedure followed that outlined in section C.2.2.1 and C.2.2.2. However, instead of modelling the natural log of the variable value, logit transformations were employed as the data were constrained to lie between 0 and 1. The logit transformation maps data in the interval [0, 1] to the real line so that predicted values are restricted to fall in the interval [0, 1].

C.2.5 Computing

All steps of the analysis were performed using the statistical computing package R 3.6.1 (R Development Core Team 2019). The following versions of packages were used for the analyses:

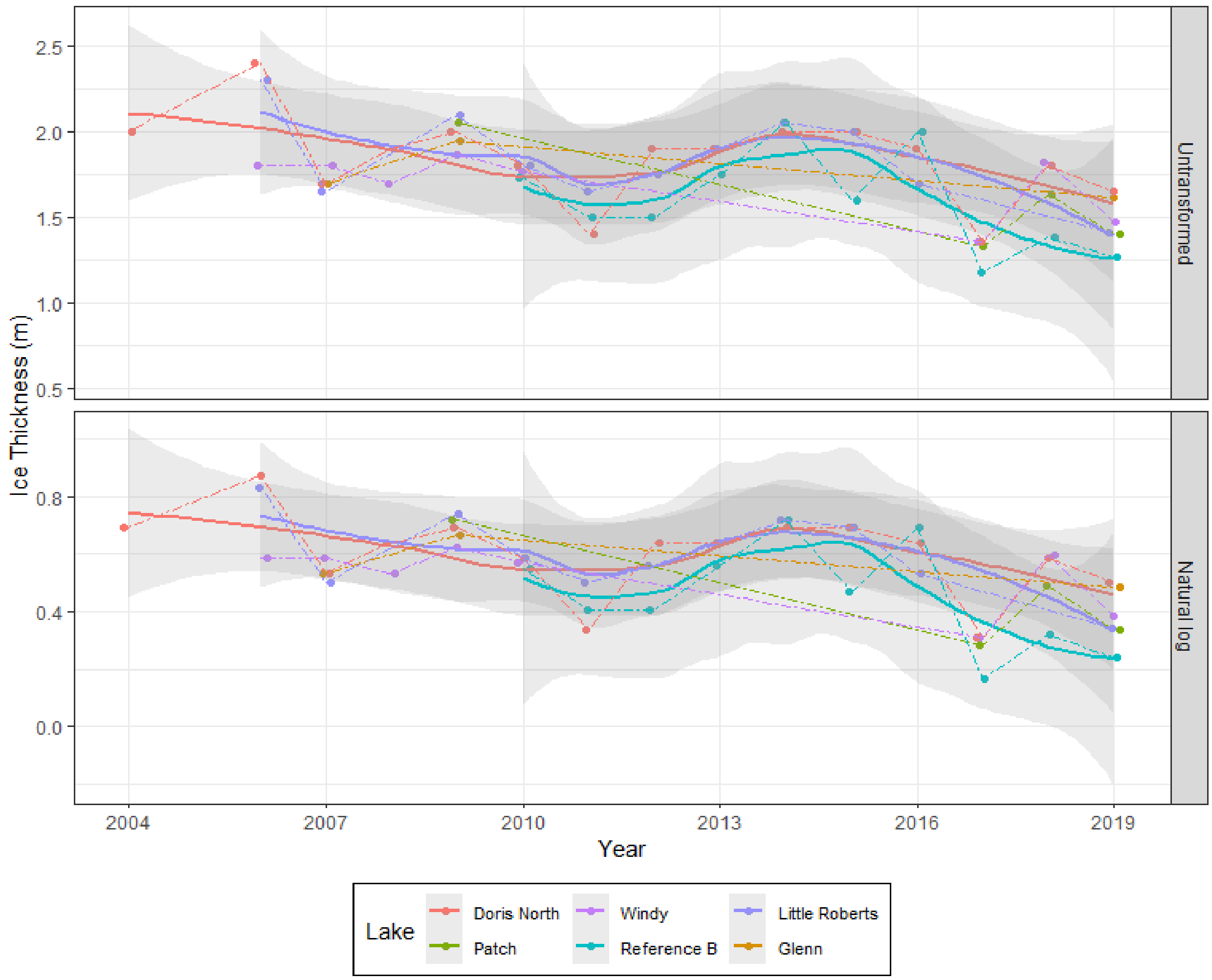
- dplyr (0.8.3);
- stringr (1.4.0);
- tidyr (1.0.0);
- lubridate (1.7.4);
- ggplot2 (3.2.1);
- knitr (1.20);
- survival (3.1-8); and
- lme4 (1.1-21).

C.3 Statistical Results for Evaluation of Effects

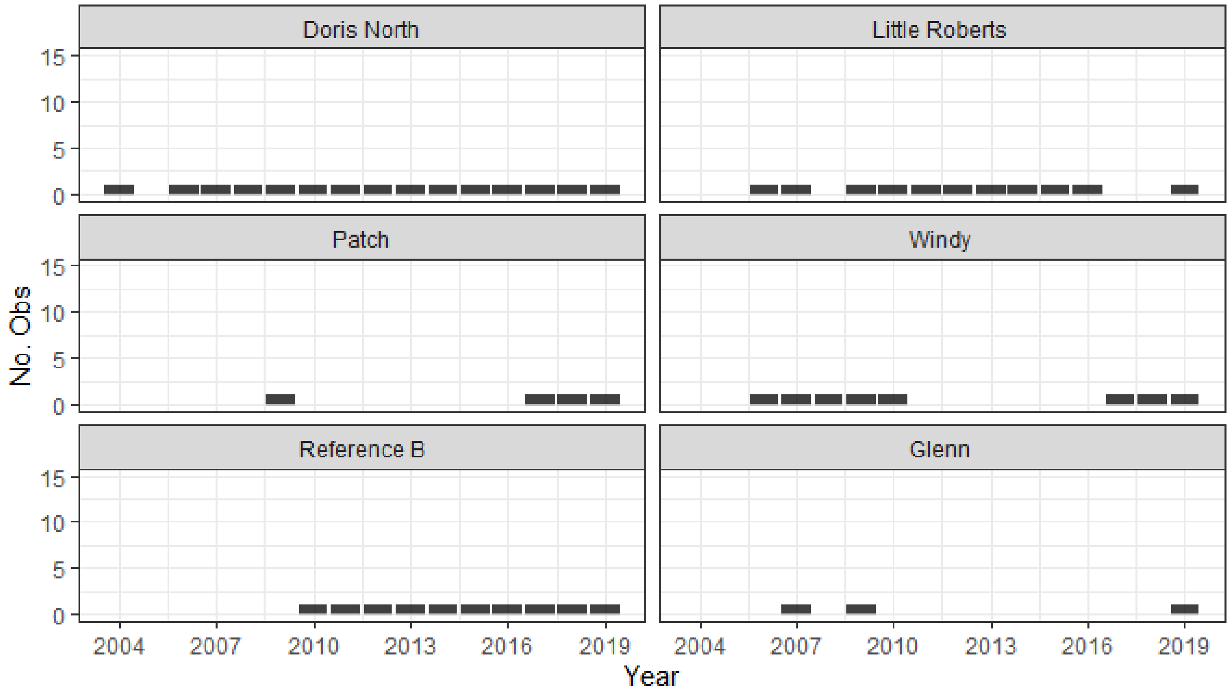
C.3.1 Ice Thickness

Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Ice thickness measurements were collected during the ice-covered season in April, May, or June. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Sample Sizes



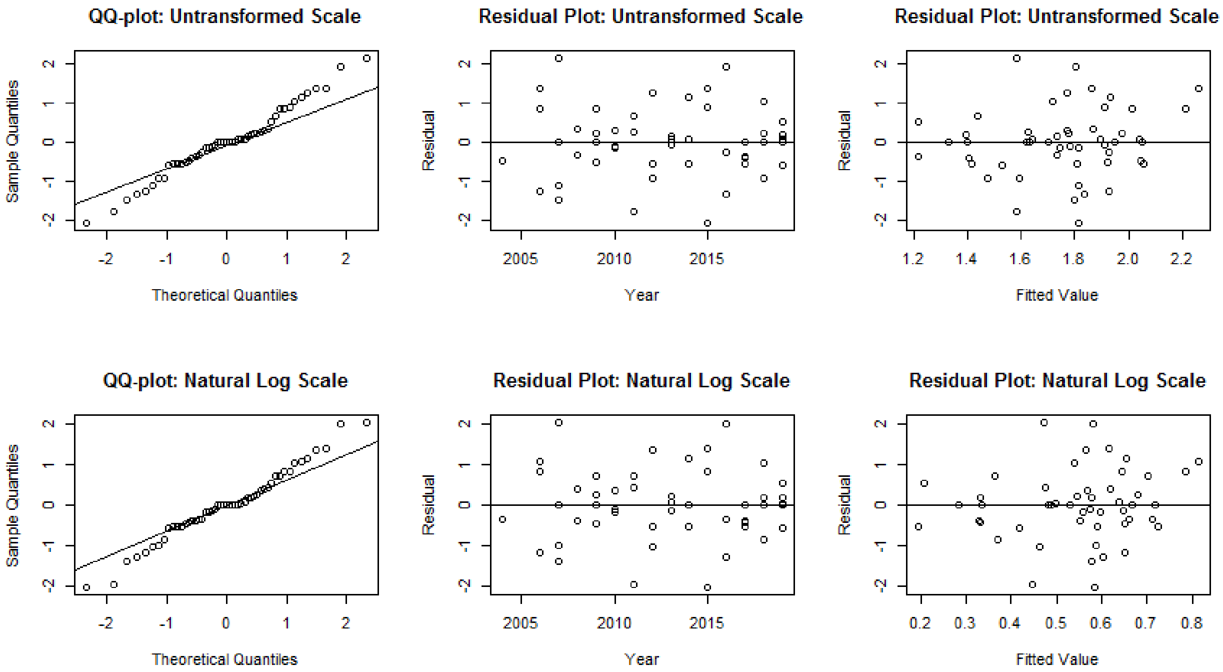
The sample sizes and median values per lake are summarized in the table below.

Lake	# Obs	Median
Doris	15	1.900
Glenn	3	1.700
Little Roberts	11	1.800
Patch	4	1.515
Reference B	10	1.550
Windy	8	1.785

The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake and Little Roberts Lake

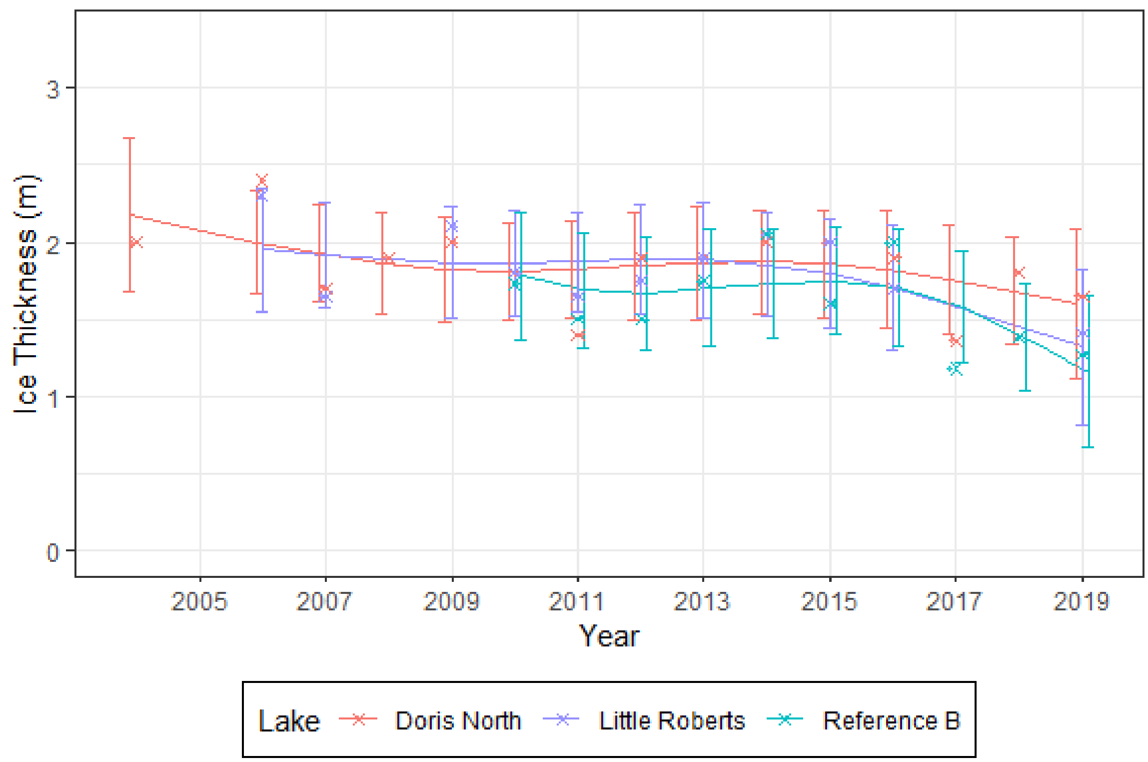
The trends in Doris Lake and Little Roberts Lake were compared to a slope of 0. If there was a significant trend, then the trend in the exposure lake (Doris or Little Roberts) was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Site	Chi.sq	DF	P.value
Compare to slope 0	Doris	5.345	4	0.2537
Compare to slope 0	Little Roberts	8.912	4	0.0633

Doris and Little Roberts do not exhibit significant deviation from no trend.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses are first performed to compare the change in ice thickness from the before to the after period in the exposure site. If a change is detected, then before-after-control-impact linear modeling is applied to compare the change before and after baseline years between Reference B and Patch.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	-0.27	0.4176	-0.6465	0.5842	not sig.

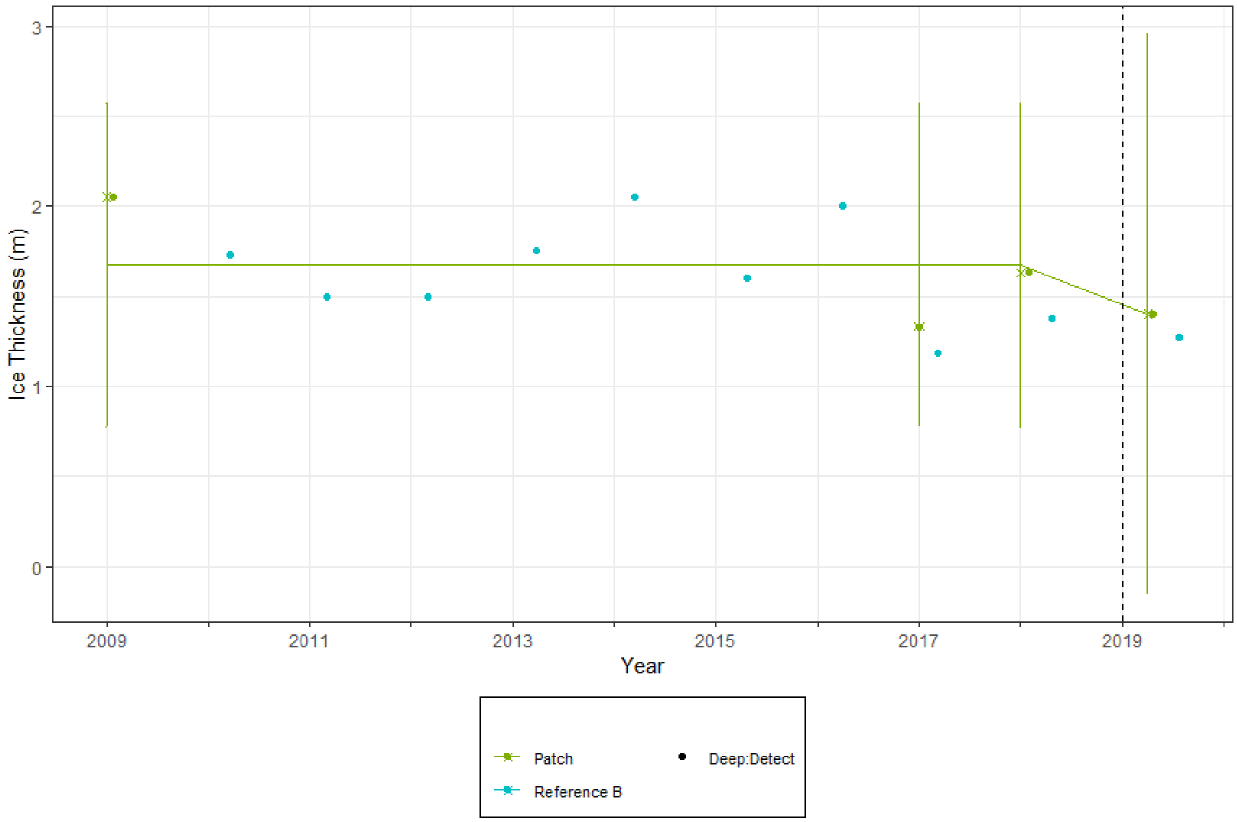
Conclusion:

The change in mean ice thickness in Patch Lake from *before* to *after* was not significantly (p = 0.5842) different.

BACI analysis not performed.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses are first performed to compare the change in ice thickness from the before to the after period in the exposure site. If a change is detected, then before-after-control-impact linear modeling is applied to compare the change before and after baseline years between Reference B and Windy.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	-0.2614	0.1836	-1.424	0.2042	not sig.

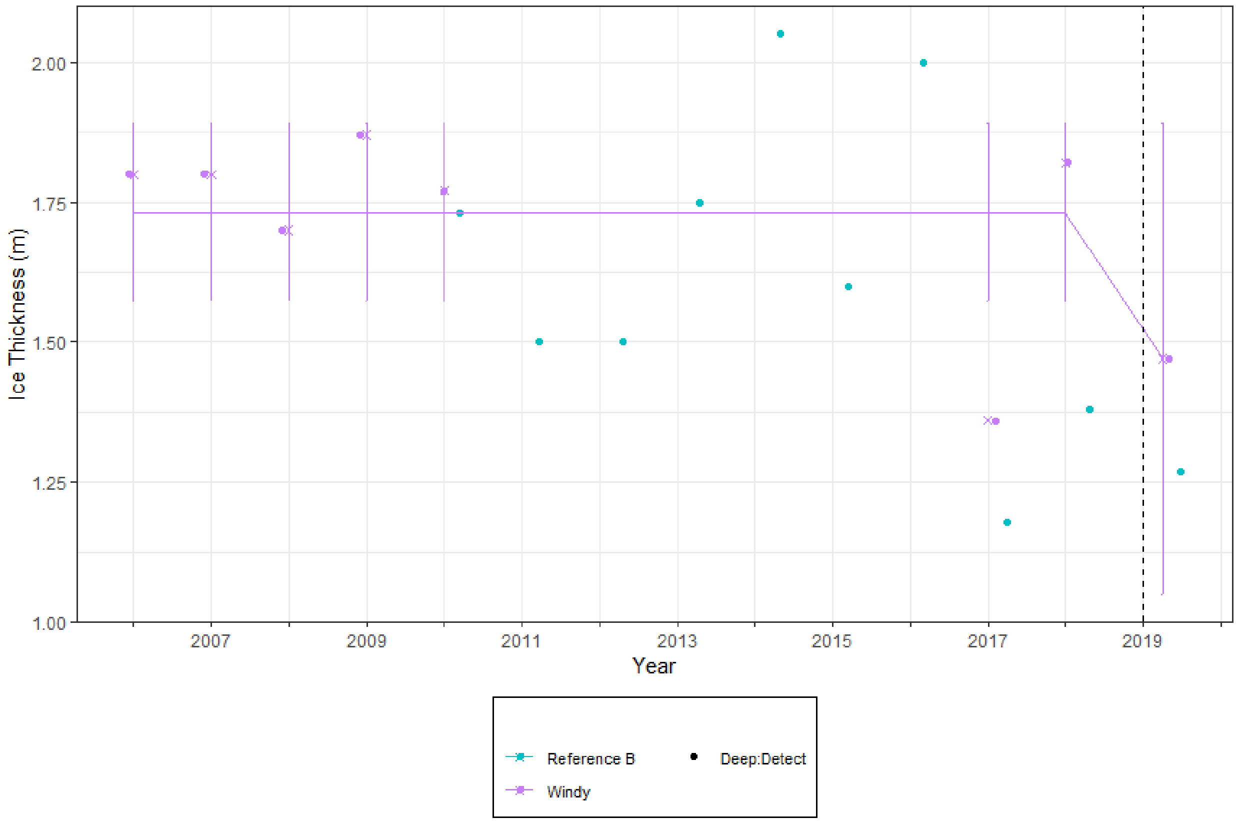
Conclusion:

The change in mean ice thickness in Windy Lake from *before* to *after* was not significantly (p = 0.2042) different.

BACI analysis not performed.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Glenn Lake

Before-after analyses are first performed to compare the change in ice thickness from the before to the after period in the exposure site. If a change is detected, then before-after-control-impact linear modeling is applied to compare the change before and after baseline years between Reference B and Glenn.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	-0.205	0.2165	-0.9469	0.5174	not sig.

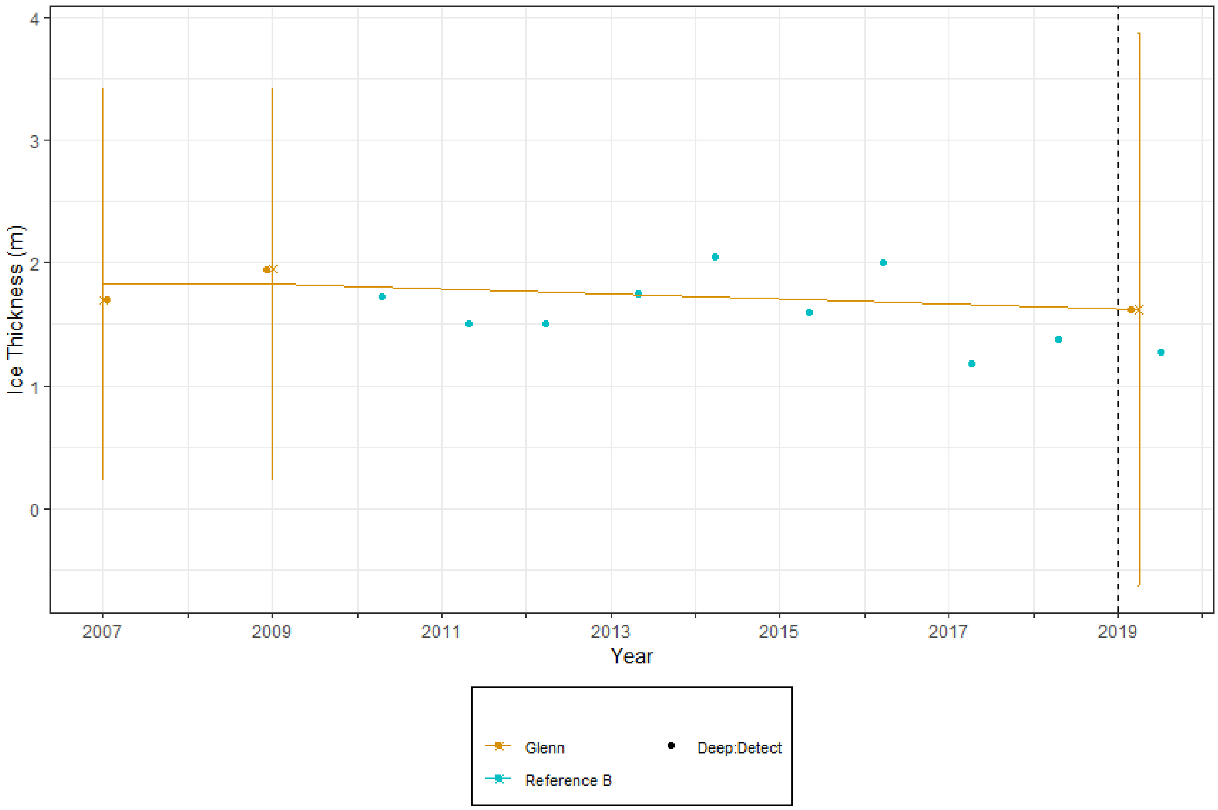
Conclusion:

The change in mean ice thickness in Glenn Lake from before to after was not significantly (p = 0.5174) different.

BACI analysis not performed.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.

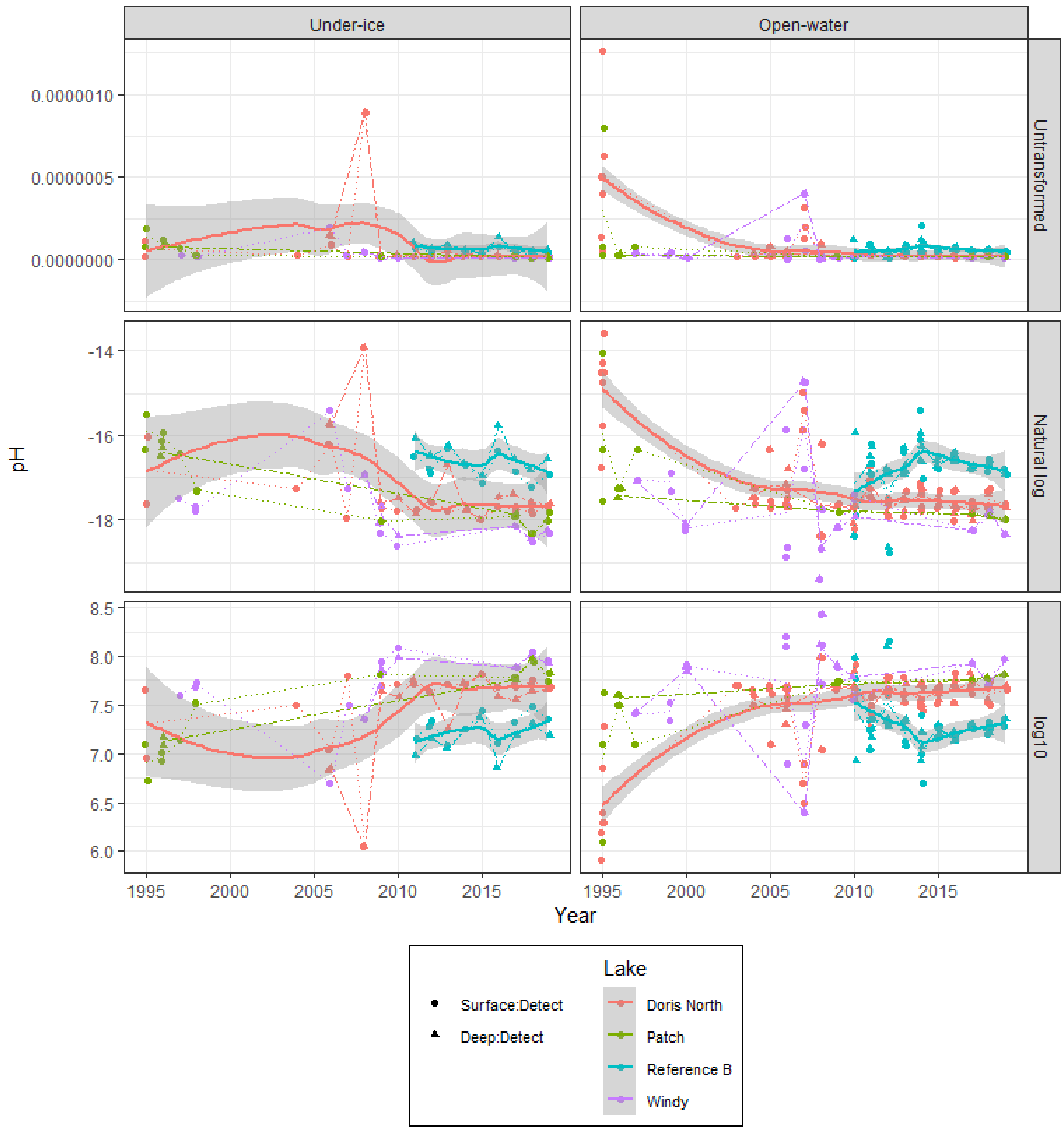


C.3.2 Water Quality

C.3.2.1 pH

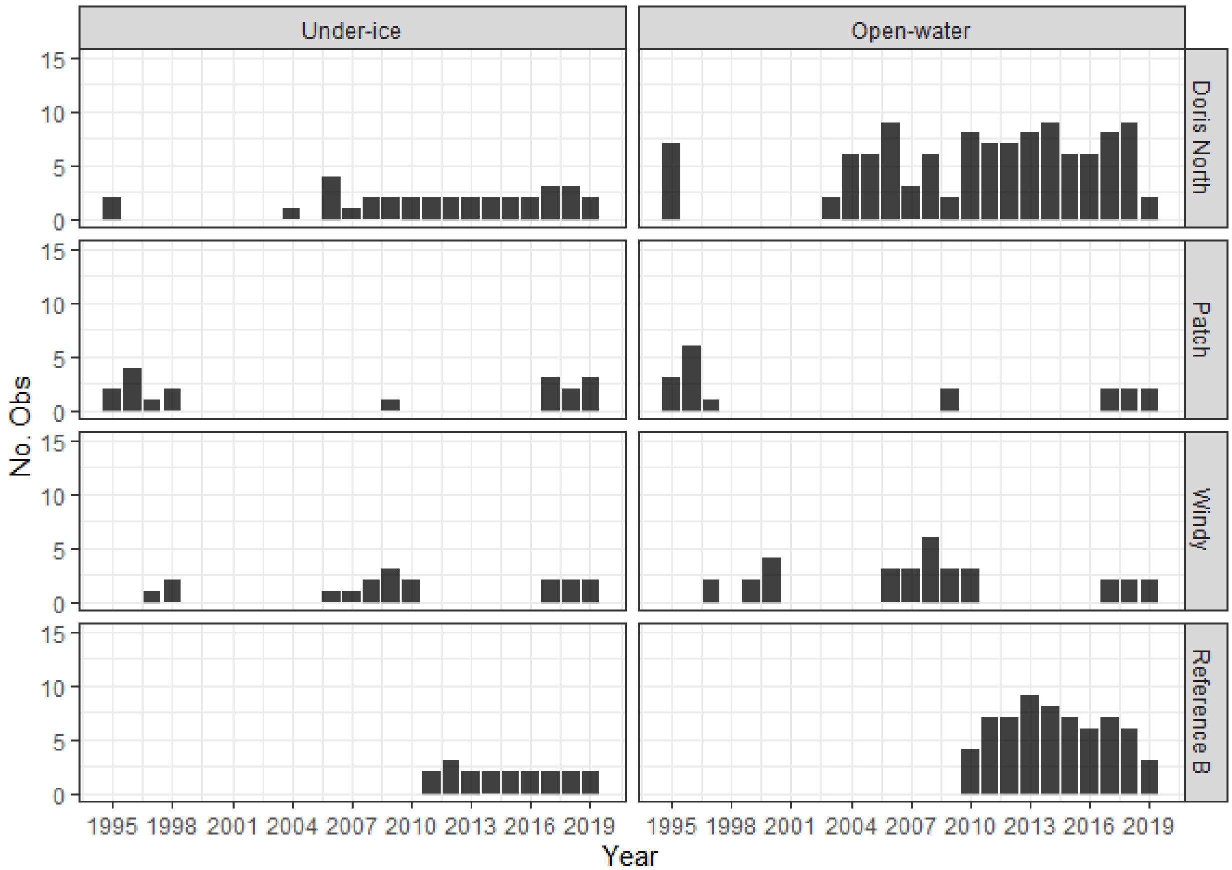
Observed Data

The following plots show all the observed data on untransformed, natural log scale, and log (base 10) scales. For analysis of untransformed and natural log transformed pH, pH values were first converted to the concentration of hydrogen ions ([H+] = 10^{-pH}). For the log (base 10) transformation, raw pH values are presented, since pH = -log10[H+]. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

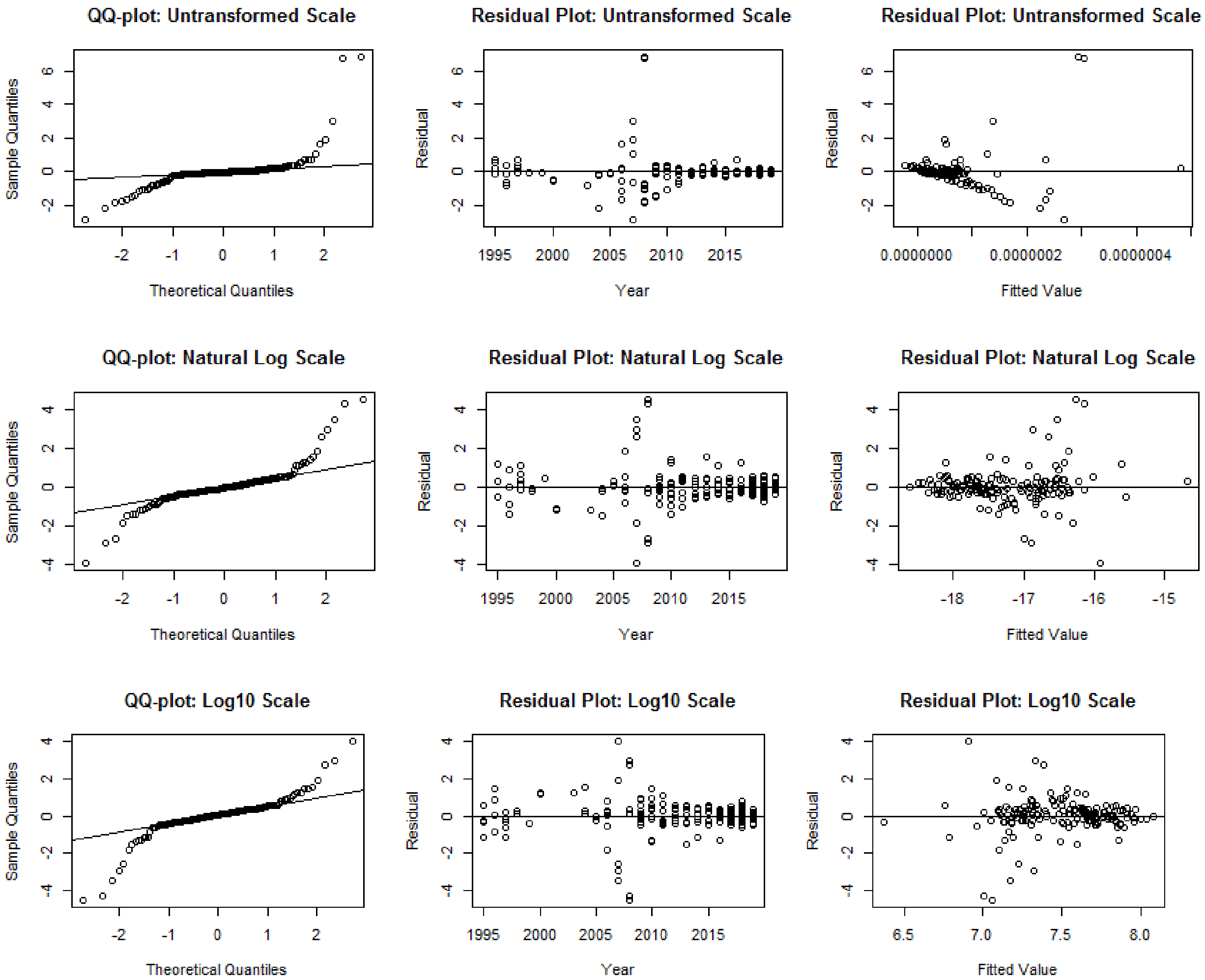
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	34	0	0	0	0.0000000
Doris	Open-water	111	0	0	0	0.0000000
Patch	Under-ice	18	0	0	0	0.0000000
Patch	Open-water	18	0	0	0	0.0000000
Reference B	Under-ice	19	0	0	0	0.0000001
Reference B	Open-water	64	0	0	0	0.0000001
Windy	Under-ice	18	0	0	0	0.0000000
Windy	Open-water	32	0	0	0	0.0000000

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2008	Under-ice	Deep	0.0000009	0	6.720
Doris	2008	Under-ice	Surface	0.0000009	0	6.819

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2007	Under-ice	Surface	0.0000000	-15.915	-3.974
Doris	2008	Under-ice	Deep	0.0000009	-16.137	4.289
Doris	2008	Under-ice	Surface	0.0000009	-16.251	4.510
Windy	2007	Open-water	Deep	0.0000004	-16.527	3.479

Outliers on log10 scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2007	Under-ice	Surface	0.0000000	6.912	3.974
Doris	2008	Under-ice	Deep	0.0000009	7.008	-4.289
Doris	2008	Under-ice	Surface	0.0000009	7.058	-4.510
Windy	2007	Open-water	Deep	0.0000004	7.177	-3.479

The log10 data meets residual assumptions better than the untransformed data. Analysis proceeds with log10 data since pH is in log base 10 units.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	17.863	4	0.0013
Compare to Reference B	0.653	4	0.9570

Doris Lake appears to show significant deviation from no trend. Doris Lake does not exhibit significant deviation from the trend of Reference B lake.

Open-water

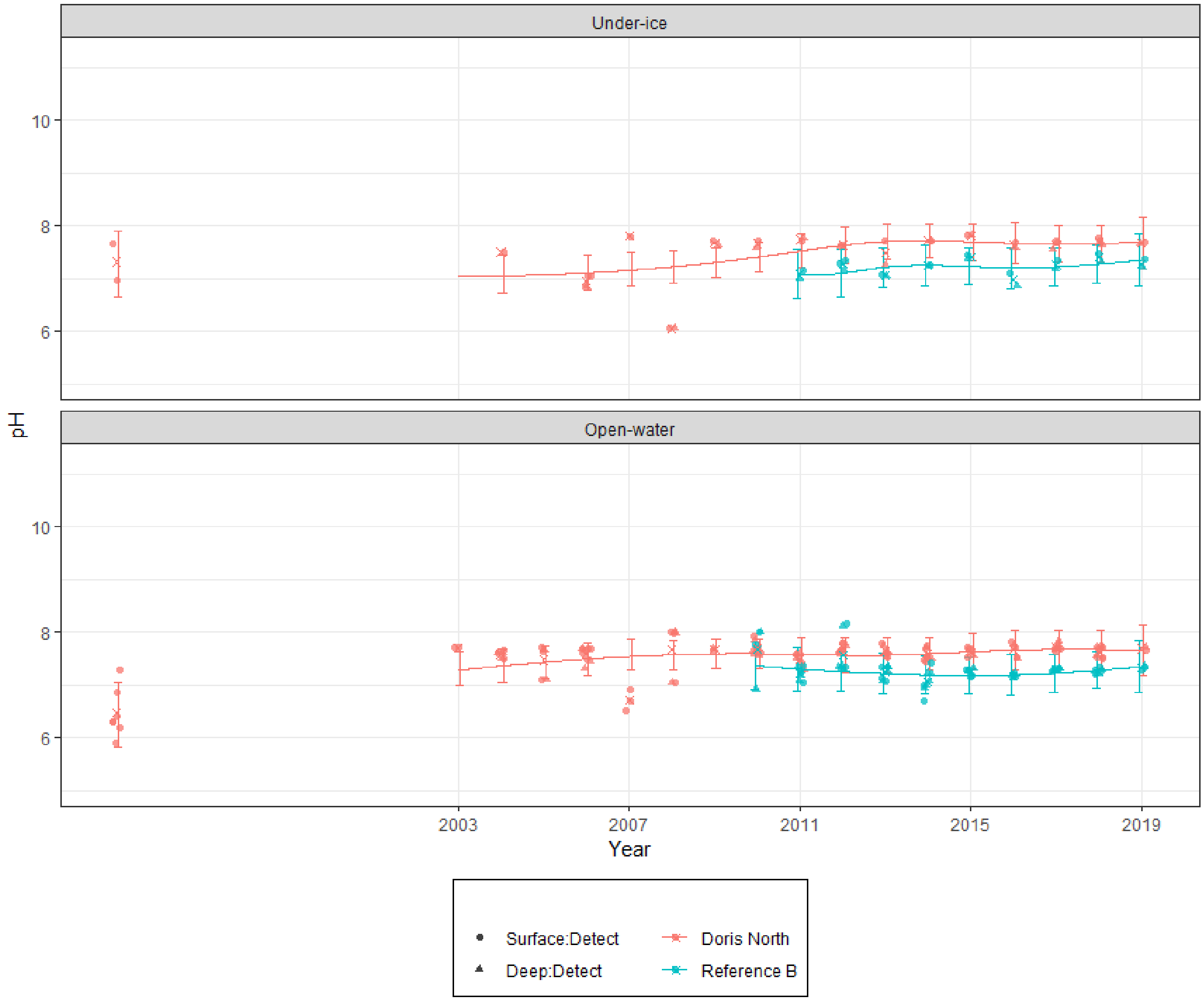
Analysis	Chi.sq	DF	P.value
Compare to slope 0	22.492	4	0.0002
Compare to Reference B	1.573	4	0.8136

Doris Lake appears to show significant deviation from no trend. Doris Lake does not exhibit significant deviation from the trend of Reference B lake.

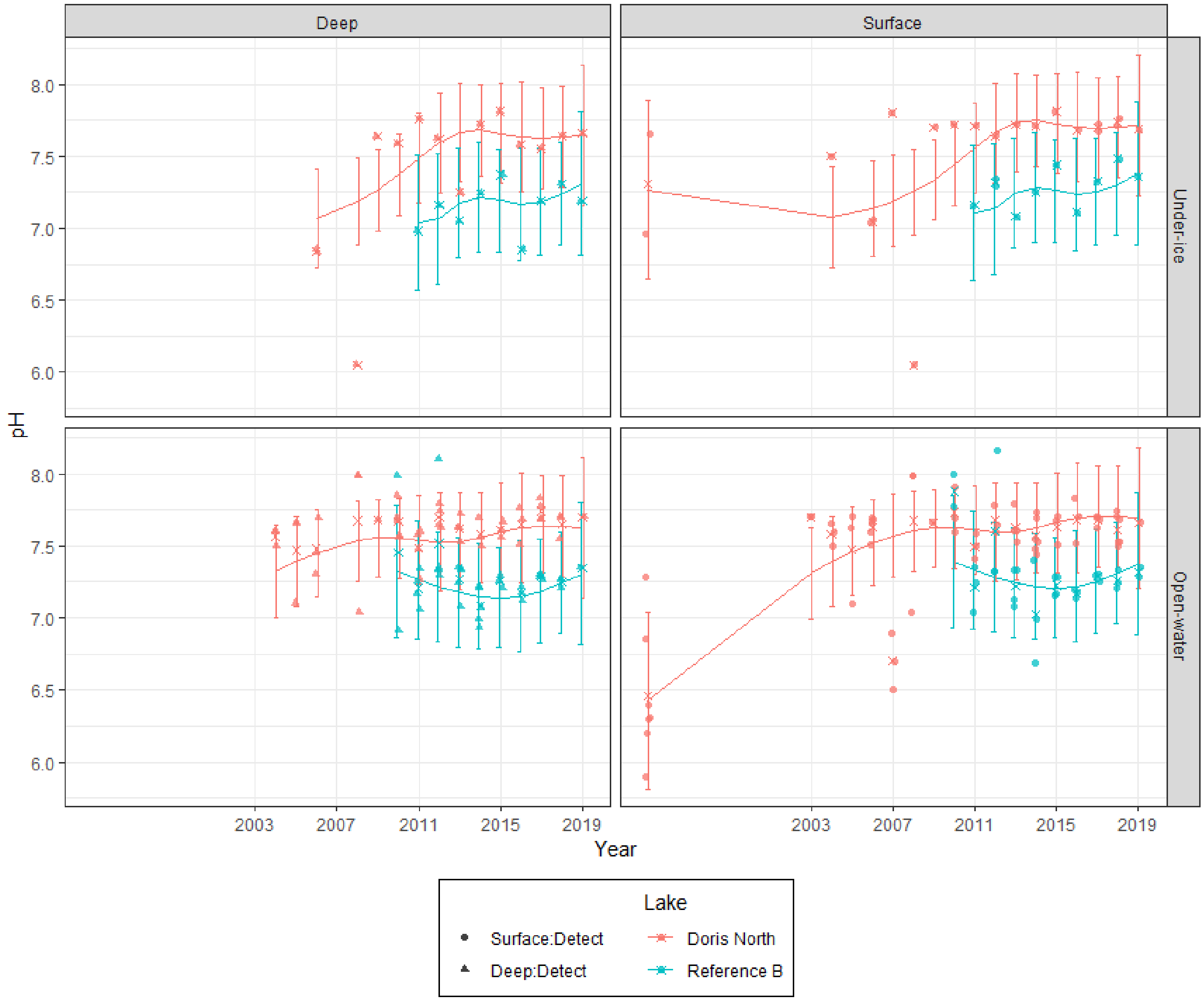
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x’s represent annual observed means). Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses are first performed to compare the change in pH from the before to the after period in the exposure site. If a change is detected, then before-after-control-impact linear modeling is applied to compare the change in pH before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.3461	0.4513	5.958	0.7668	0.4725	not sig.

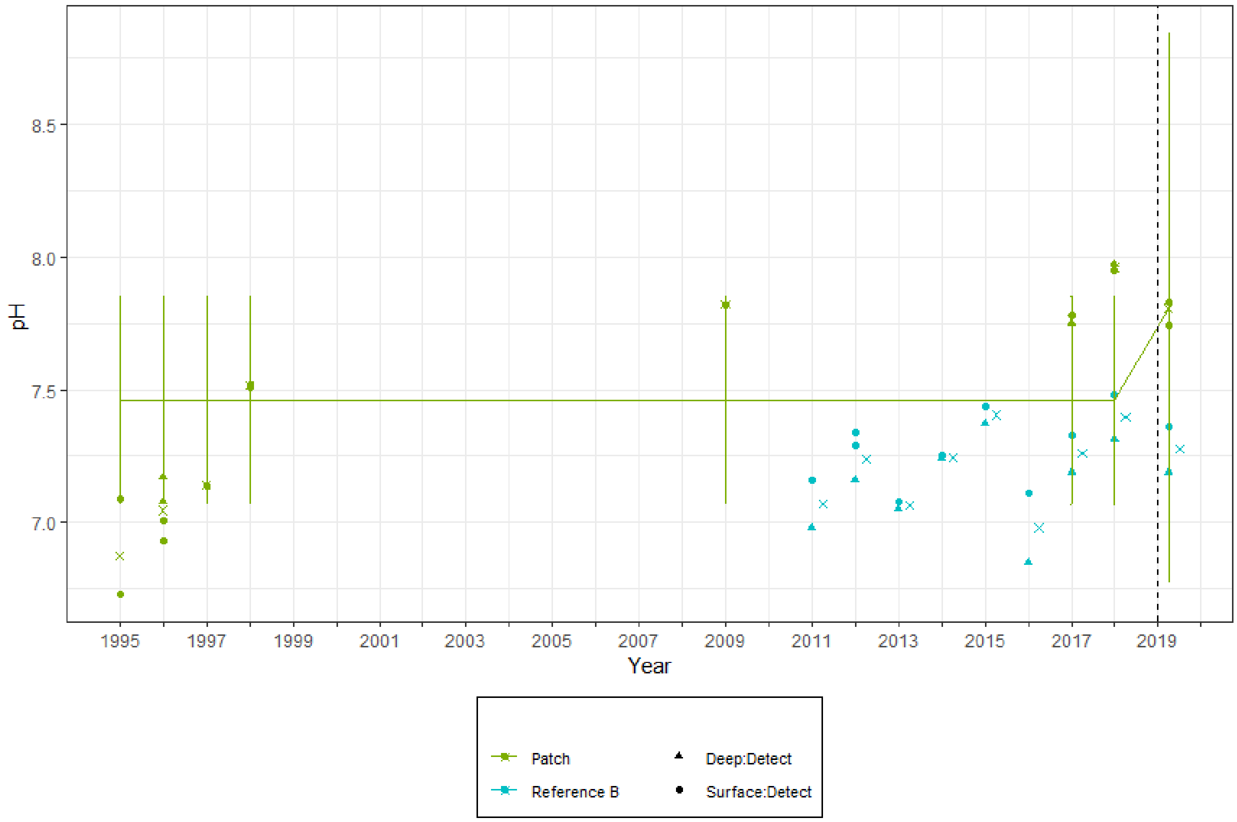
Conclusion:

The change in pH in Patch Lake from before to after was not significantly (p = 0.4725) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means). Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.4023	0.538	4.989	0.7477	0.4884	not sig.

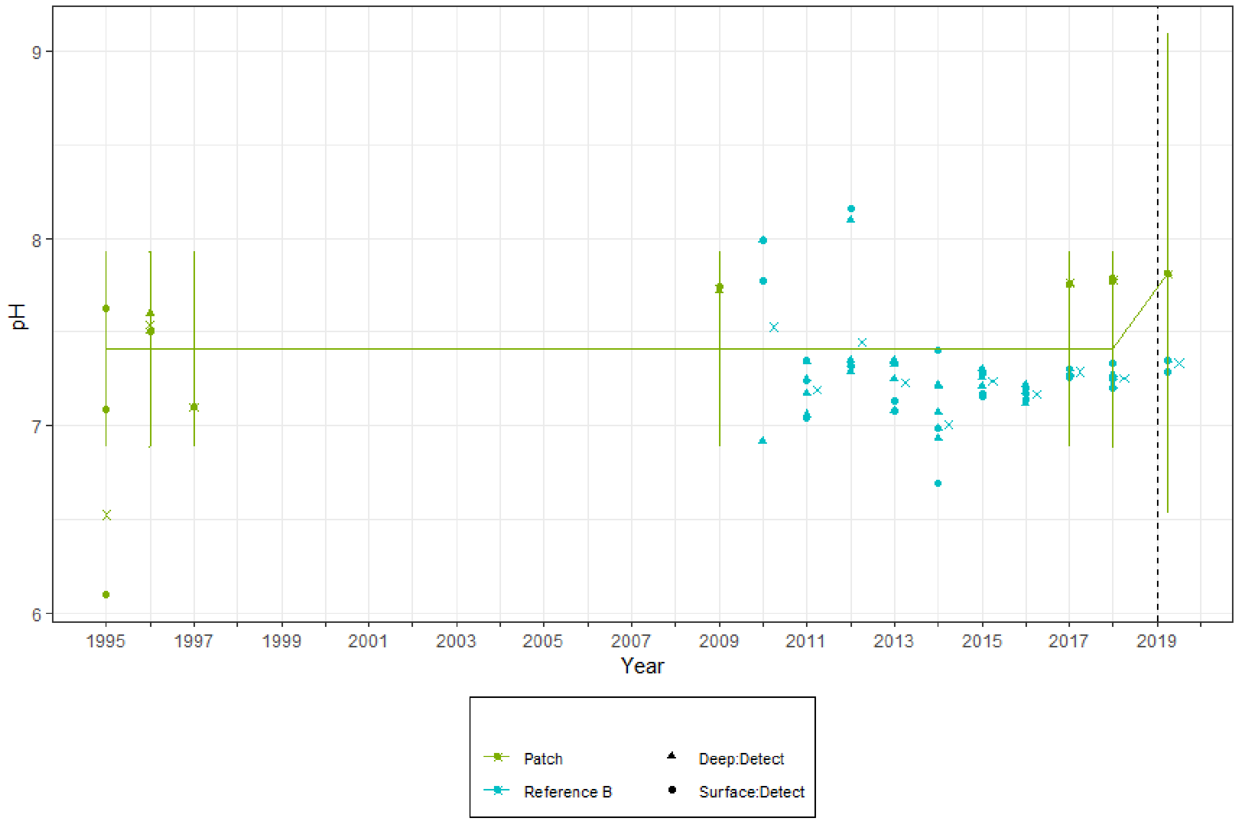
Conclusion:

The change in pH in Patch Lake from *before* to *after* was not significantly (p = 0.4884) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means). Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses are first performed to compare the change in pH from the before to the after period in the exposure site. If a change is detected, then before-after-control-impact linear modeling is applied to compare the change in pH before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.3256	0.4486	7.919	0.7257	0.4889	not sig.

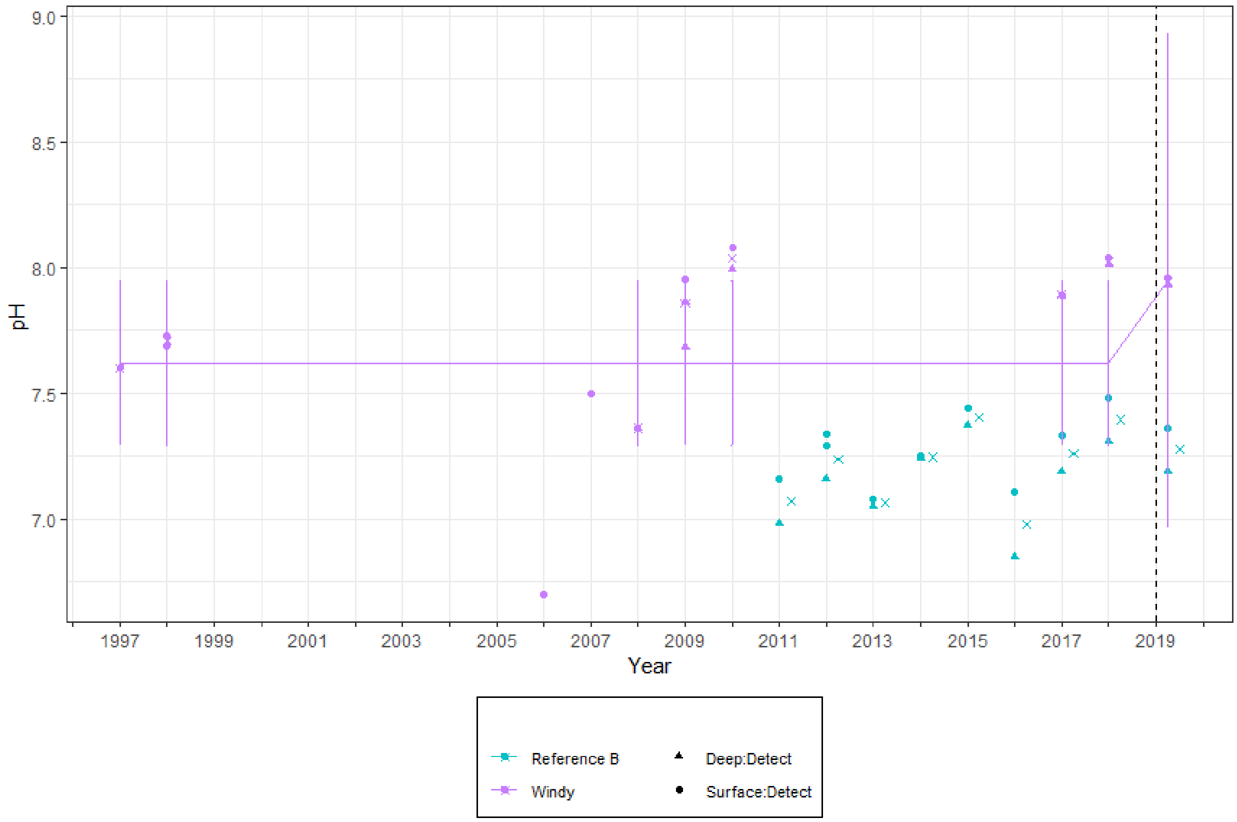
Conclusion:

The change in pH in Windy Lake from before to after was not significantly (p = 0.4889) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means). Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.3889	0.4631	8.988	0.8399	0.4227	not sig.

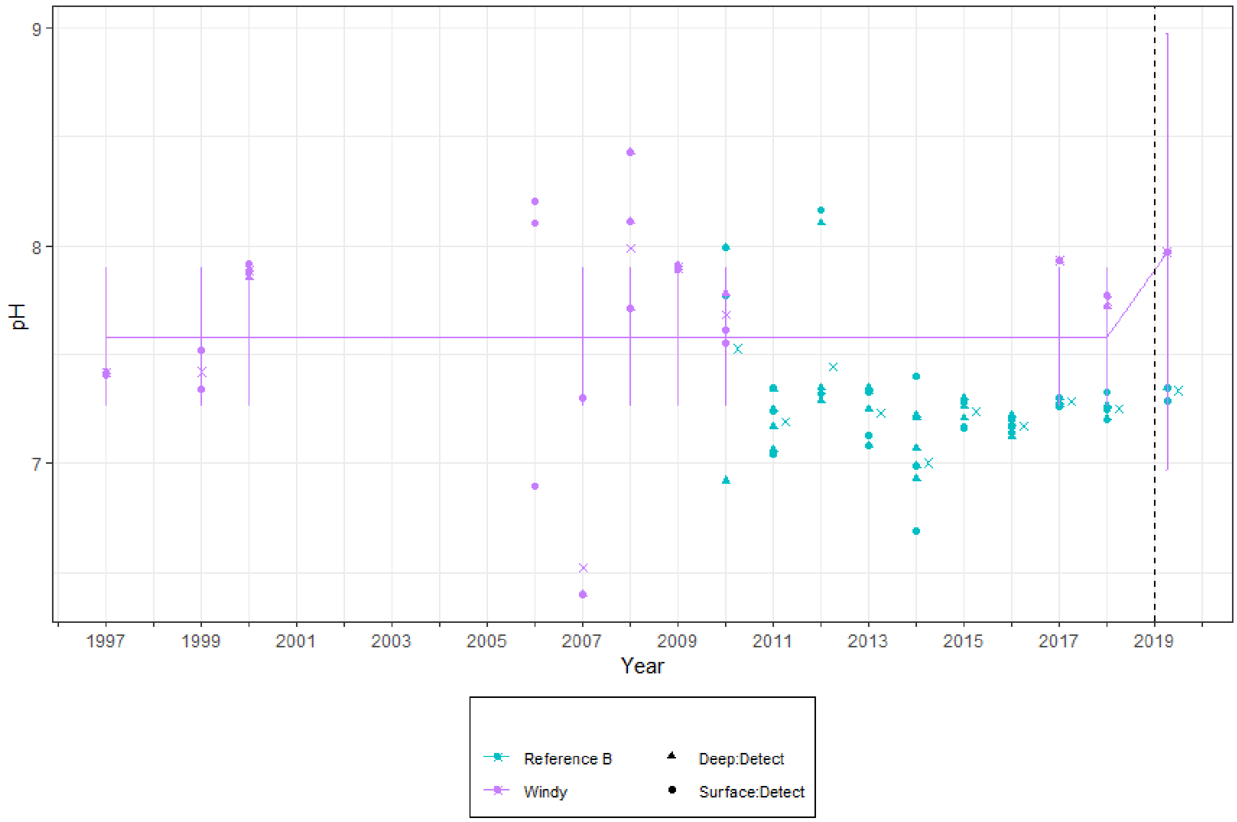
Conclusion:

The change in pH in Windy Lake from *before* to *after* was not significantly (p = 0.4227) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

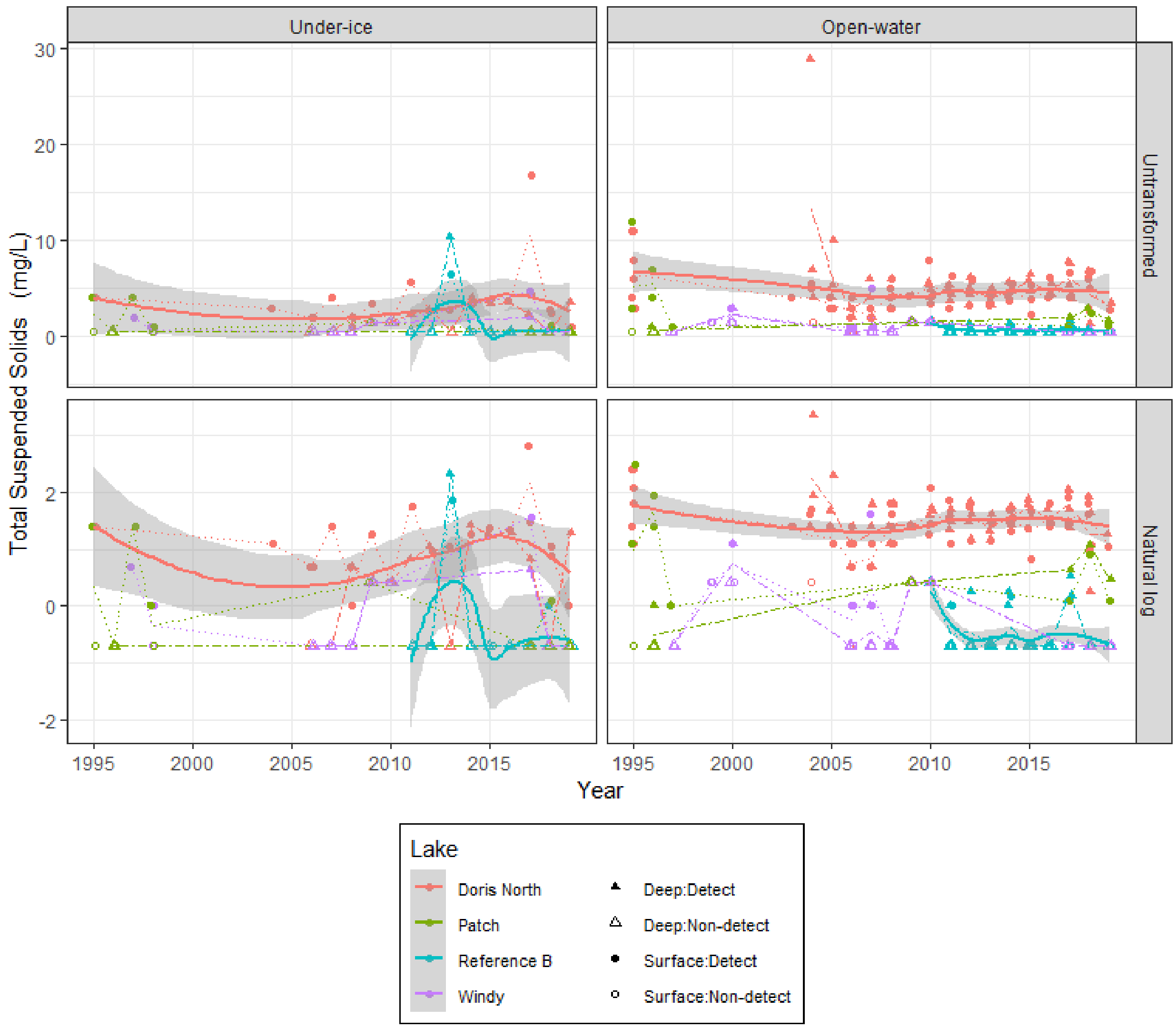
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means). Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.2 Total Suspended Solids

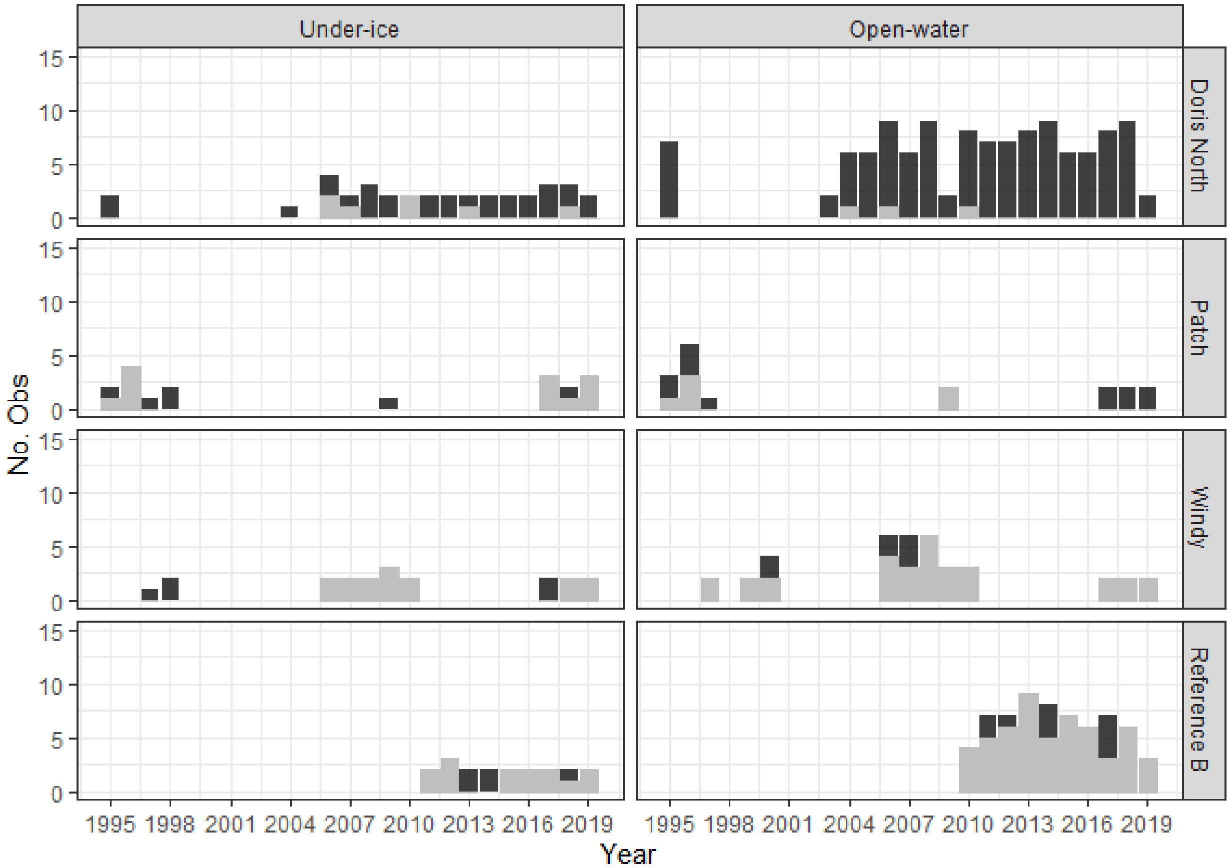
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

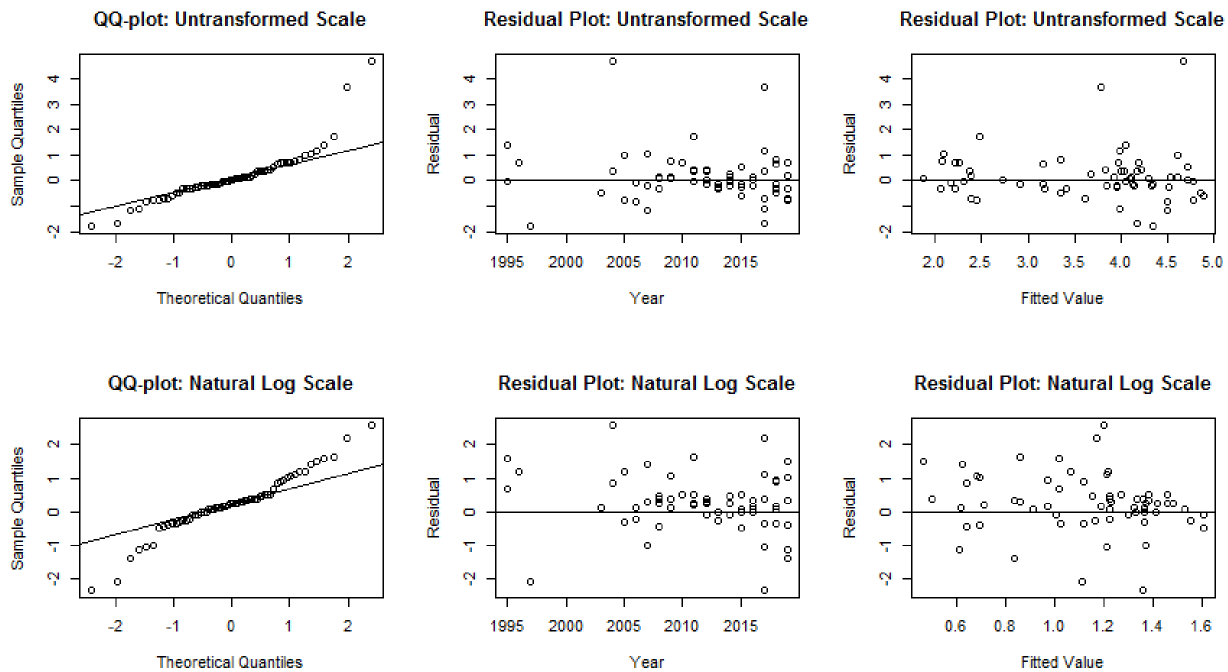
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	36	8	0.22	0	2.90
Doris	Open-water	117	3	0.03	0	4.30
Patch	Under-ice	18	14	0.78	1	1.00
Patch	Open-water	18	6	0.33	0	1.75
Reference B	Under-ice	19	16	0.84	1	1.00
Reference B	Open-water	64	54	0.84	1	1.00
Windy	Under-ice	20	16	0.80	1	1.00
Windy	Open-water	38	31	0.82	1	1.00

More than 50% of data under detection limit in Patch under-ice, Reference B under-ice, Reference B open-water, Windy under-ice, and Windy open-water. Data from those site-season groupings will be removed from the analysis. Doris under-ice and Patch open-water exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. The analysis proceeds with linear mixed effects regression for Patch.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2004	Open-water	Deep	13.33	4.669	4.689
Doris	2017	Under-ice	Surface	10.60	3.790	3.685

Outliers on natural log scale: None

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	15.26	4	0.0042

Doris Lake appears to show significant deviation from no trend.

Open-water

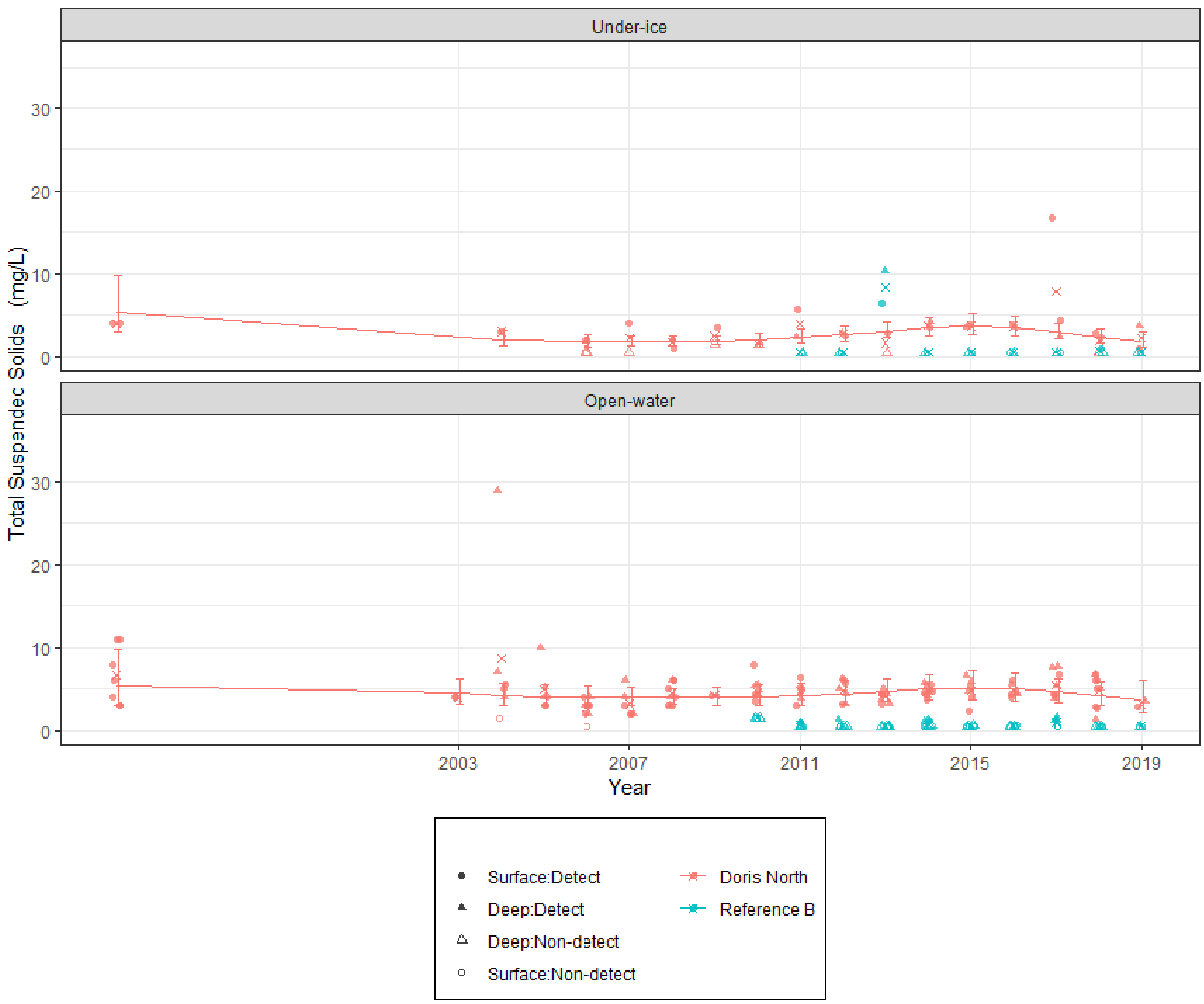
Analysis	Chi.sq	DF	P.value
Compare to slope 0	1.792	4	0.7739

Doris Lake does not exhibit significant deviation from no trend.

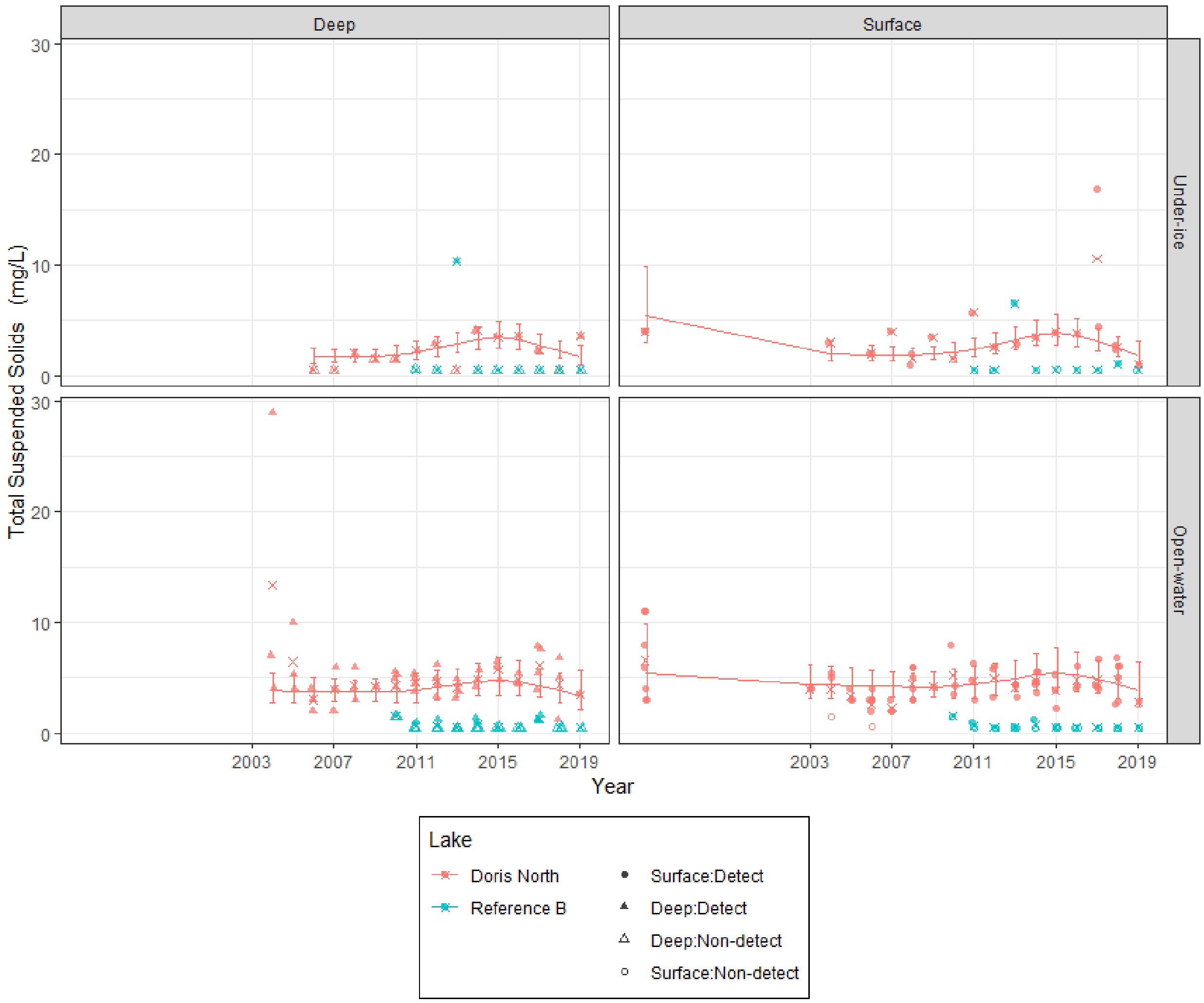
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models are fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.3327	0.5387	9	-0.6175	0.5522	not sig.

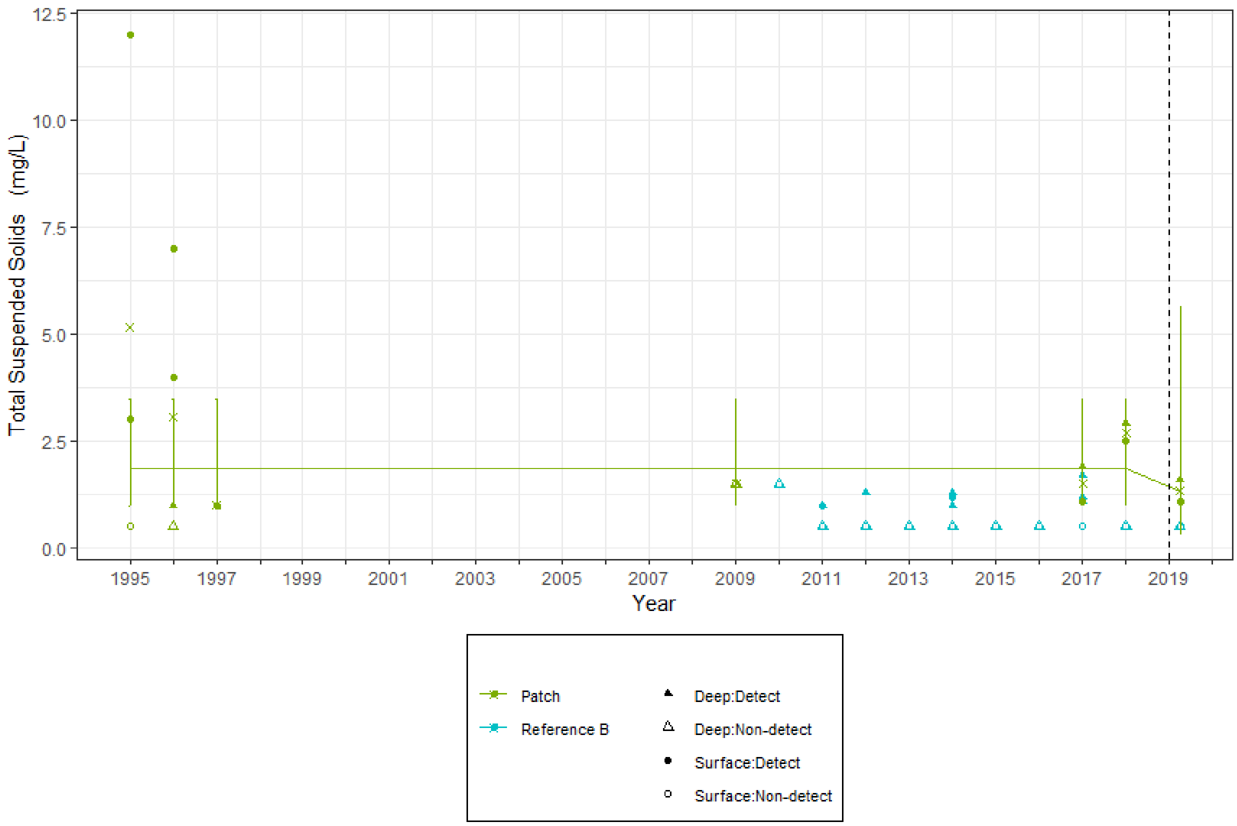
Conclusion:

The change in total suspended solids concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.5522) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

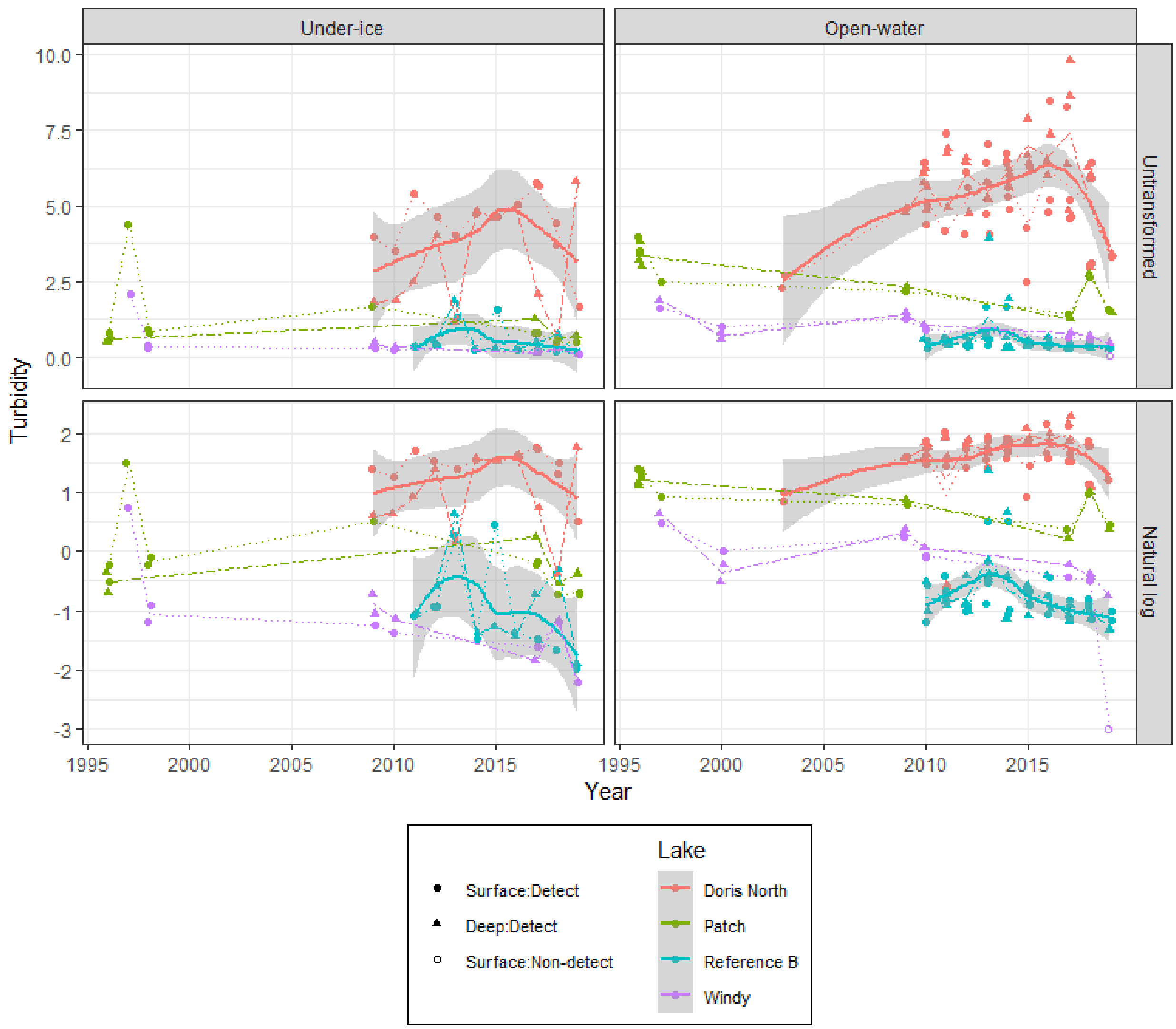
Open-water Before-vs-After Analysis

Analysis not performed.

C.3.2.3 Turbidity

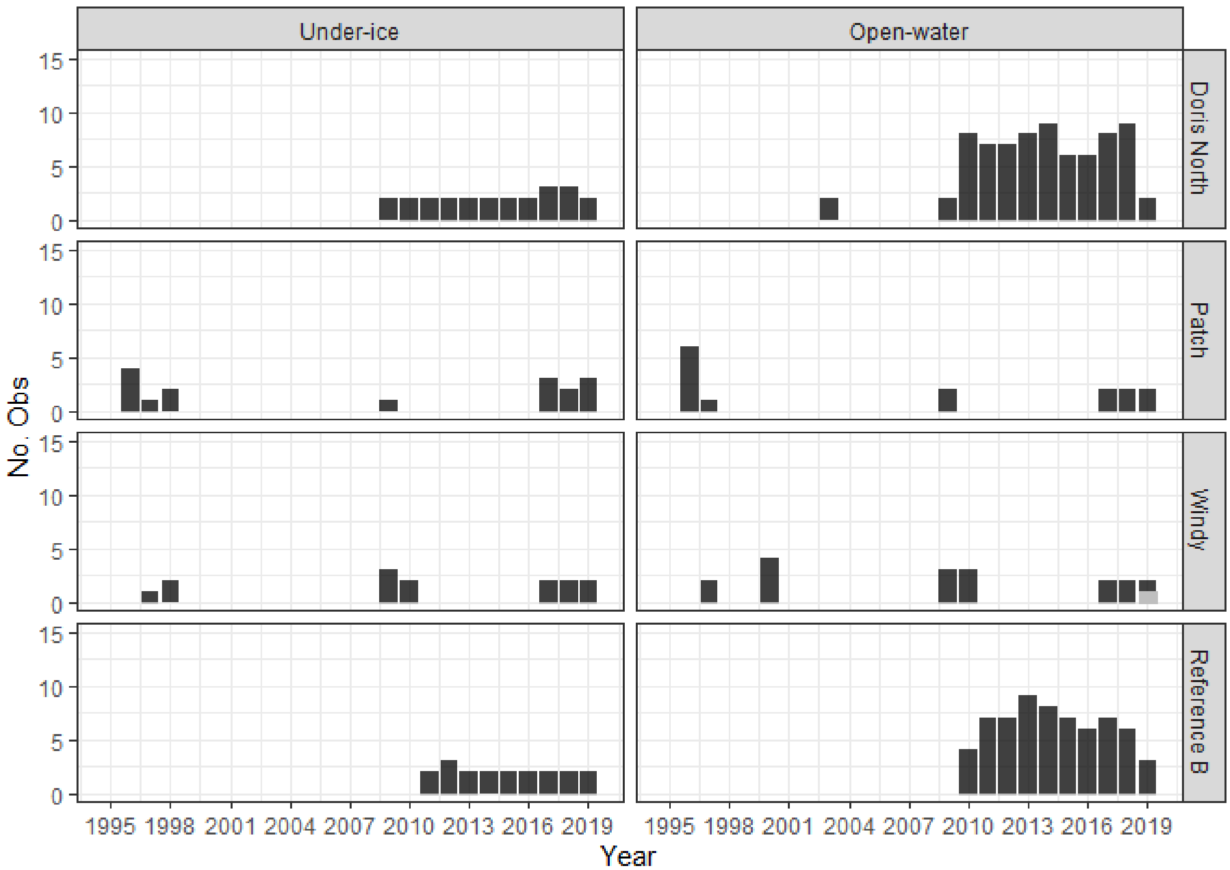
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

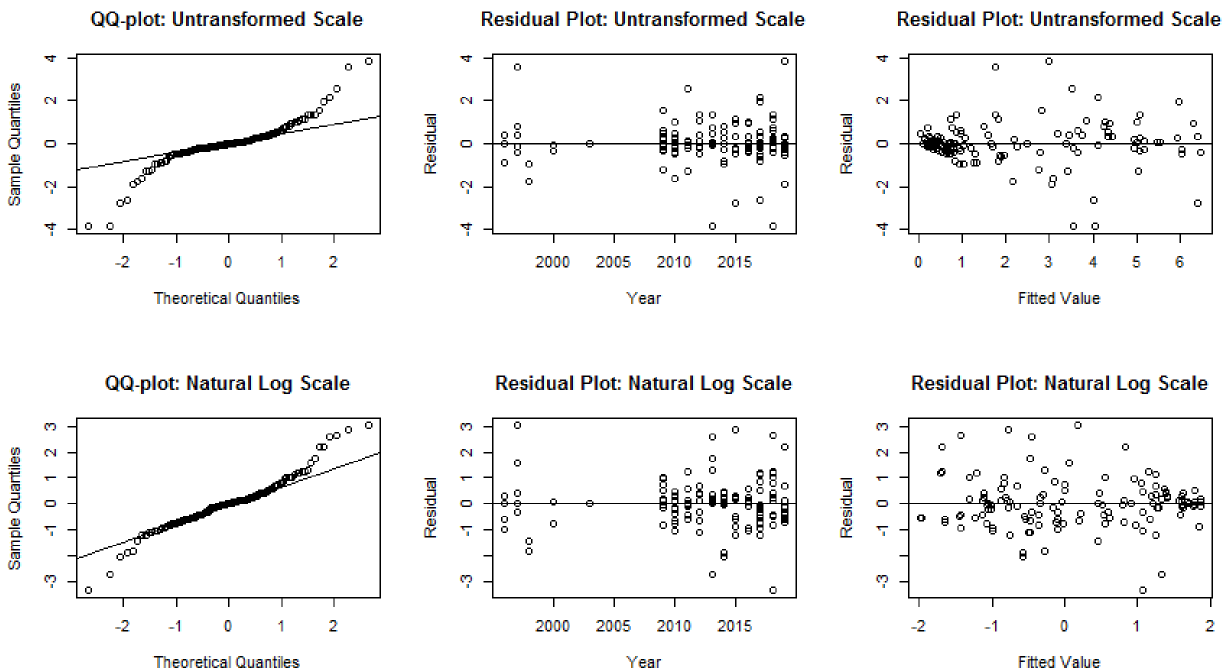
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	24	0	0.00	0.0	4.245
Doris	Open-water	74	0	0.00	0.0	5.720
Patch	Under-ice	16	0	0.00	0.0	0.745
Patch	Open-water	15	0	0.00	0.0	2.670
Reference B	Under-ice	19	0	0.00	0.0	0.340
Reference B	Open-water	64	0	0.00	0.0	0.410
Windy	Under-ice	14	0	0.00	0.0	0.300
Windy	Open-water	18	1	0.06	0.5	0.920

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2013	Under-ice	Deep	1.18	4.044	-3.857
Doris	2018	Under-ice	Deep	0.69	3.557	-3.861
Doris	2019	Under-ice	Deep	5.82	2.975	3.831
Patch	1997	Under-ice	Surface	4.40	1.769	3.543

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2018	Under-ice	Deep	0.69	1.065	-3.367
Patch	1997	Under-ice	Surface	4.40	0.184	3.042

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data. However, there was an outlier retained in the analysis. Results should be interpreted with caution and along with graphical results.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	4.487	4	0.3441

Doris Lake does not exhibit significant deviation from no trend.

Open-water

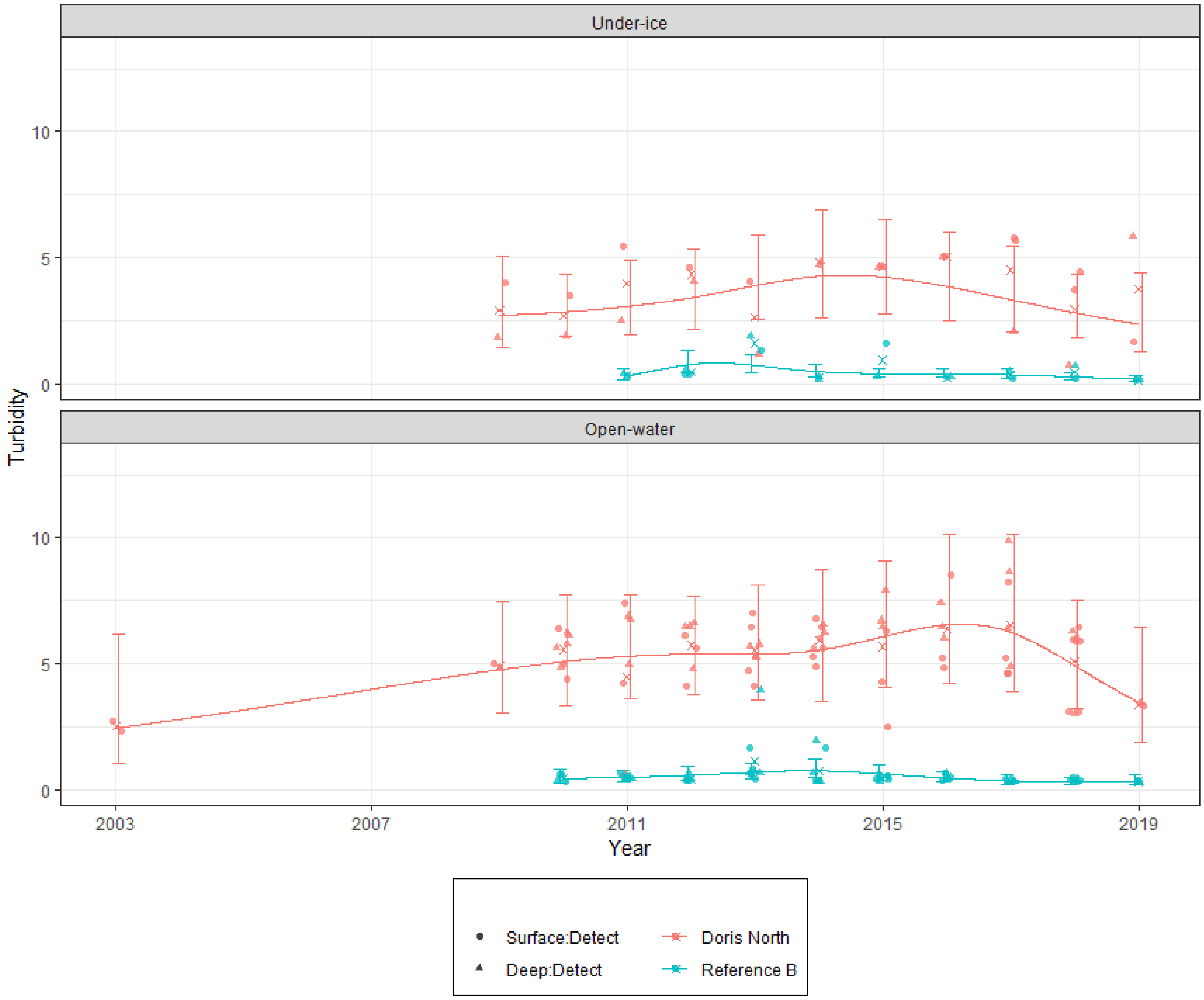
Analysis	Chi.sq	DF	P.value
Compare to slope 0	6.652	4	0.1555

Doris Lake does not exhibit significant deviation from no trend.

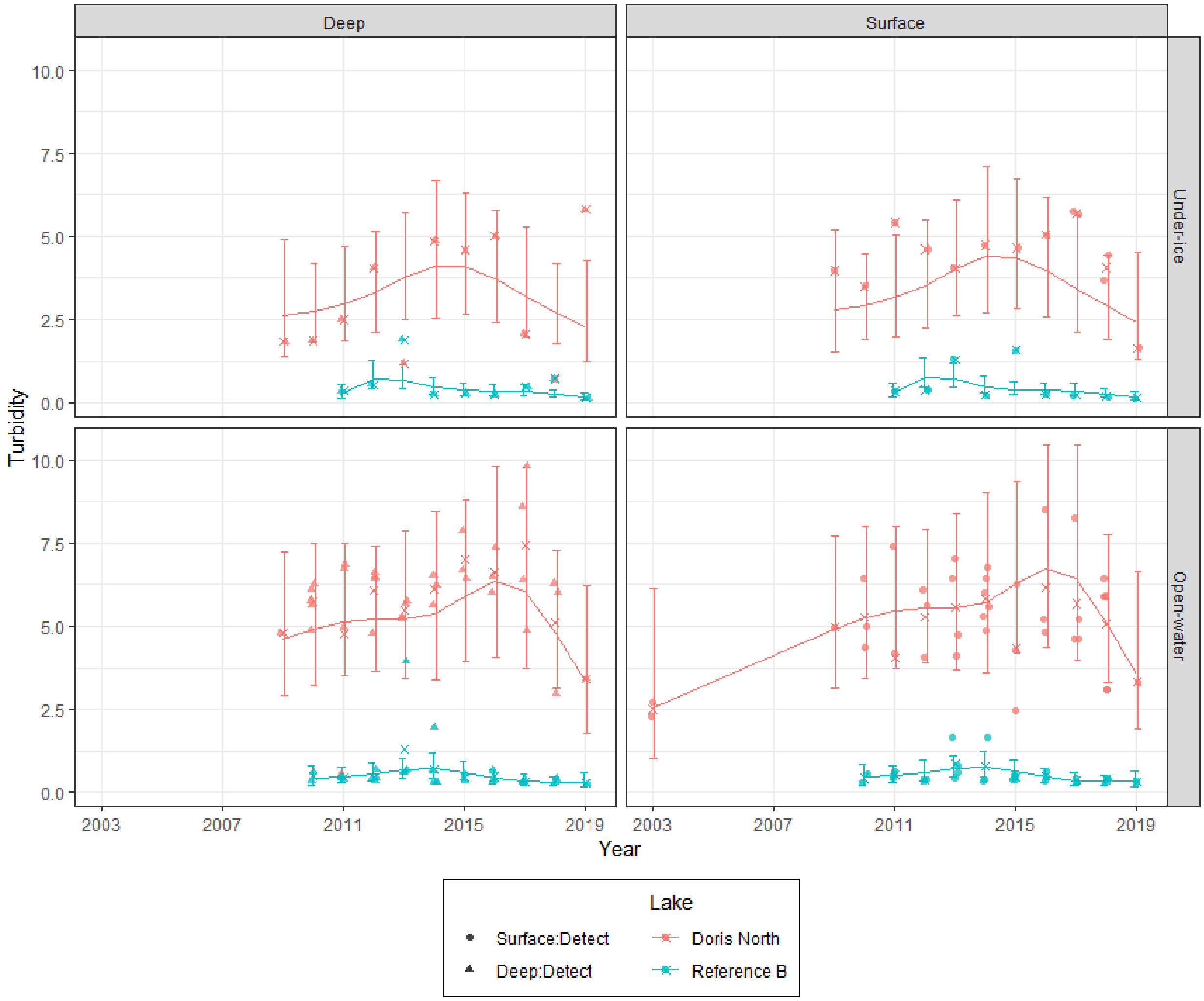
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.7021	0.8596	4.797	-0.8168	0.4527	not sig.

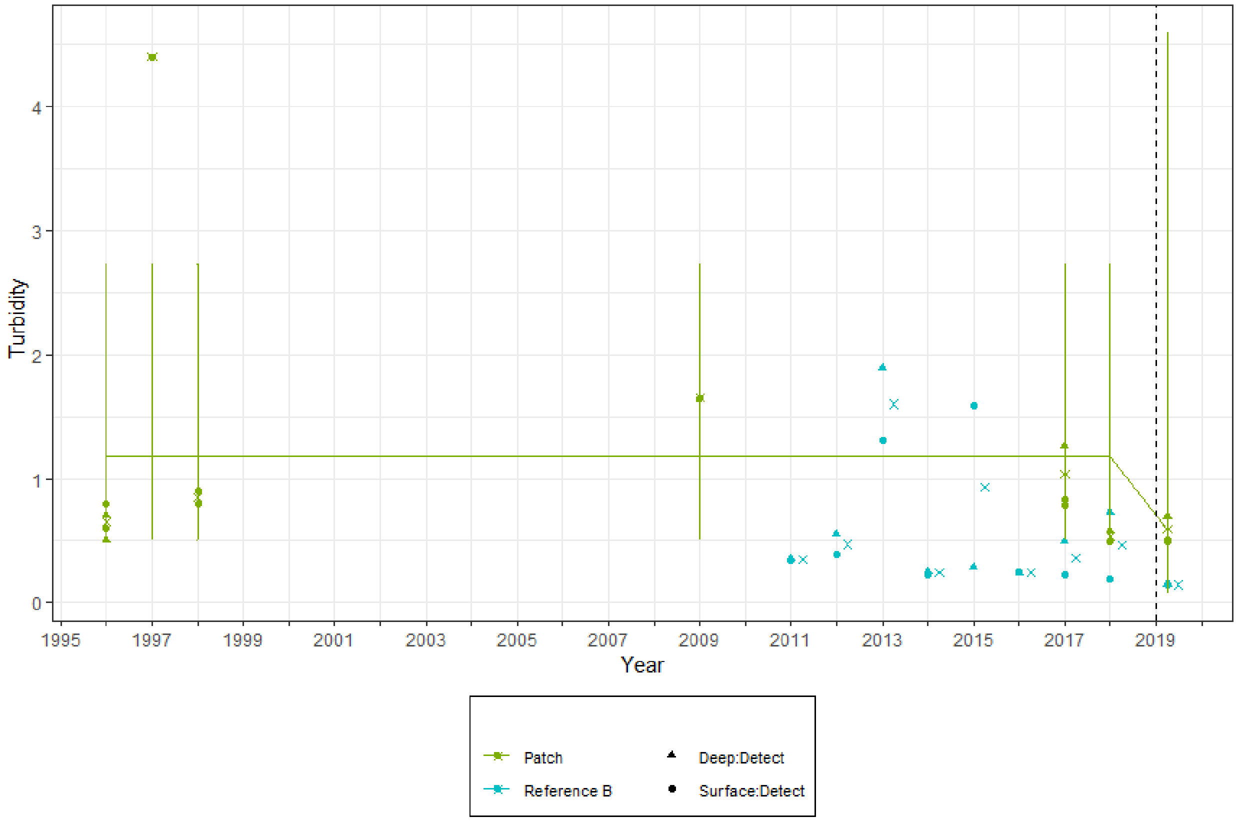
Conclusion:

The change in turbidity at the Patch site from *before* to *after* was not significantly (p = 0.4527) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.4386	0.3904	4.005	-1.123	0.324	not sig.

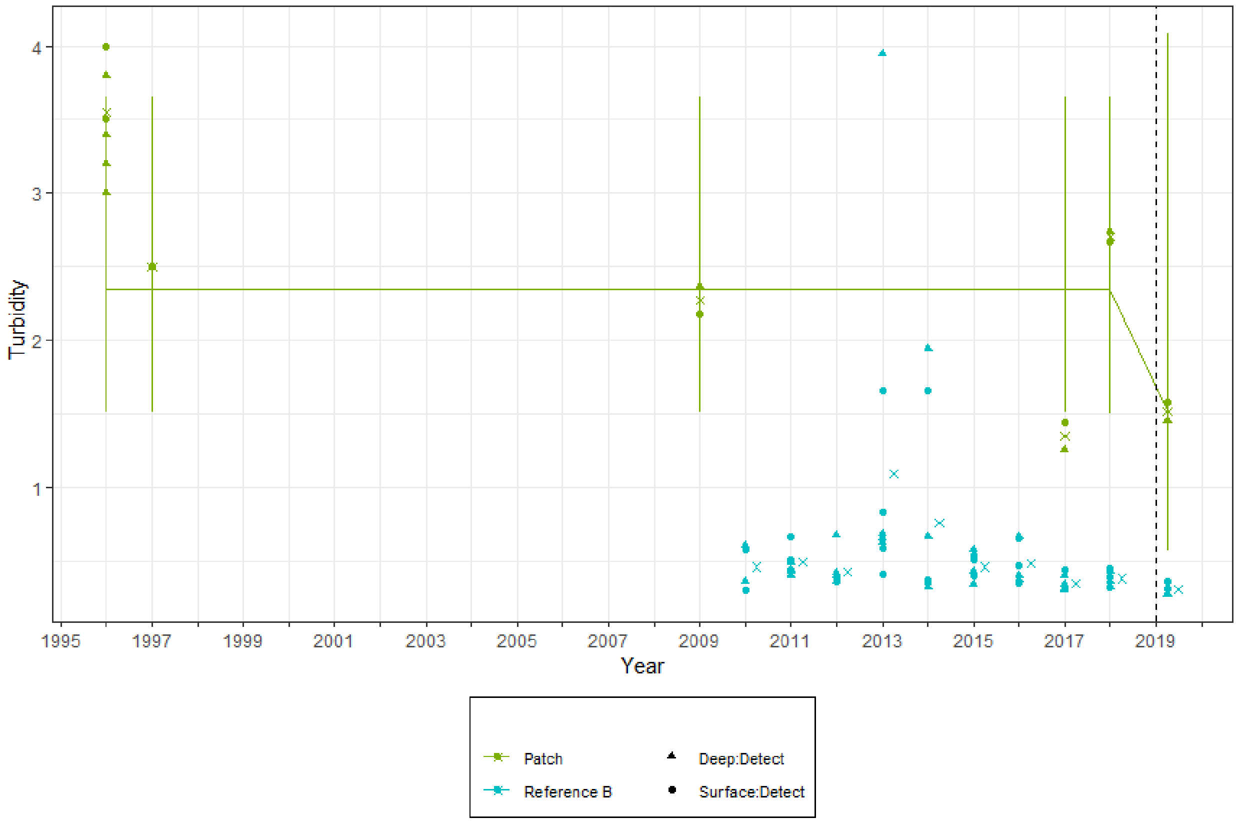
Conclusion:

The change in turbidity in Patch Lake from *before* to *after* was not significantly (p = 0.324) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-1.293	0.9254	4.847	-1.397	0.223	not sig.

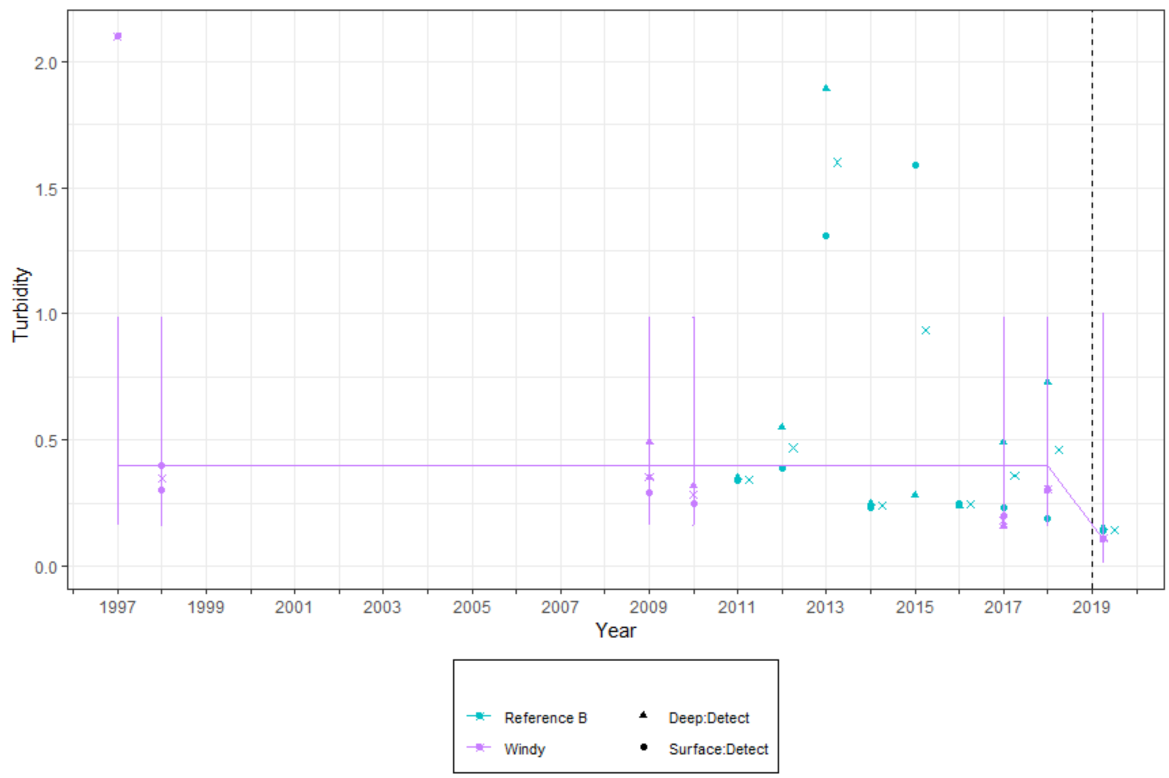
Conclusion:

The change in turbidity in Windy Lake from *before* to *after* was not significantly (p = 0.223) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-1.854	0.4363	11	-4.25	0.0014	sig.

Conclusion:

The change in turbidity in Windy Lake from *before* to *after* was significantly (p = 0.0014) different.

Open-water BACI Analysis

Results of the ANOVA test on the fixed effects of the model:

	Sum Sq.	Mean Sq.	NumDF	DenDF	F value	p
class	0.0000	0.0000	1	20.735	0.0001	0.9920
period	1.7695	1.7695	1	7.163	12.4853	0.0092
Depth.Zone	0.2023	0.2023	1	18.357	1.4272	0.2470
class:period	1.4937	1.4937	1	20.735	10.5397	0.0039

Estimated marginal means for site class by period:

Class	Period	LSmean	SE	DF	LowerCL	UpperCL
Exposure	after	-1.8754	0.3799	12.31	-2.7008	-1.0499
Reference	after	-1.2015	0.3799	12.31	-2.0269	-0.3760
Exposure	before	0.0277	0.1530	18.75	-0.2928	0.3483
Reference	before	-0.6502	0.1258	15.06	-0.9182	-0.3822

Summary of BACI contrasts for relative difference between changes from the *before* to *after* in Windy and Reference B, with 95% confidence intervals:

Windy vs:	Estimate	Lower C.I.	Upper C.I.	Significance
Reference Sites	-1.352	-2.218	-0.4852	sig.

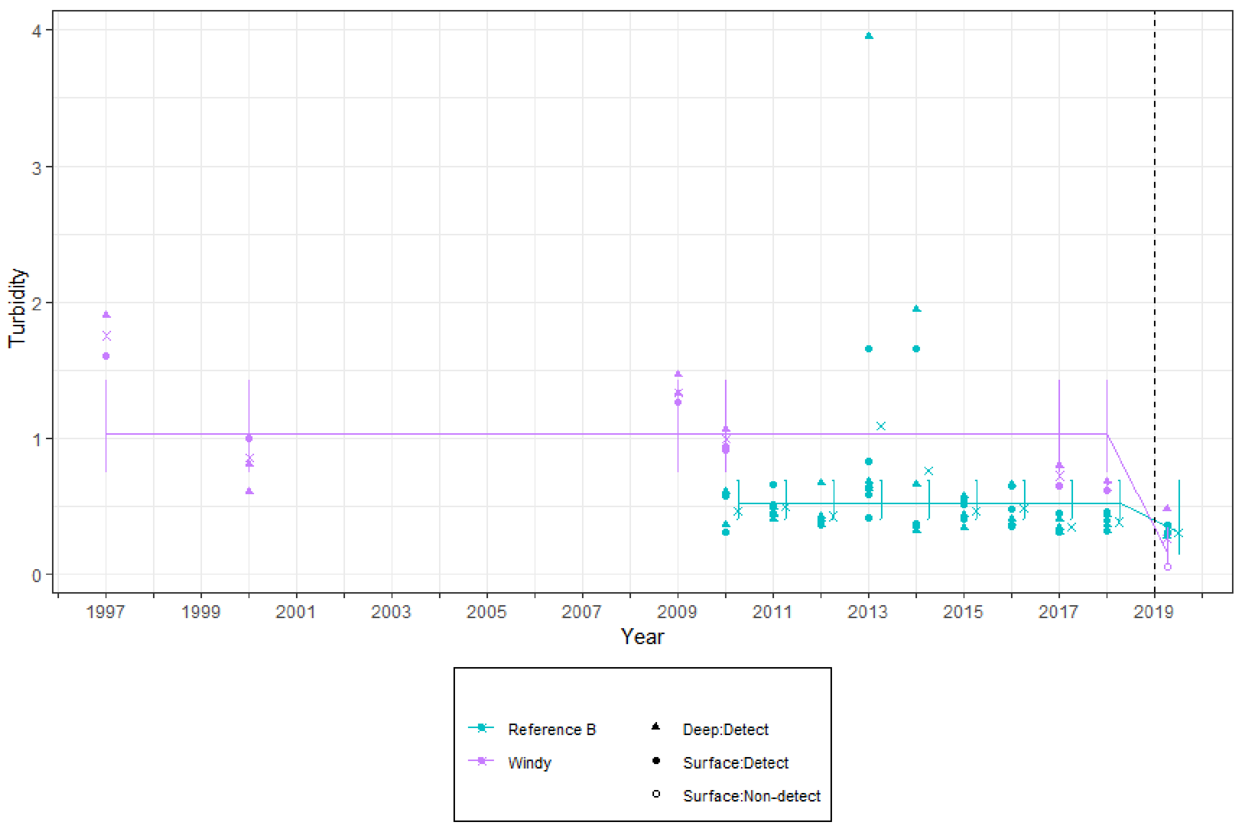
A BACI contrast is identified as *significant* if the confidence interval does not include 0.

Conclusion:

The change in turbidity in Windy Lake from *before* to *after* was significantly (p = 0.004) different from the change at Reference B, according to the test on the BACI term (*class:period*).

Open-water Observed Data and Fitted Values

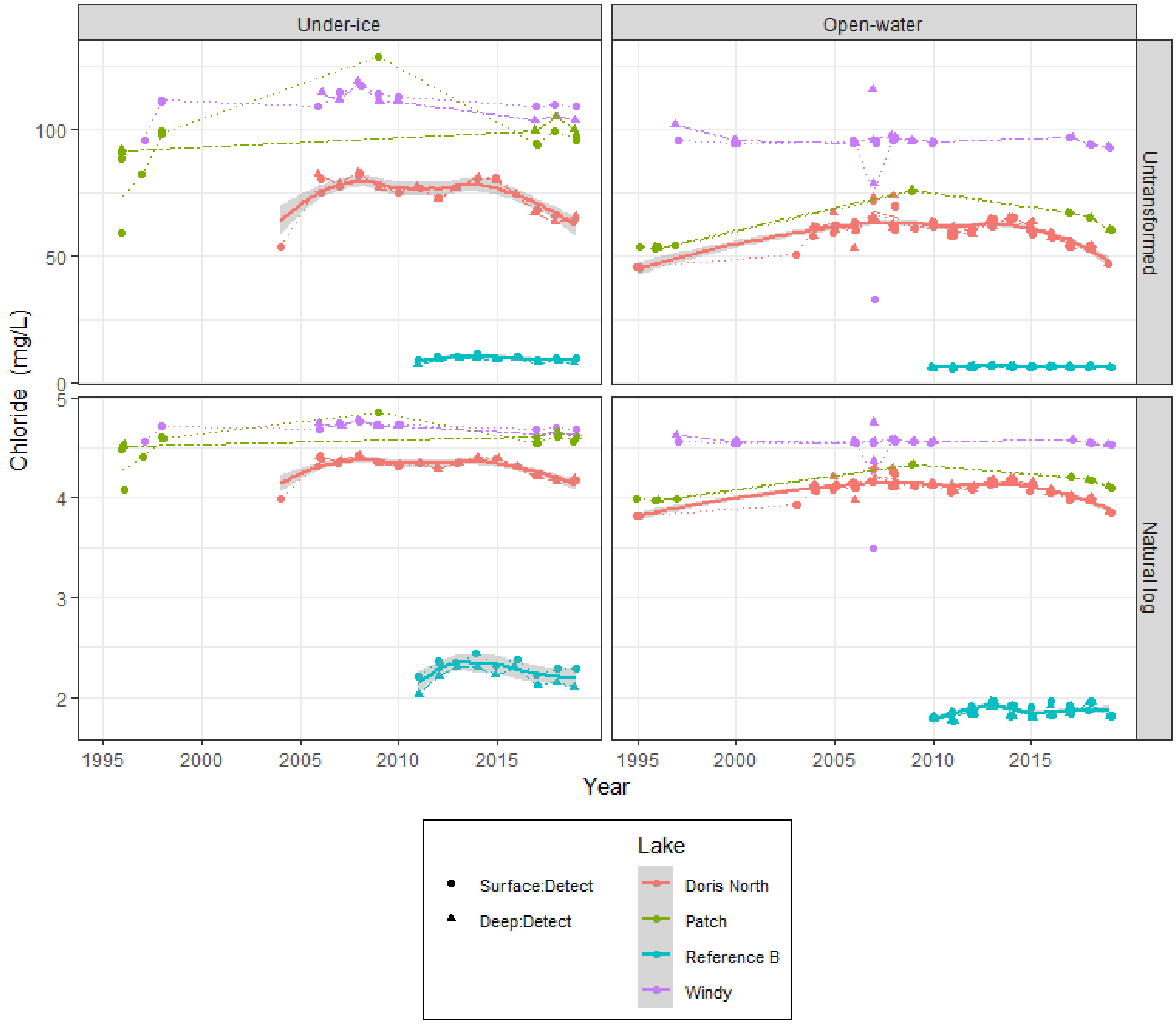
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for exposure and reference sites. Vertical dashed line represents the start of the after period.



C.3.2.4 Chloride

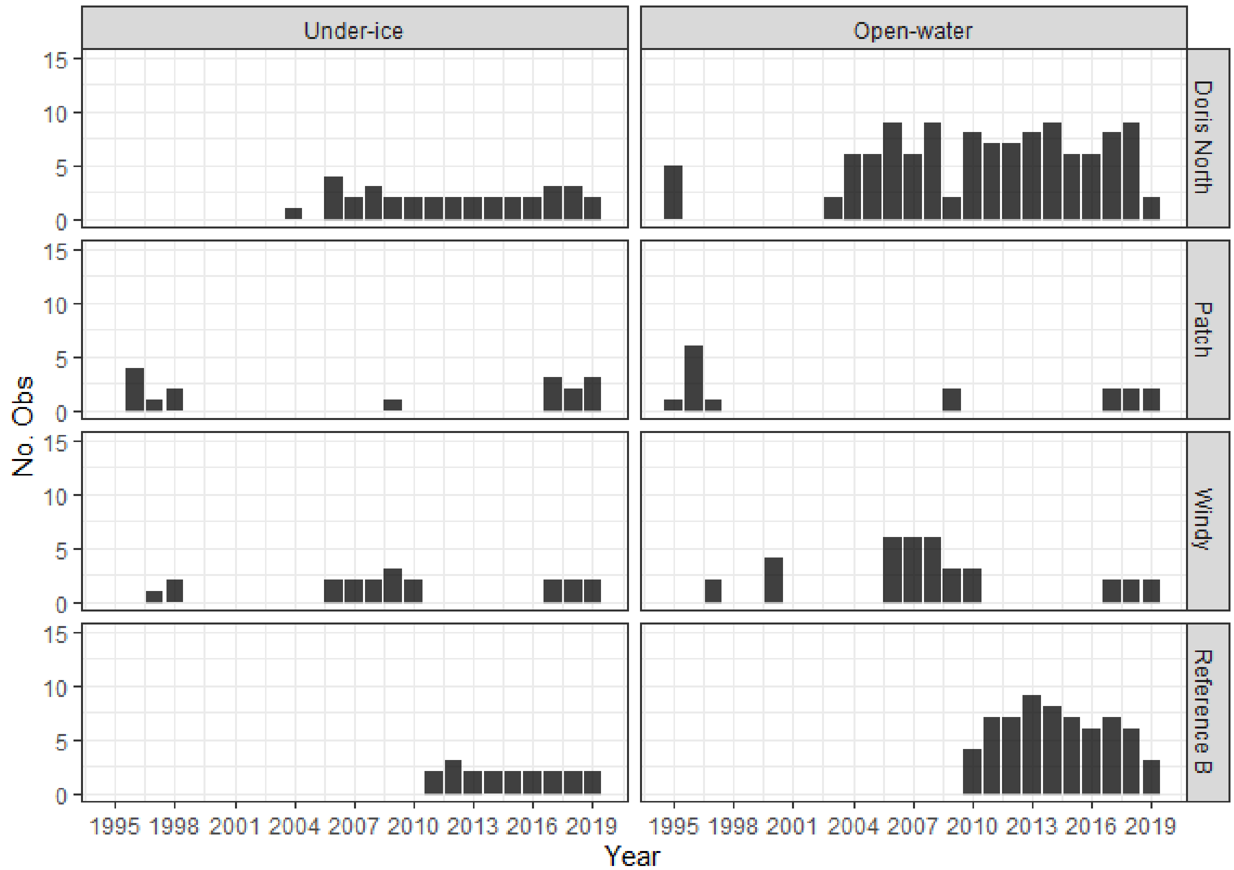
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

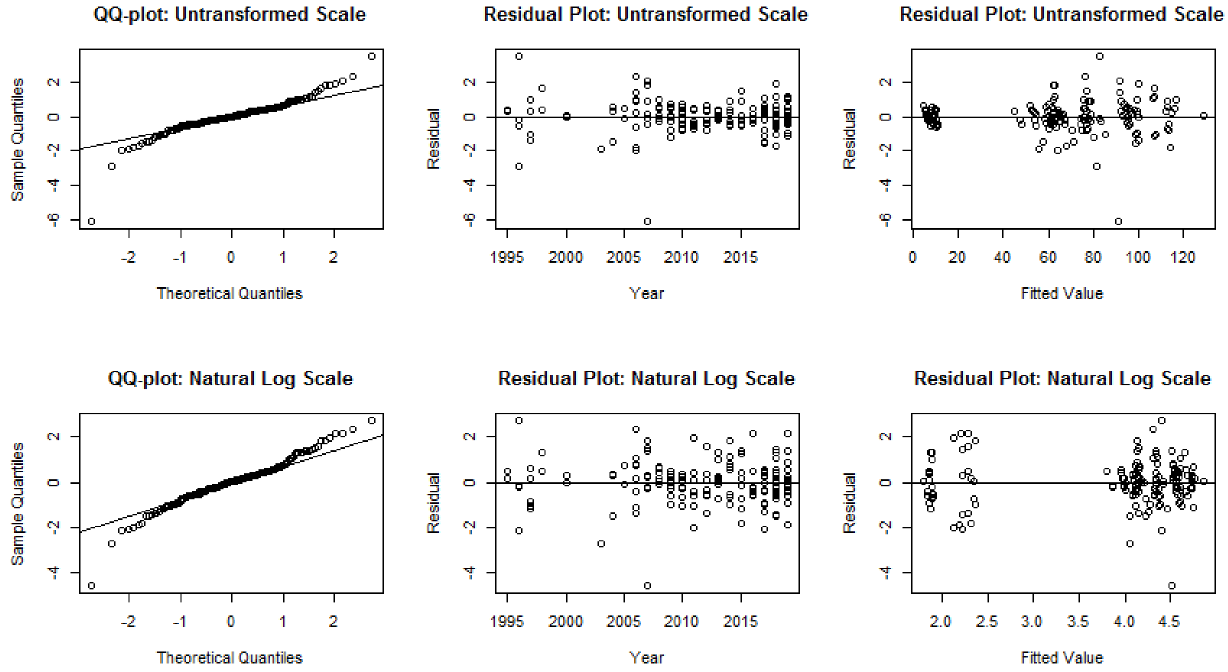
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	34	0	0	0	76.70
Doris	Open-water	115	0	0	0	61.20
Patch	Under-ice	16	0	0	0	96.65
Patch	Open-water	16	0	0	0	57.35
Reference B	Under-ice	19	0	0	0	9.89
Reference B	Open-water	64	0	0	0	6.41
Windy	Under-ice	20	0	0	0	111.00
Windy	Open-water	36	0	0	0	95.50

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Patch	1996	Under-ice	Deep	91.65	82.34	3.510
Windy	2007	Open-water	Surface	74.57	90.76	-6.108

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Windy	2007	Open-water	Surface	74.57	4.516	-4.582

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data. However, there was an outlier retained in the analysis. Results should be interpreted with caution and along with graphical results.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	57.98	4	0.0000
Compare to Reference B	28.36	4	0.0000

Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B lake.

Open-water

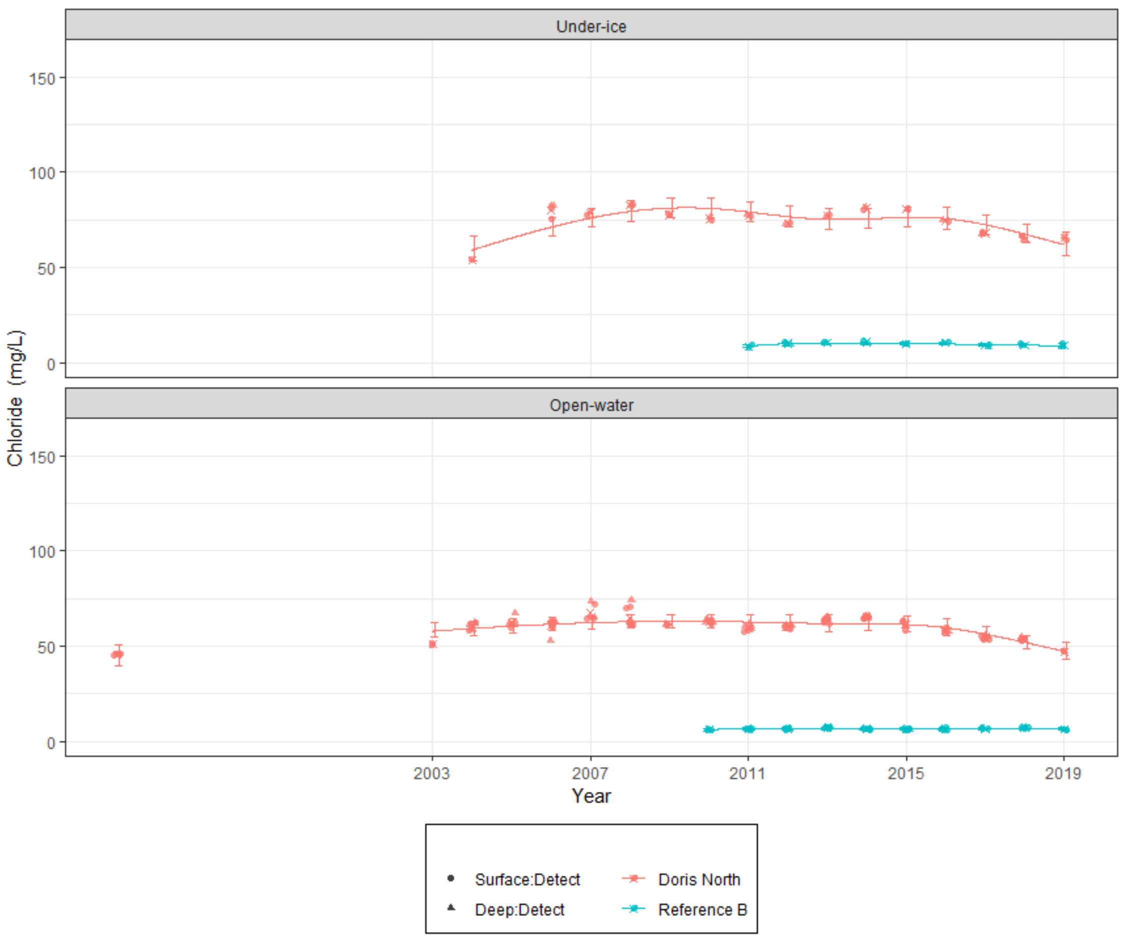
Analysis	Chi.sq	DF	P.value
Compare to slope 0	74.97	4	0.0000
Compare to Reference B	44.83	4	0.0000

Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B lake.

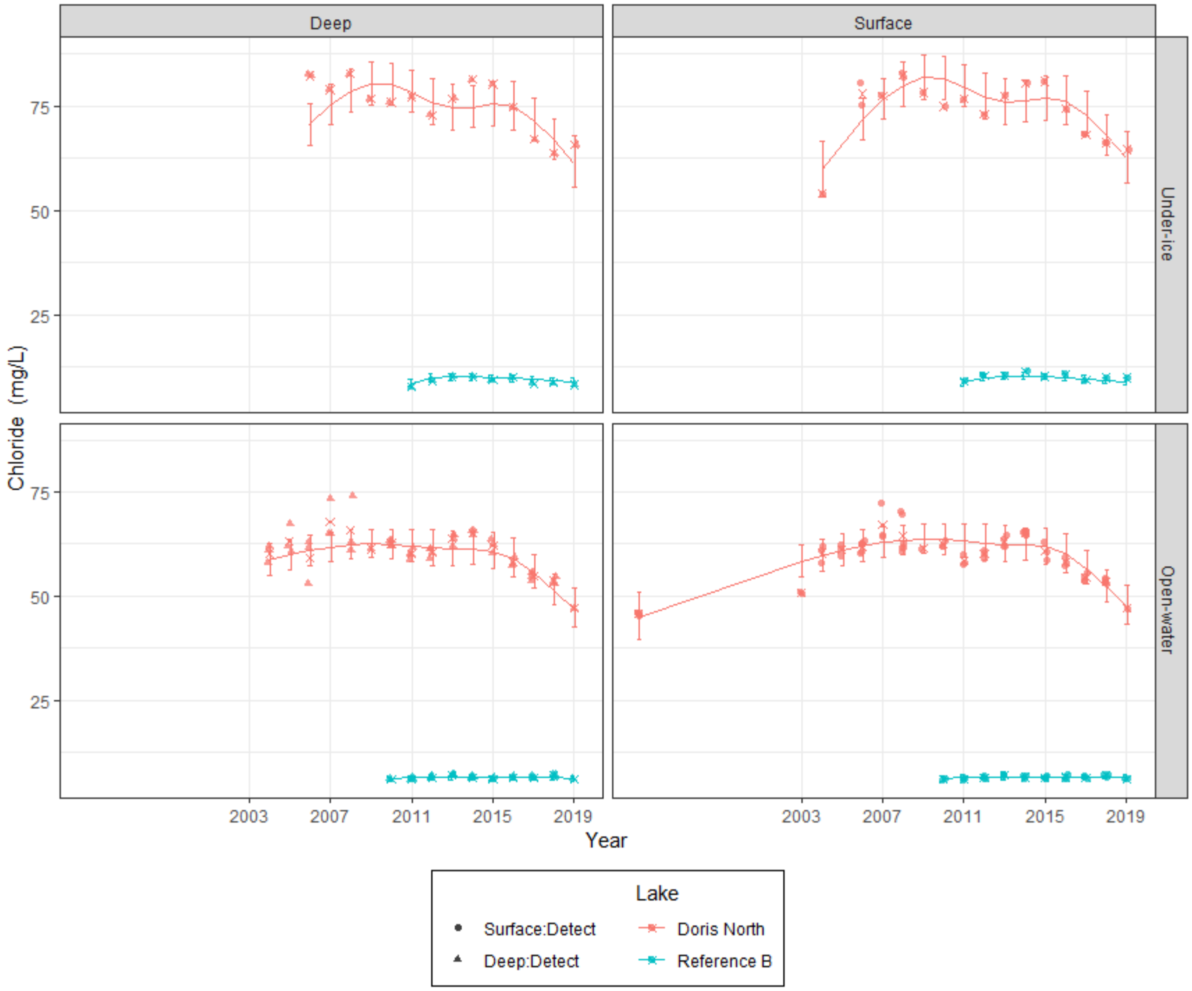
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0114	0.1829	4.578	-0.0626	0.9528	not sig.

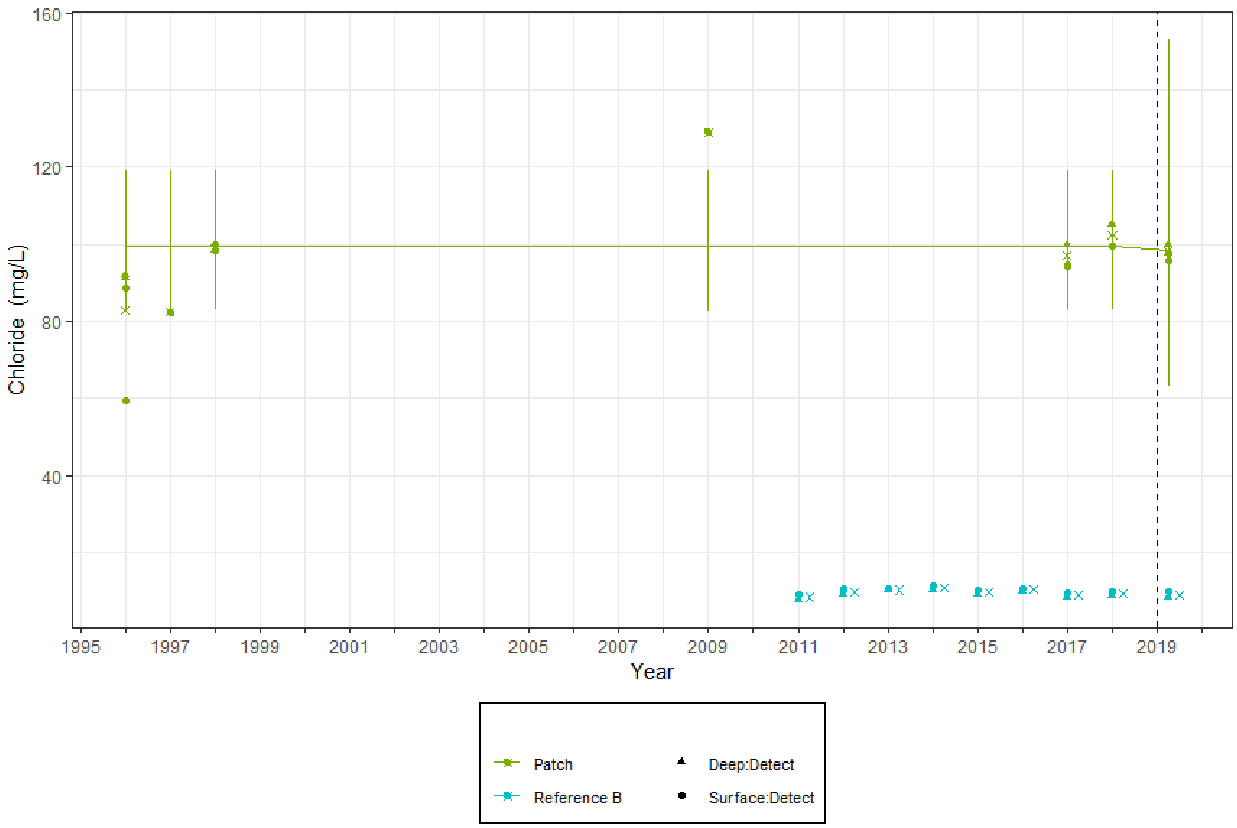
Conclusion:

The change in chloride concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.9528) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0083	0.1594	5	-0.0518	0.9607	not sig.

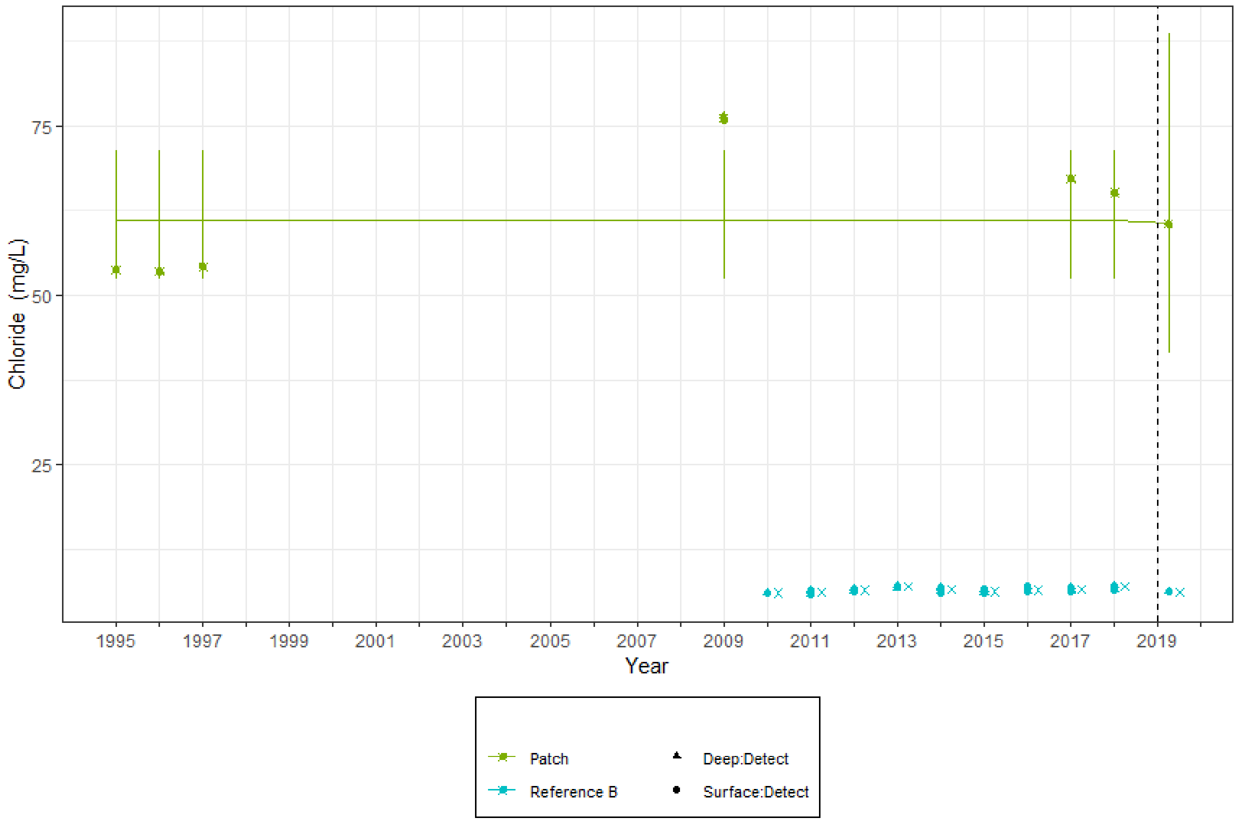
Conclusion:

The change in chloride concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.9607) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0303	0.0603	6.848	-0.5016	0.6317	not sig.

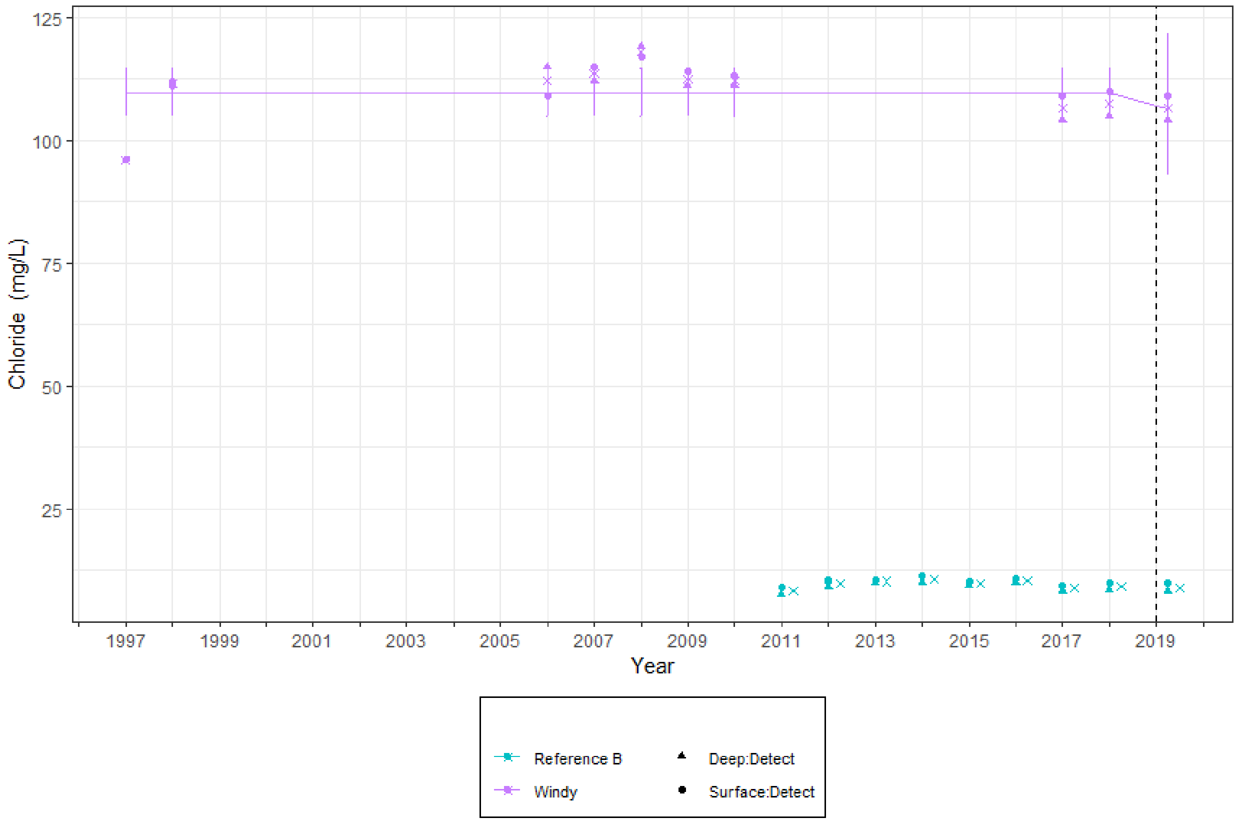
Conclusion:

The change in chloride concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.6317) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0165	0.0453	8	-0.3644	0.725	not sig.

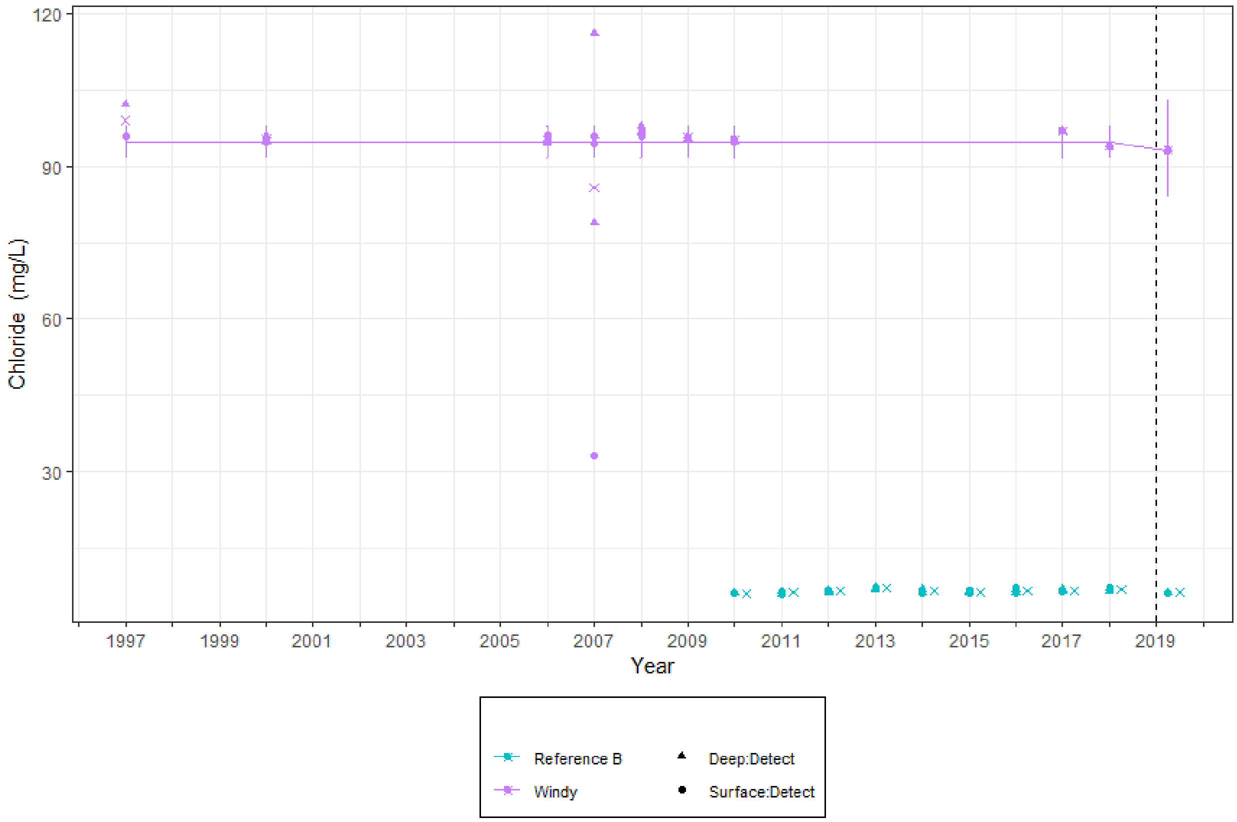
Conclusion:

The change in chloride concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.725) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

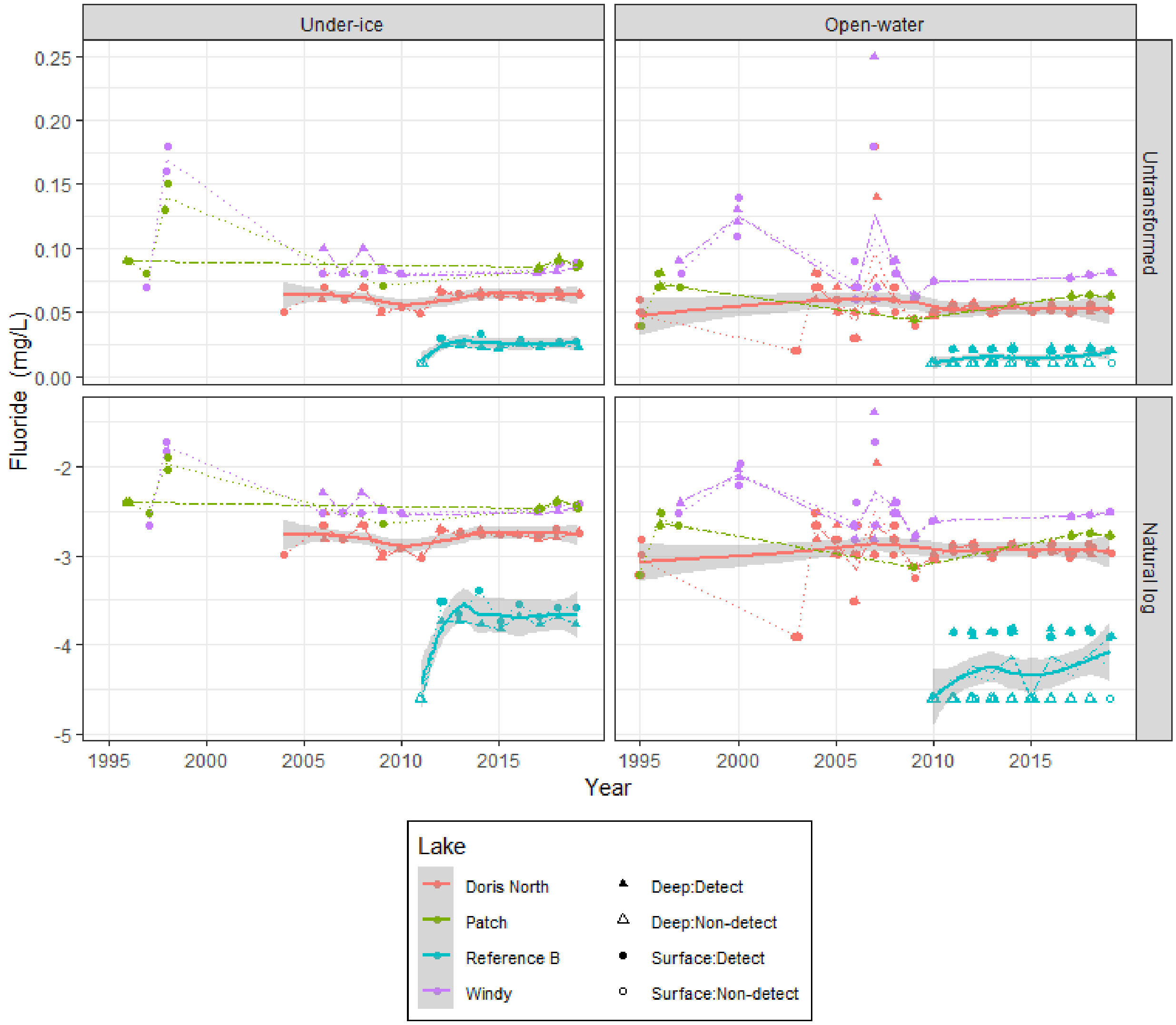
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.5 Fluoride

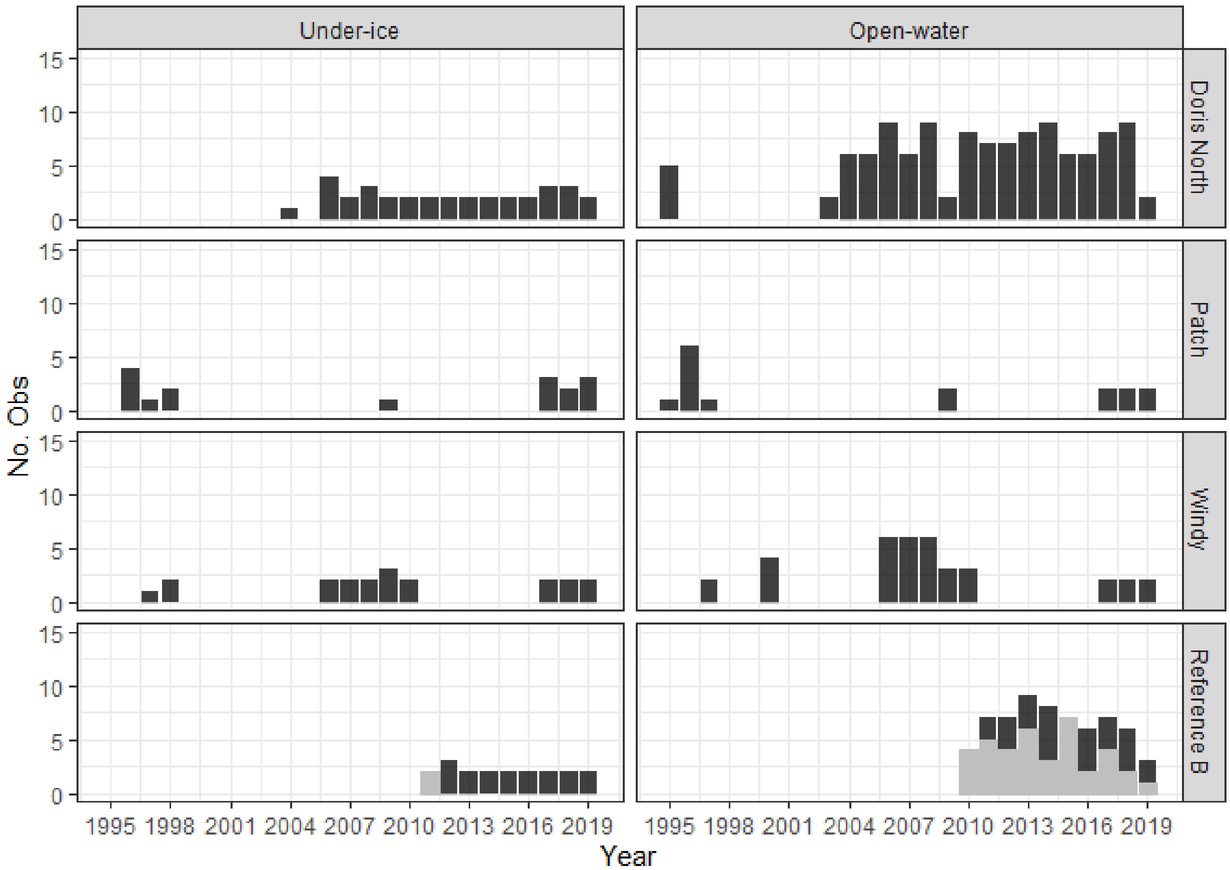
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

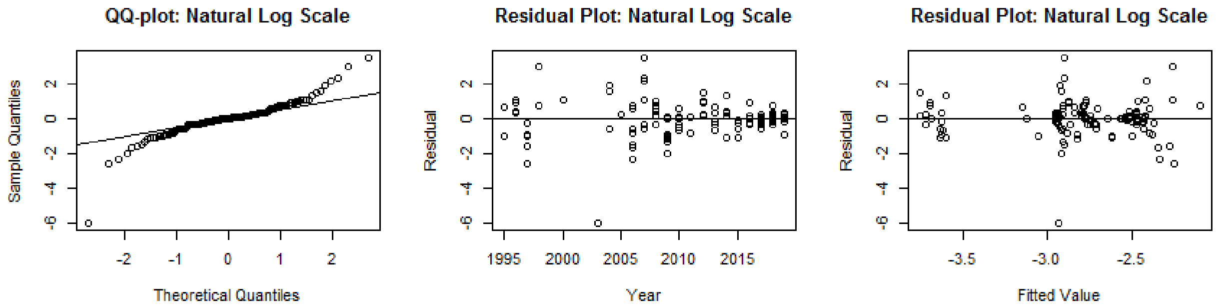
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	34	0	0.00	0.00	0.0630
Doris	Open-water	115	0	0.00	0.00	0.0530
Patch	Under-ice	16	0	0.00	0.00	0.0890
Patch	Open-water	16	0	0.00	0.00	0.0640
Reference B	Under-ice	19	2	0.11	0.00	0.0250
Reference B	Open-water	64	38	0.59	0.33	0.0200
Windy	Under-ice	20	0	0.00	0.00	0.0825
Windy	Open-water	36	0	0.00	0.00	0.0790

More than 50% of data under detection limit in Reference B open-water. Data from those site-season groupings will be removed from the analysis. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2003	Open-water	Surface	0.0200	0.058	-3.378
Doris	2007	Open-water	Surface	0.0967	0.058	3.490
Windy	1997	Under-ice	Surface	0.0700	0.117	-4.205
Windy	1998	Under-ice	Surface	0.1700	0.115	4.959
Windy	2006	Open-water	Deep	0.0667	0.100	-3.028
Windy	2007	Open-water	Deep	0.1267	0.093	3.003

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2003	Open-water	Surface	0.0200	-2.938	-6.062
Doris	2007	Open-water	Surface	0.0967	-2.905	3.538
Windy	1998	Under-ice	Surface	0.1700	-2.256	3.013

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data. However, there were outliers retained in the analysis. Results should be interpreted with caution and along with graphical results.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	1.227	4	0.8736

Doris Lake does not exhibit significant deviation from no trend.

Open-water

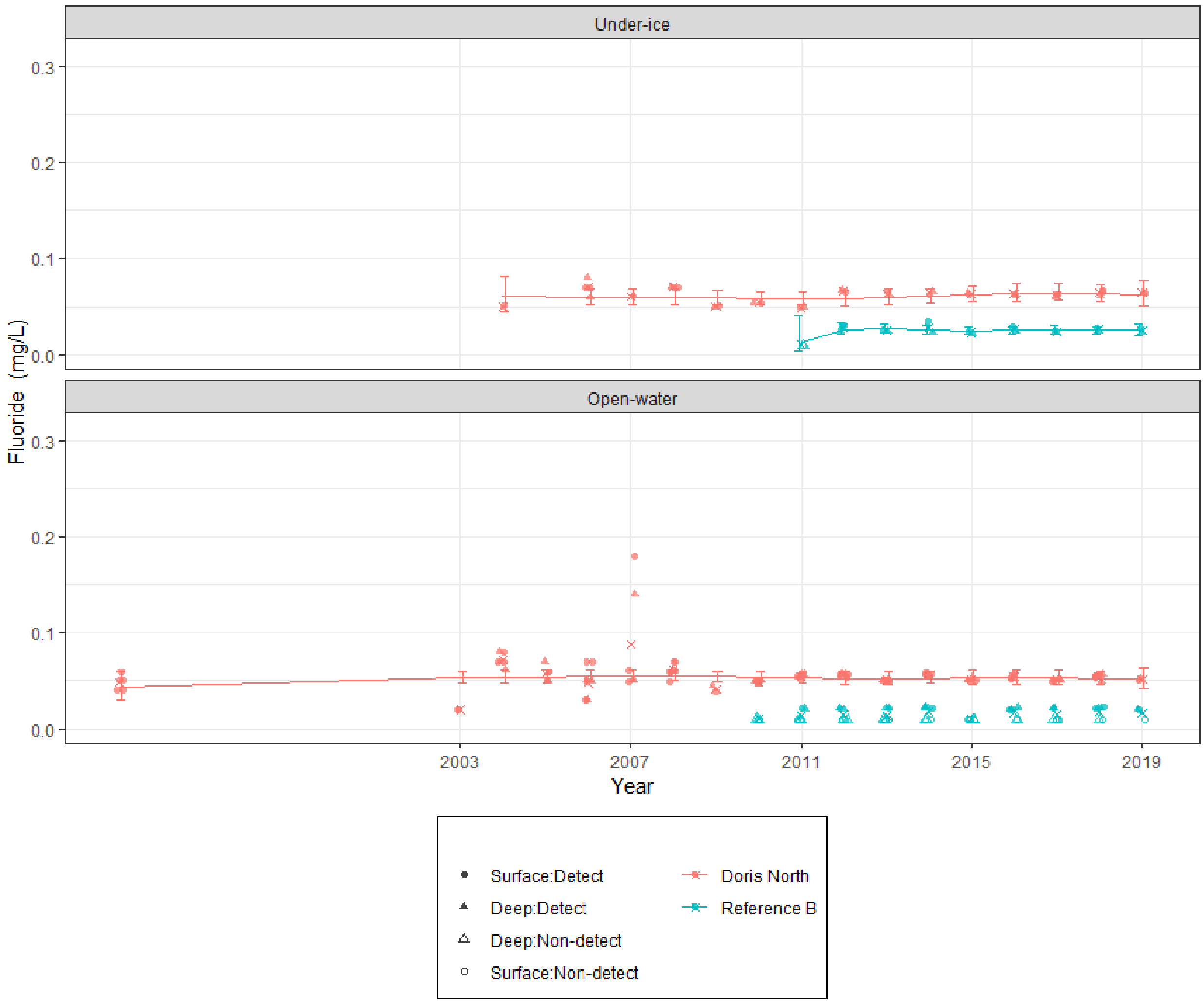
Analysis	Chi.sq	DF	P.value
Compare to slope 0	1.969	4	0.7414

Doris Lake does not exhibit significant deviation from no trend.

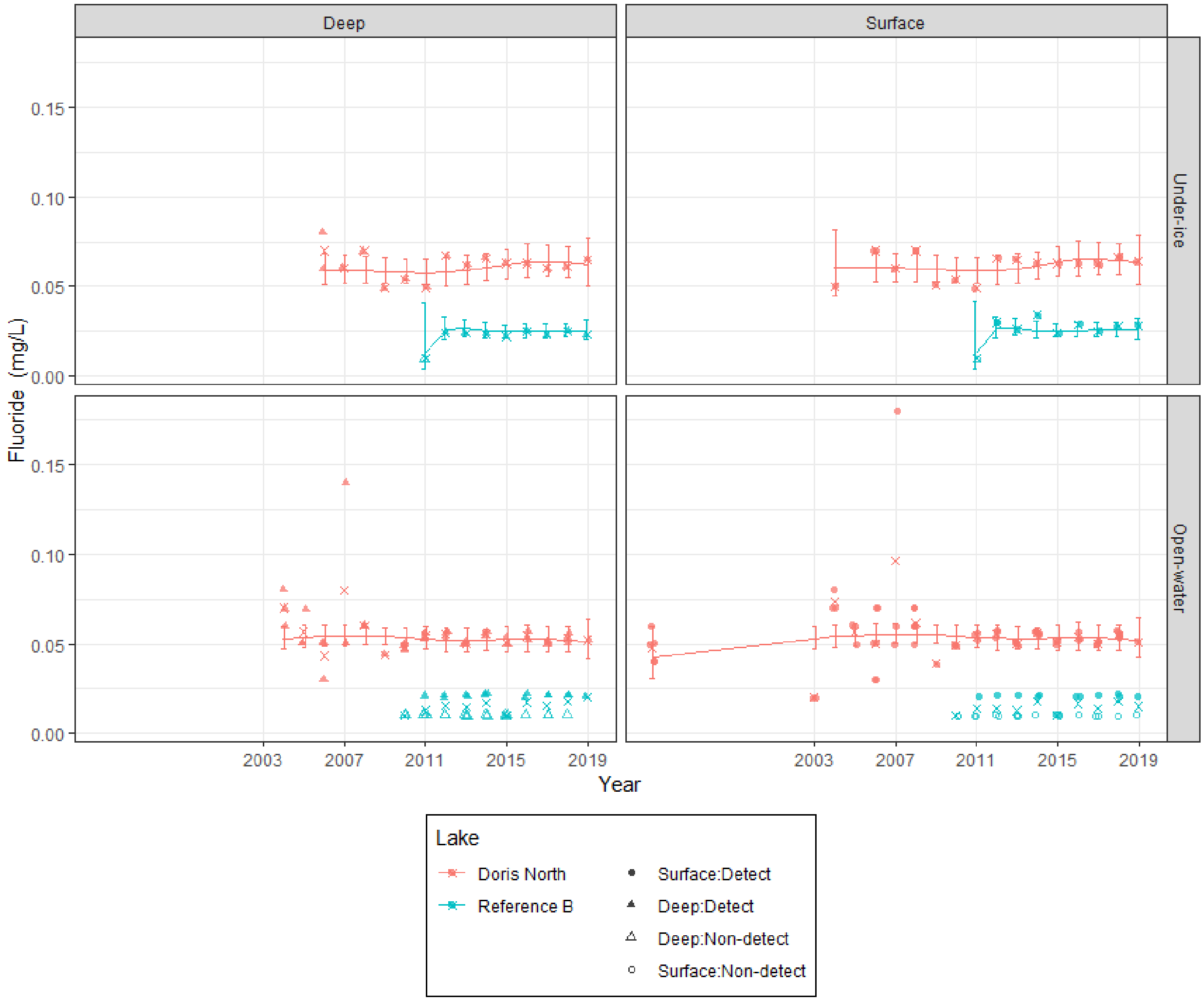
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0399	0.2513	4.996	-0.1589	0.88	not sig.

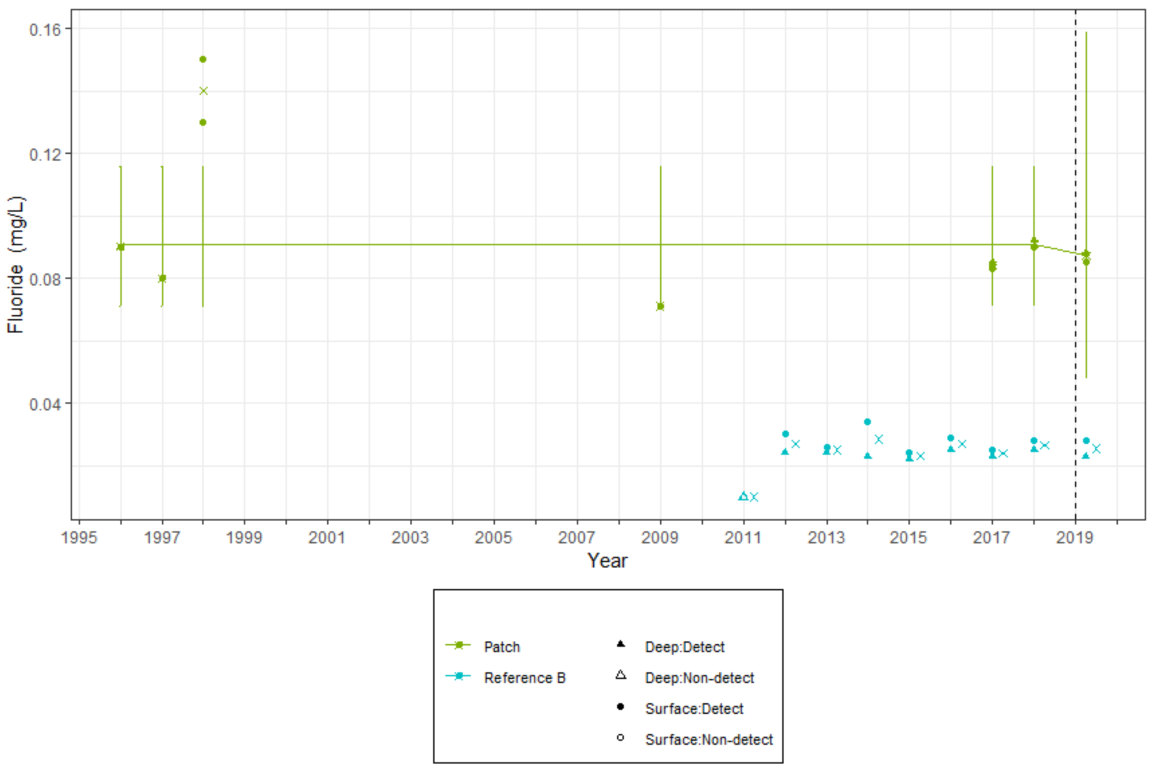
Conclusion:

The change in fluoride concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.88) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.0824	0.2741	4.992	0.3008	0.7757	not sig.

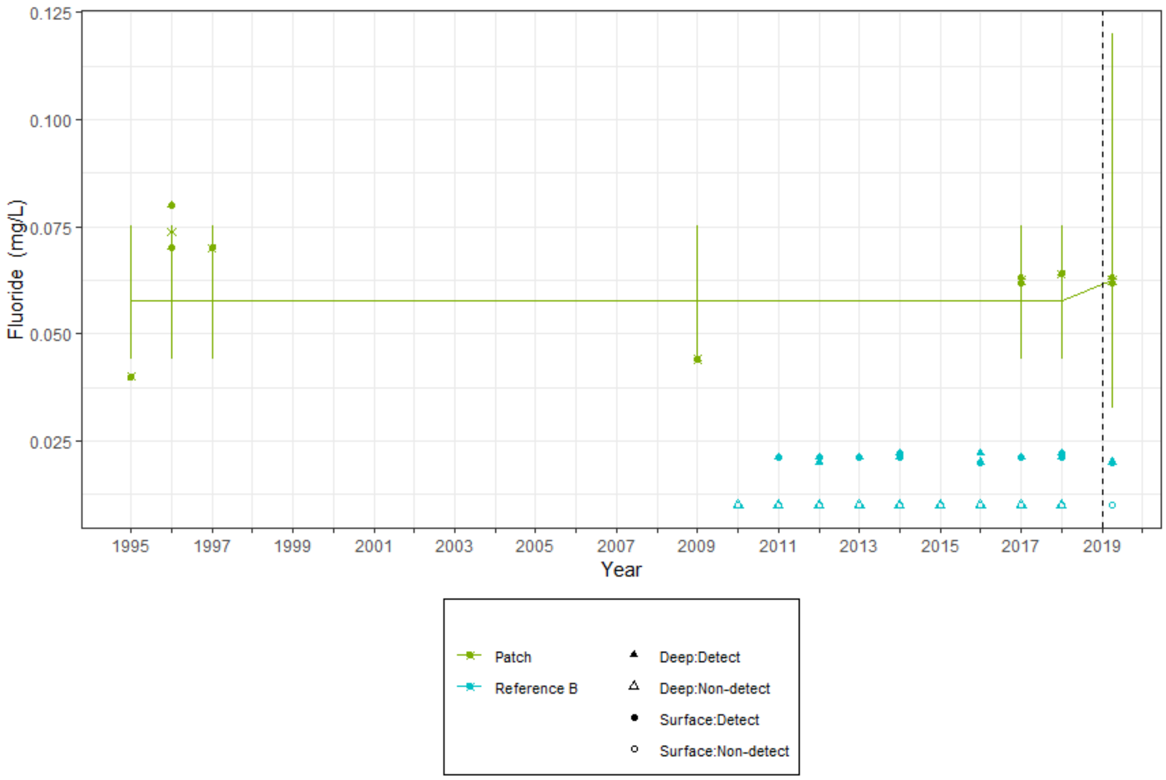
Conclusion:

The change in fuoride concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.7757) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0226	0.2582	7.038	-0.0874	0.9328	not sig.

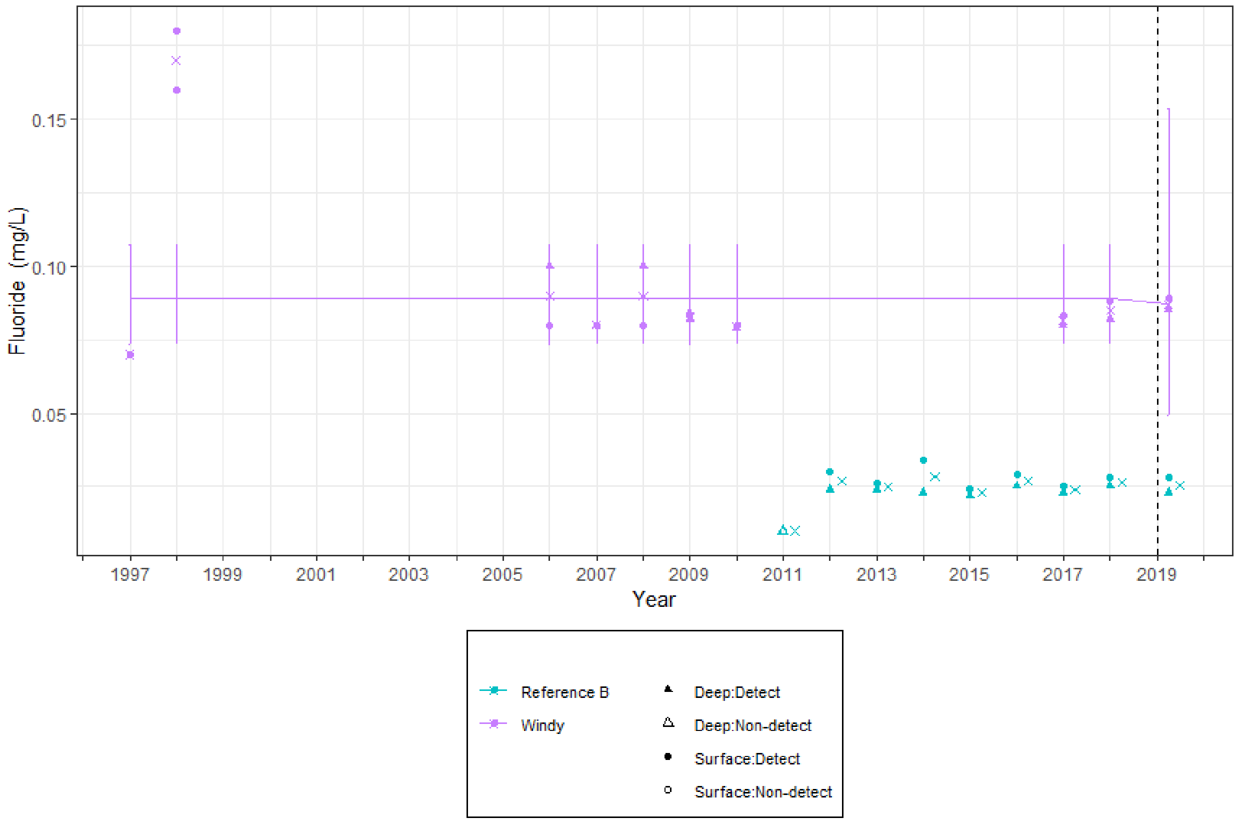
Conclusion:

The change in fluoride concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.9328) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0278	0.2414	8	-0.115	0.9113	not sig.

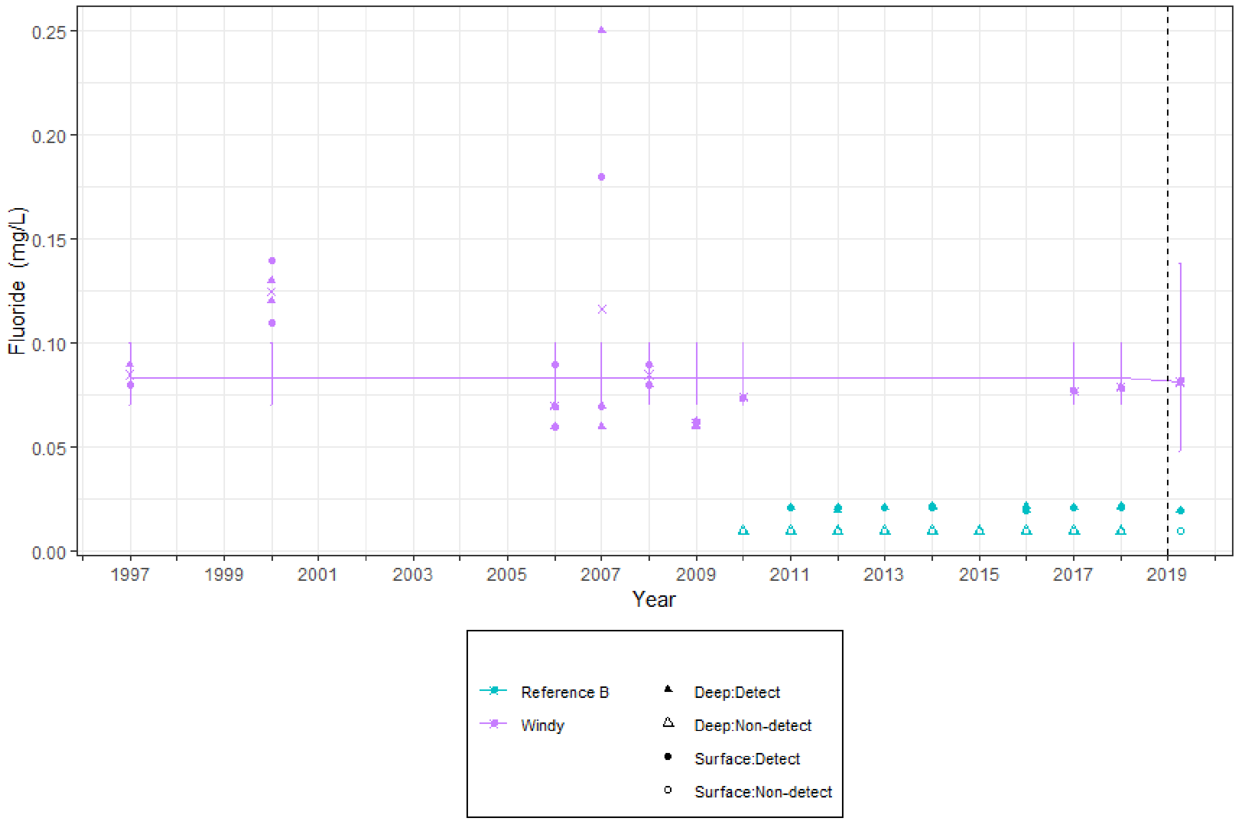
Conclusion:

The change in fluoride concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.9113) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

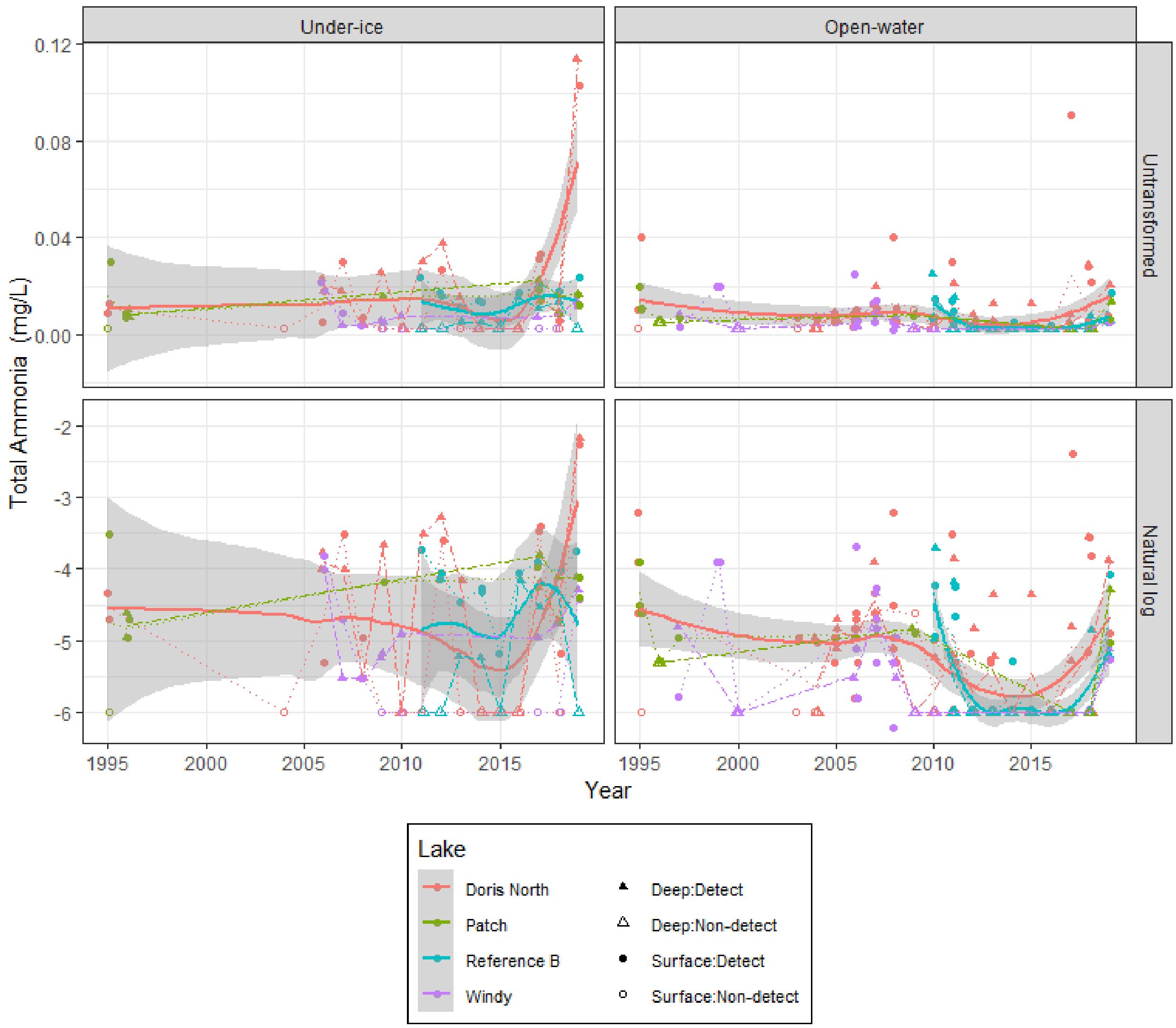
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.6 Total Ammonia

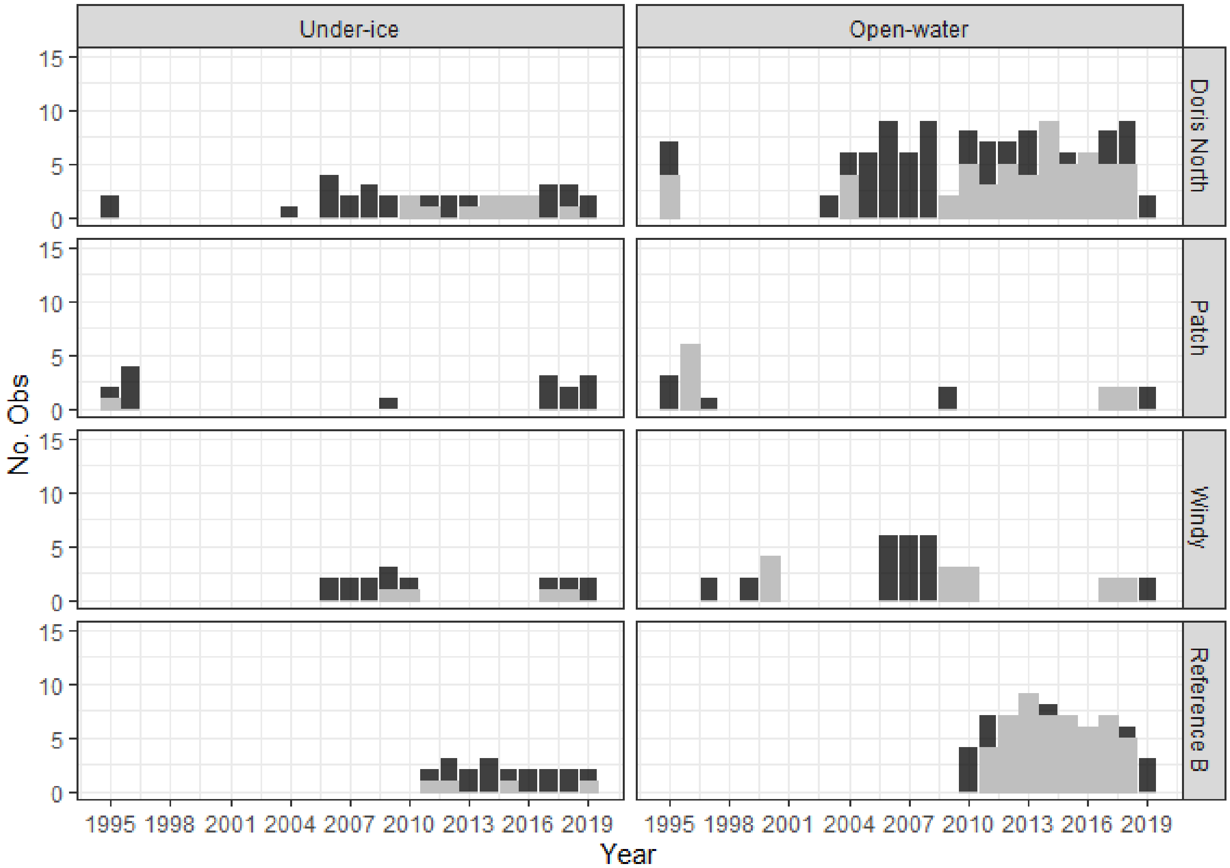
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

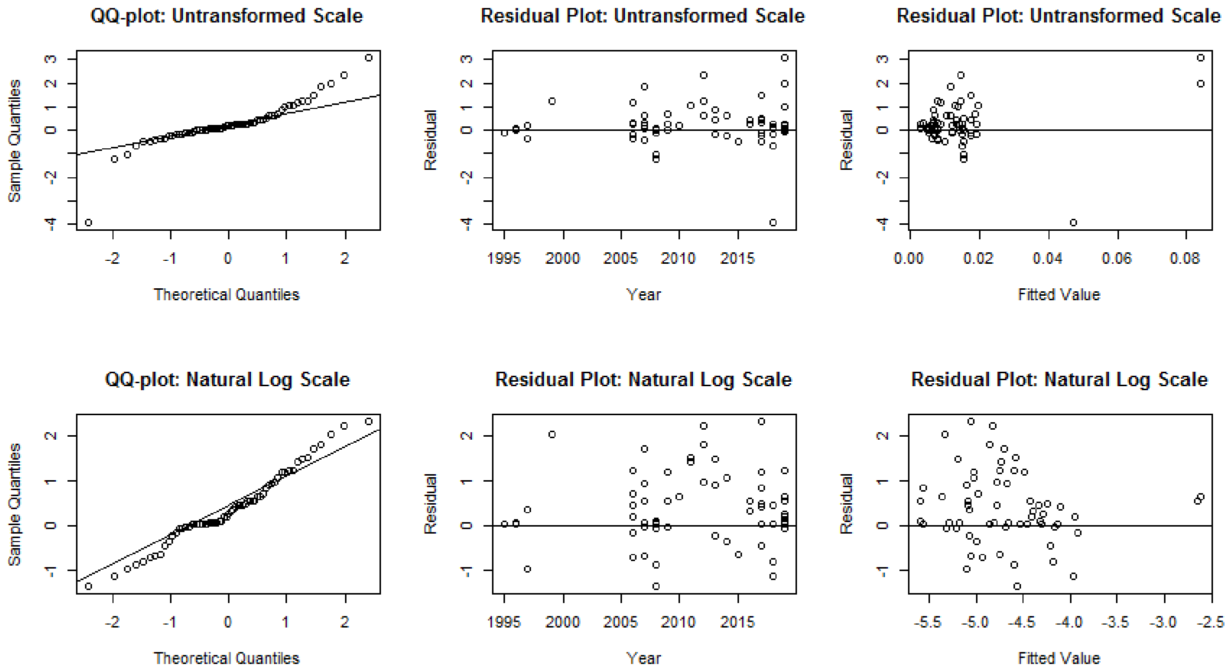
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	36	13	0.36	0.0	0.0078
Doris	Open-water	117	58	0.50	0.0	0.0050
Patch	Under-ice	15	1	0.07	0.0	0.0142
Patch	Open-water	18	10	0.56	0.0	0.0100
Reference B	Under-ice	20	4	0.20	0.5	0.0136
Reference B	Open-water	64	52	0.81	0.0	0.0050
Windy	Under-ice	17	4	0.24	0.0	0.0056
Windy	Open-water	38	14	0.37	0.0	0.0050

More than 50% of data under detection limit in Doris open-water, Patch open-water, and Reference B open-water. Data from those site-season groupings will be removed from the analysis. Doris under-ice, Doris open-water, Reference B under-ice, Windy under-ice, and Windy open-water exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2018	Under-ice	Deep	0.0087	0.047	-3.948
Doris	2019	Under-ice	Deep	0.1140	0.084	3.087

Outliers on natural log scale: None

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	17.280	4	0.0017
Compare to Reference B	9.643	4	0.0469

Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B lake.

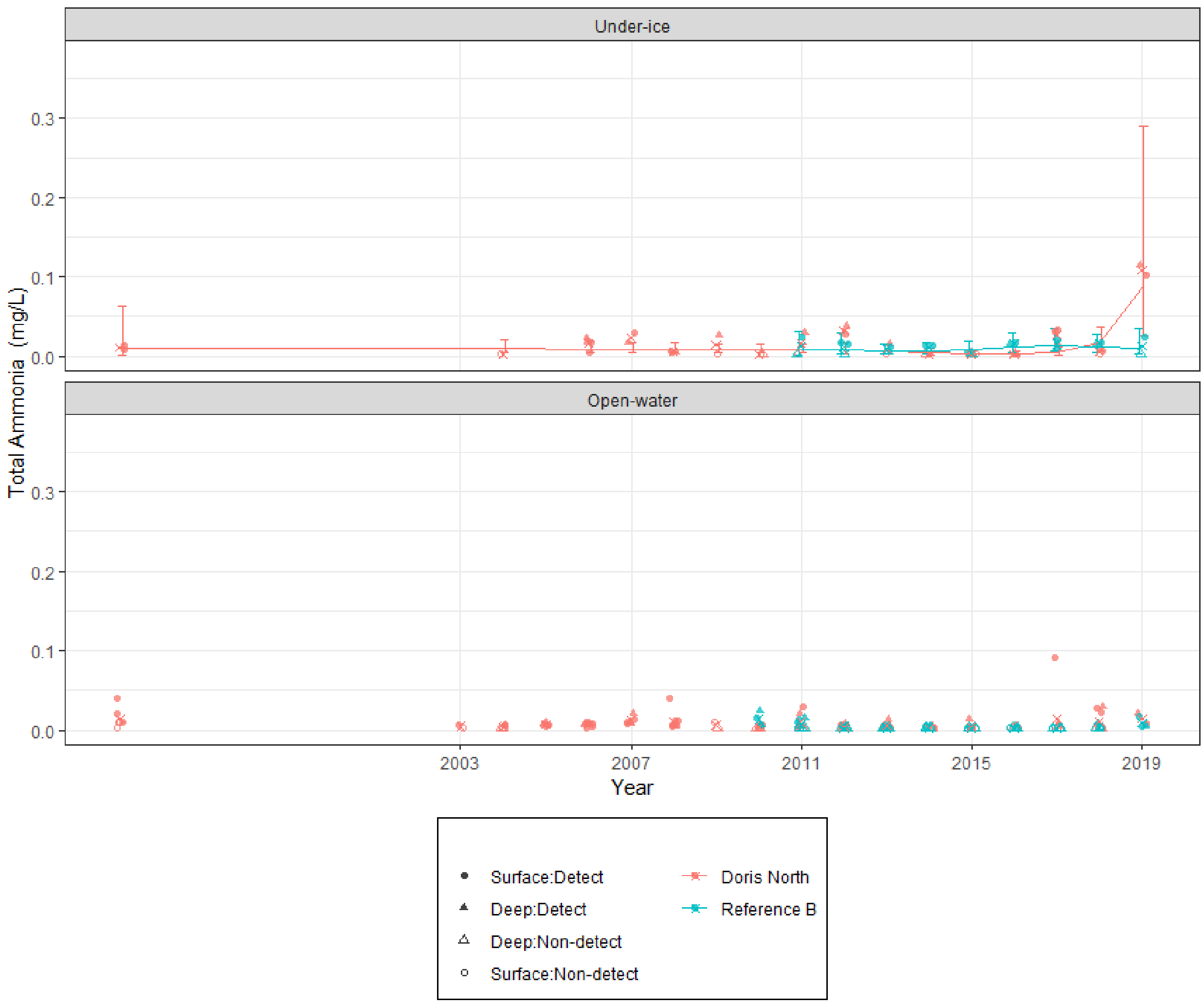
Open-water

All data from Doris open-water removed from the analysis. No analysis performed.

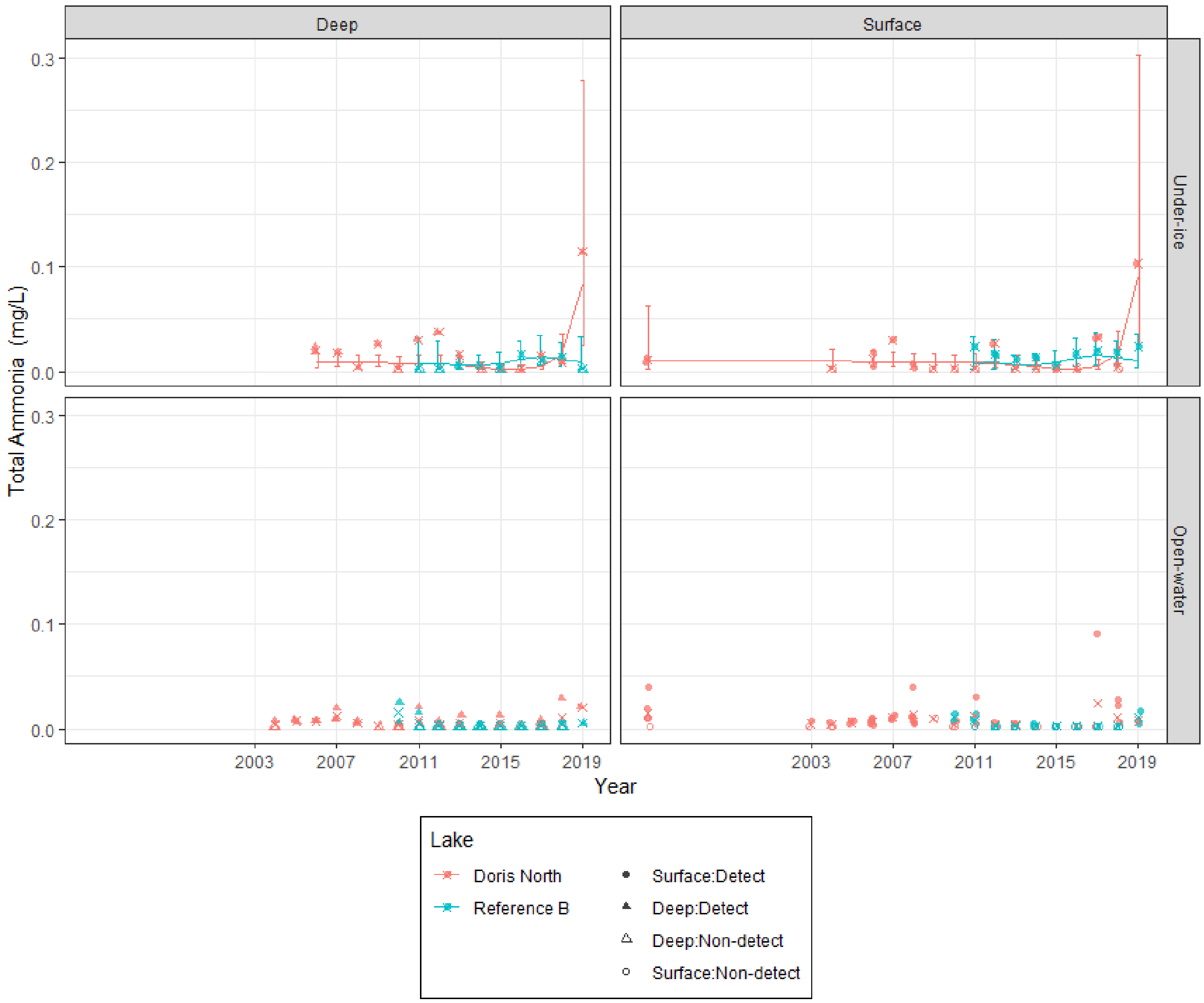
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.0766	0.3998	3.853	0.1917	0.8577	not sig.

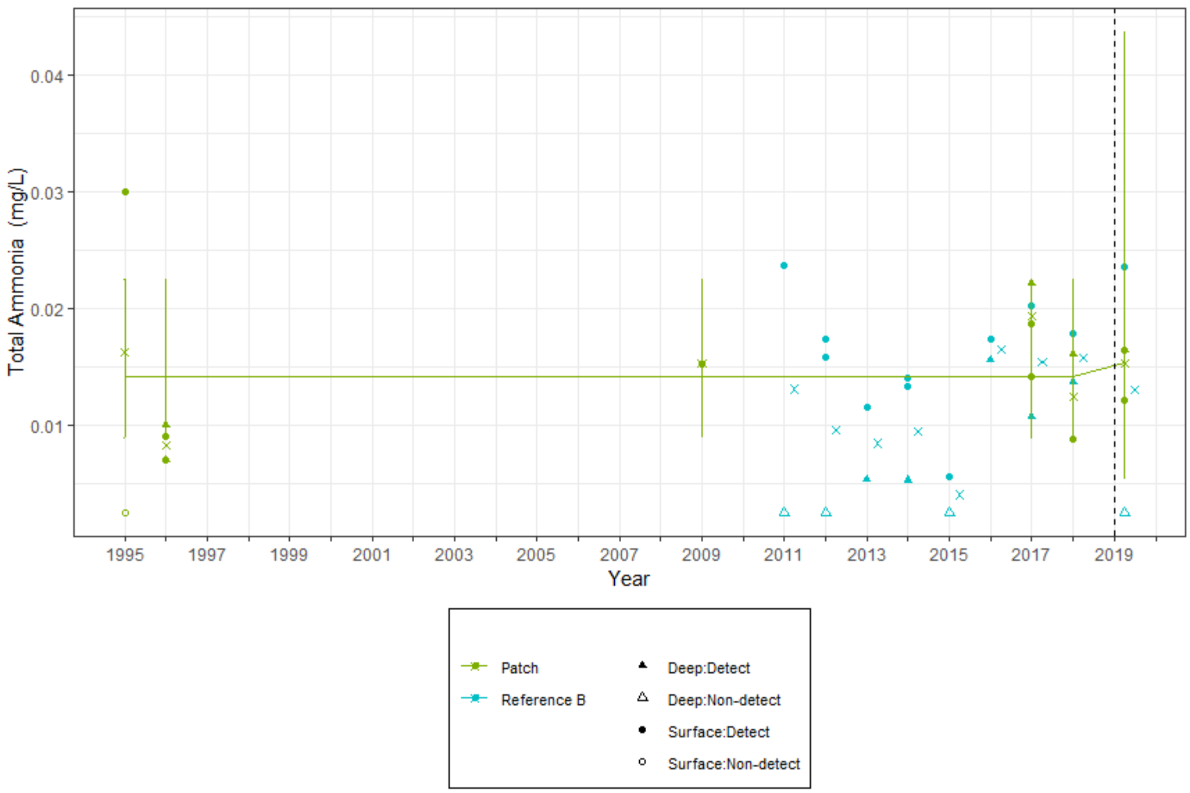
Conclusion:

The change in total Ammonia concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.8577) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Analysis not performed.

Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.855	0.6303	6	1.356	0.2238	not sig.

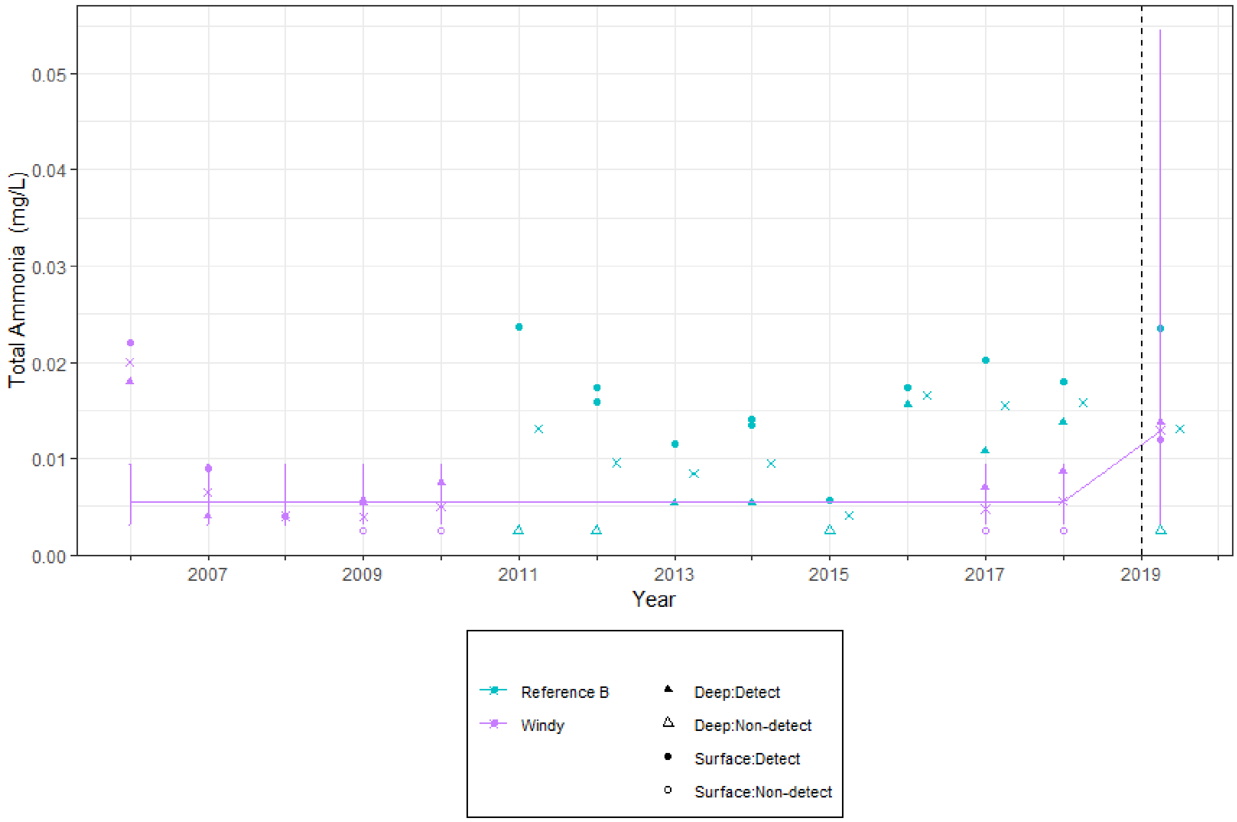
Conclusion:

The change in total ammonia concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.2238) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.2359	0.7292	8.078	0.3235	0.7545	not sig.

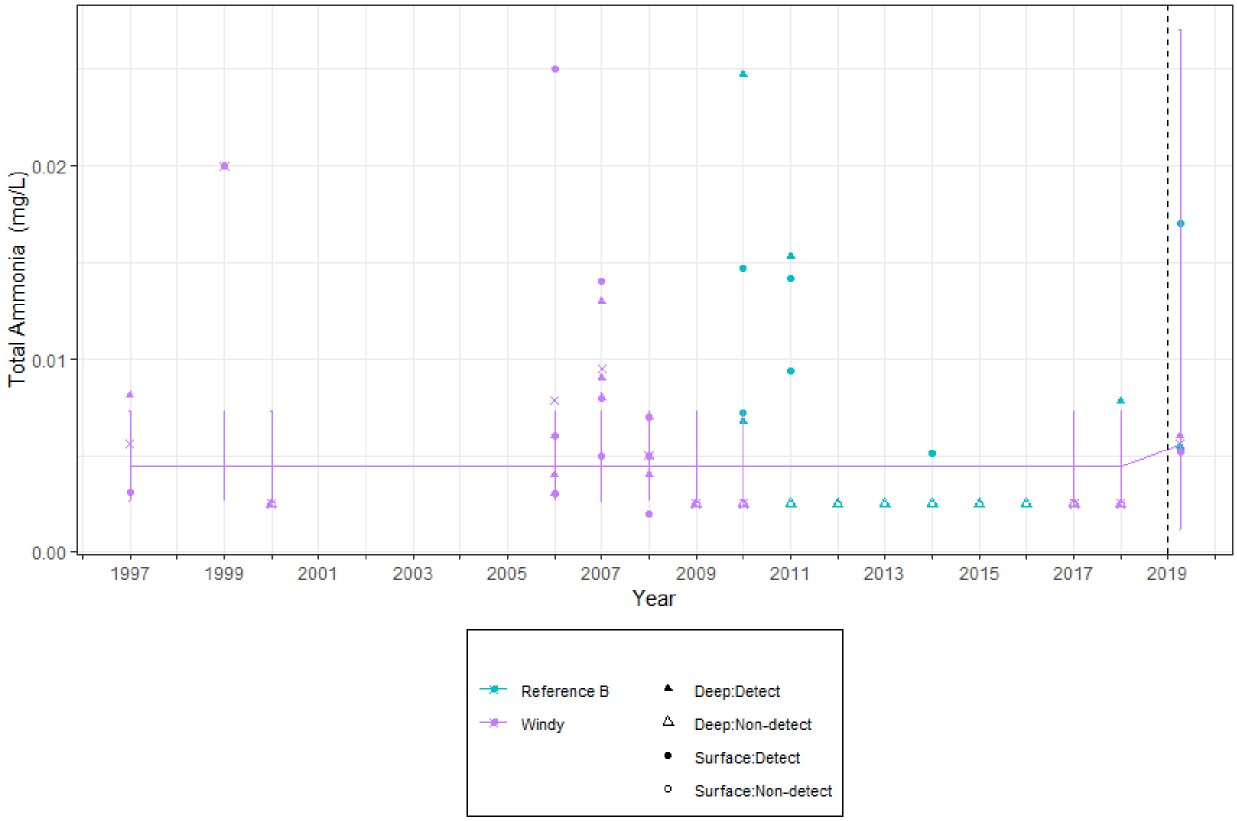
Conclusion:

The change in total ammonia concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.7545) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

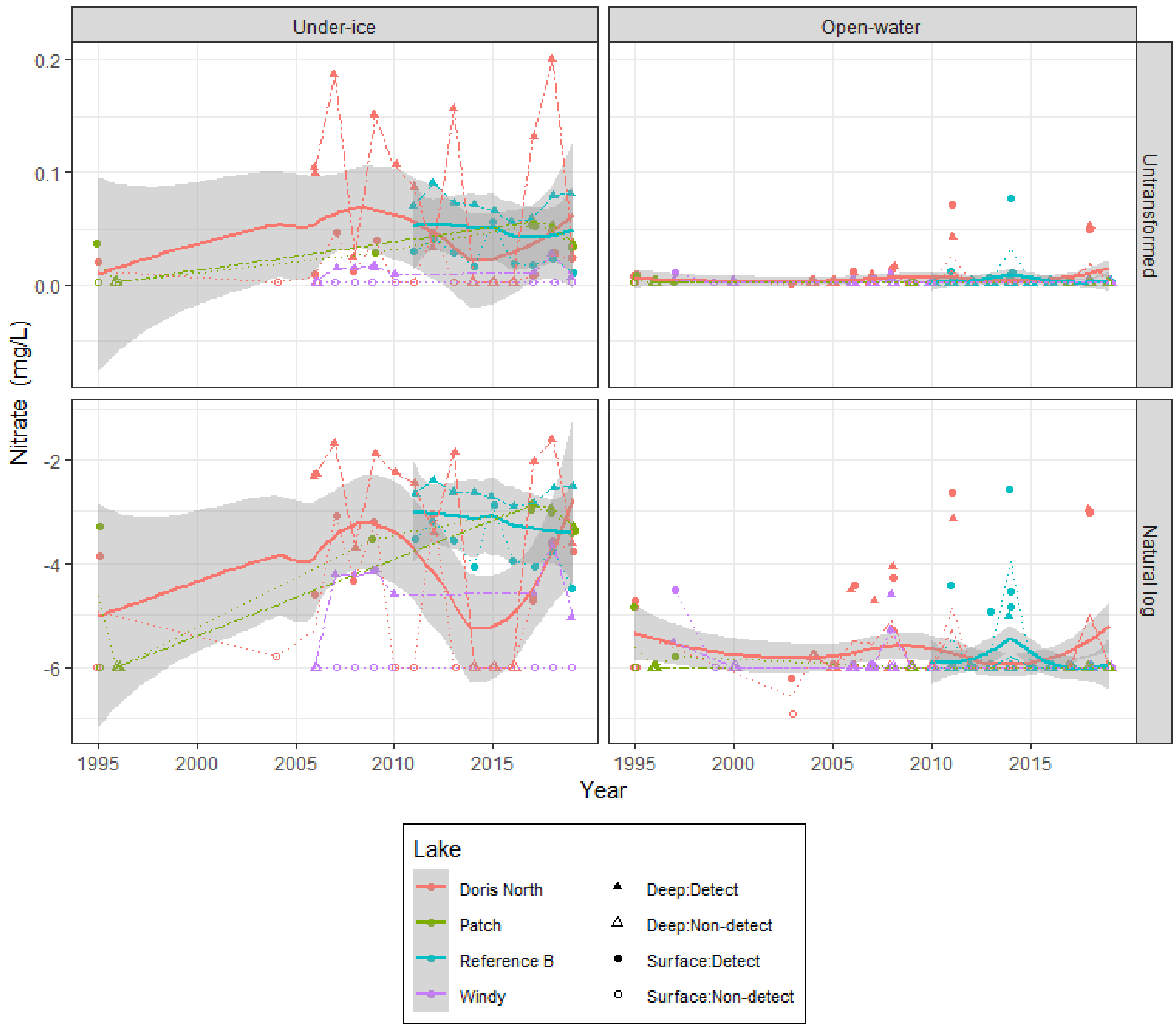
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.7 Nitrate

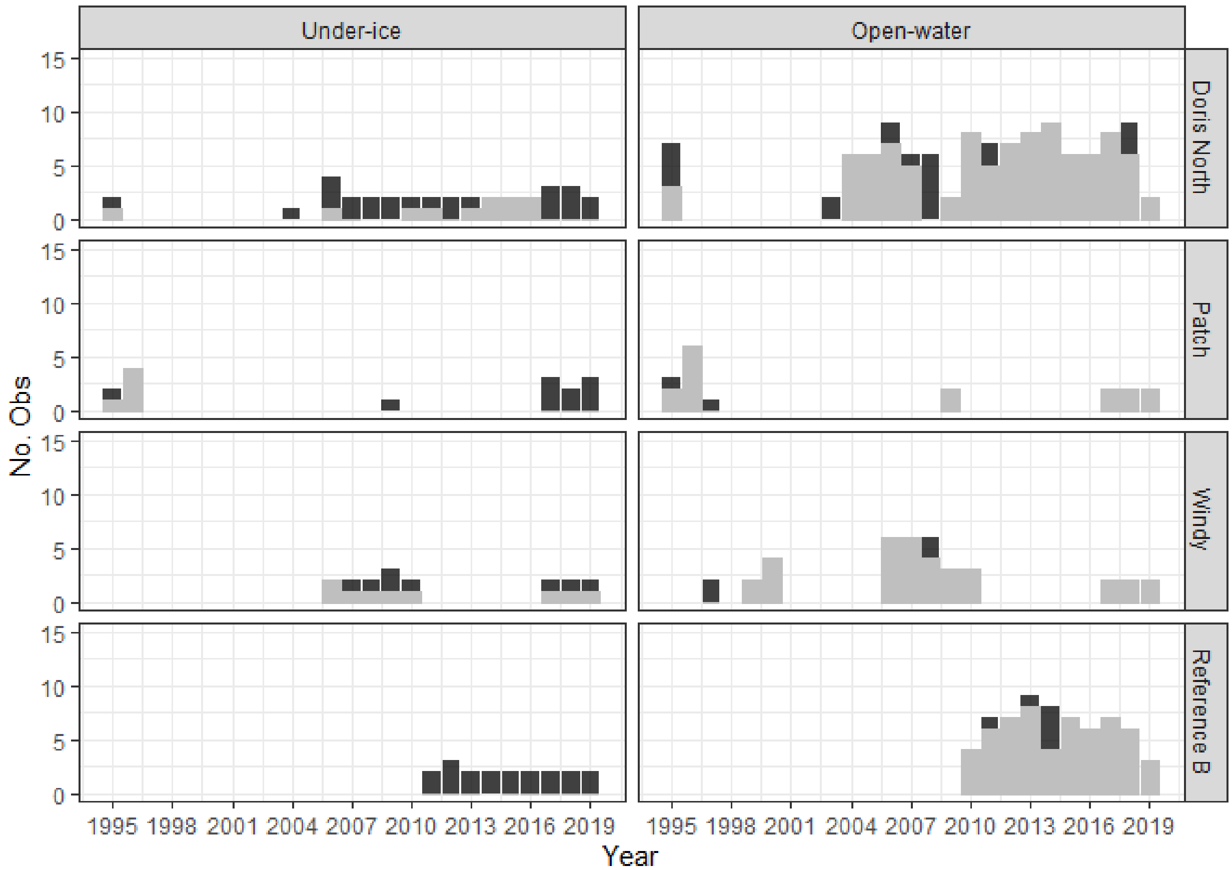
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

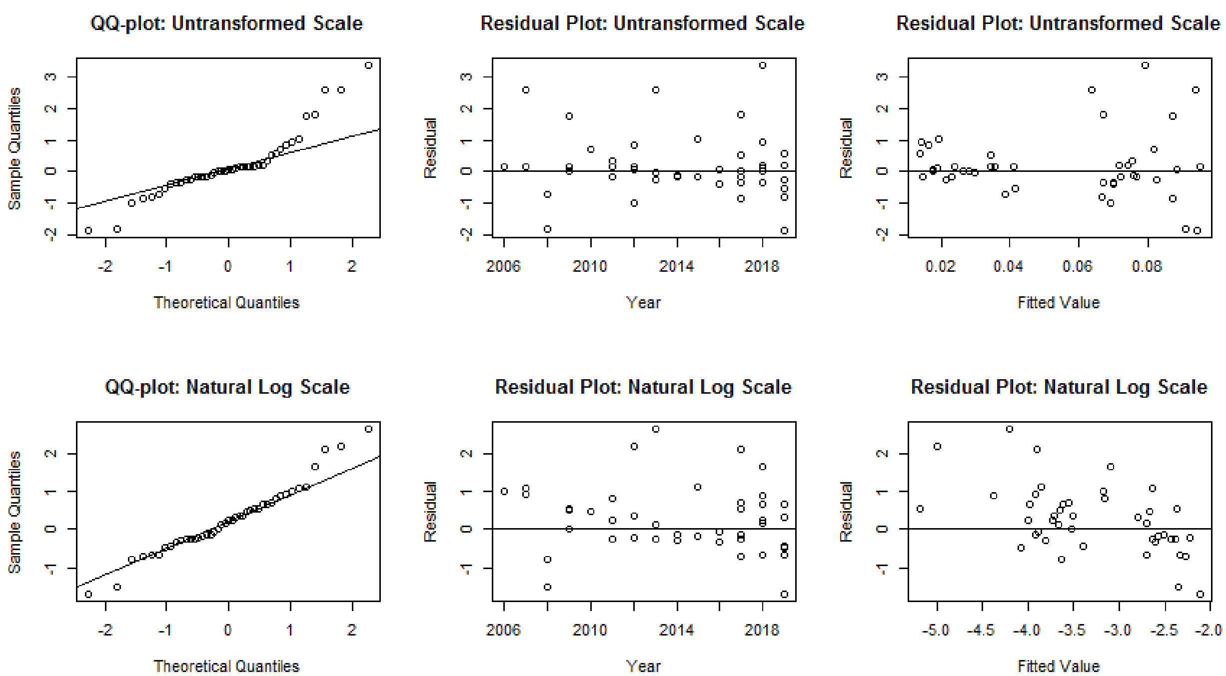
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	12	0.34	0.0	0.0230
Doris	Open-water	114	98	0.86	1.0	0.0050
Patch	Under-ice	15	5	0.33	0.0	0.0347
Patch	Open-water	18	16	0.89	1.0	0.0050
Reference B	Under-ice	19	0	0.00	0.0	0.0558
Reference B	Open-water	64	58	0.91	1.0	0.0050
Windy	Under-ice	17	9	0.53	0.5	0.0050
Windy	Open-water	38	34	0.89	1.0	0.0050

More than 50% of data under detection limit in Doris open-water, Patch open-water, Reference B open-water, Windy under-ice, and Windy open-water. Data from those site-season groupings will be removed from the analysis. Doris under-ice and Patch under-ice exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. The analysis proceeds with linear mixed effects regression for Patch.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2018	Under-ice	Deep	0.201	0.079	3.383

Outliers on natural log scale: None

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	19.618	4	0.0006
Compare to Reference B	8.707	4	0.0689

Doris Lake appears to show significant deviation from no trend. Doris Lake does not exhibit significant deviation from the trend of Reference B lake.

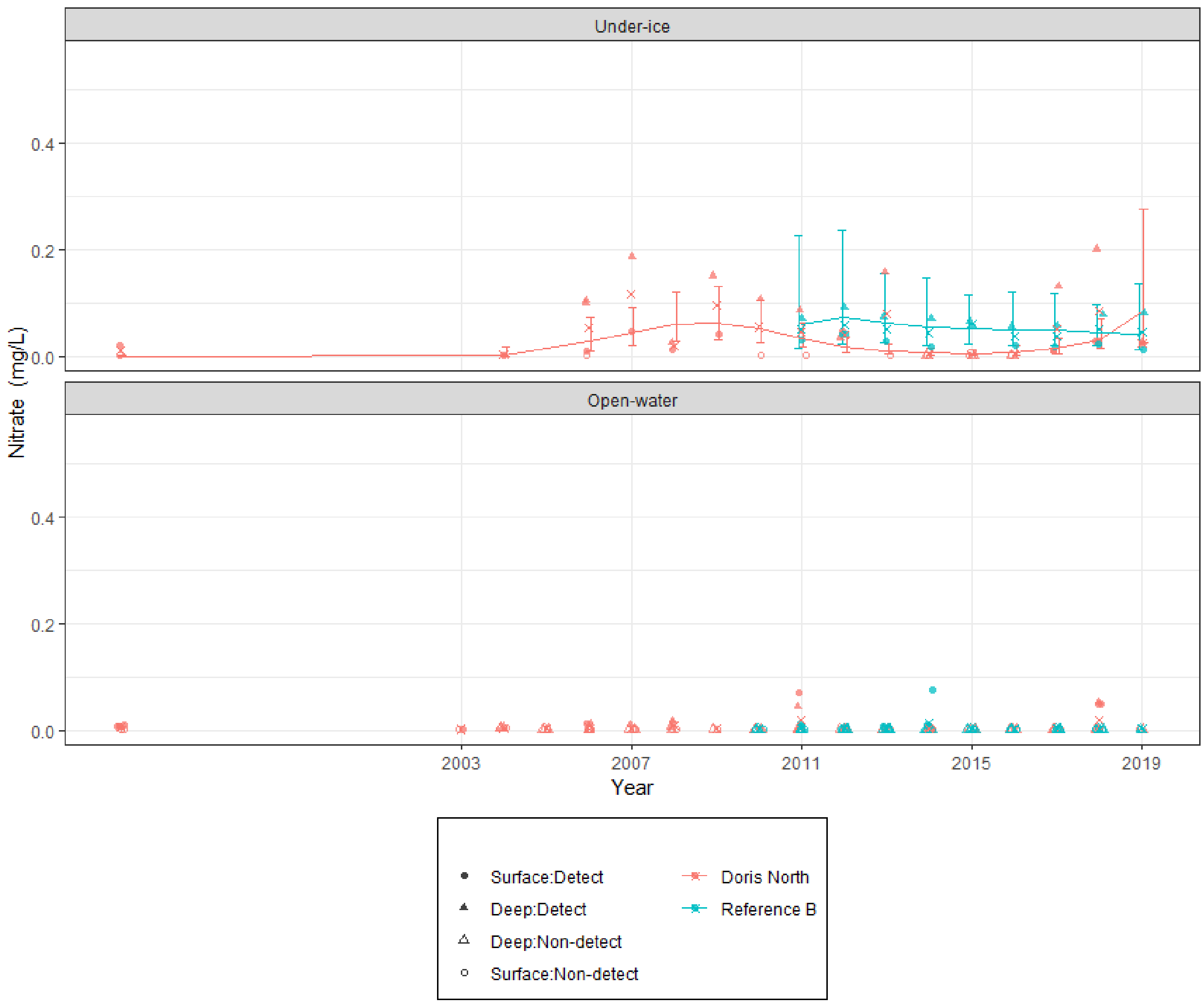
Open-water

All data from Doris open-water removed from the analysis. No analysis performed.

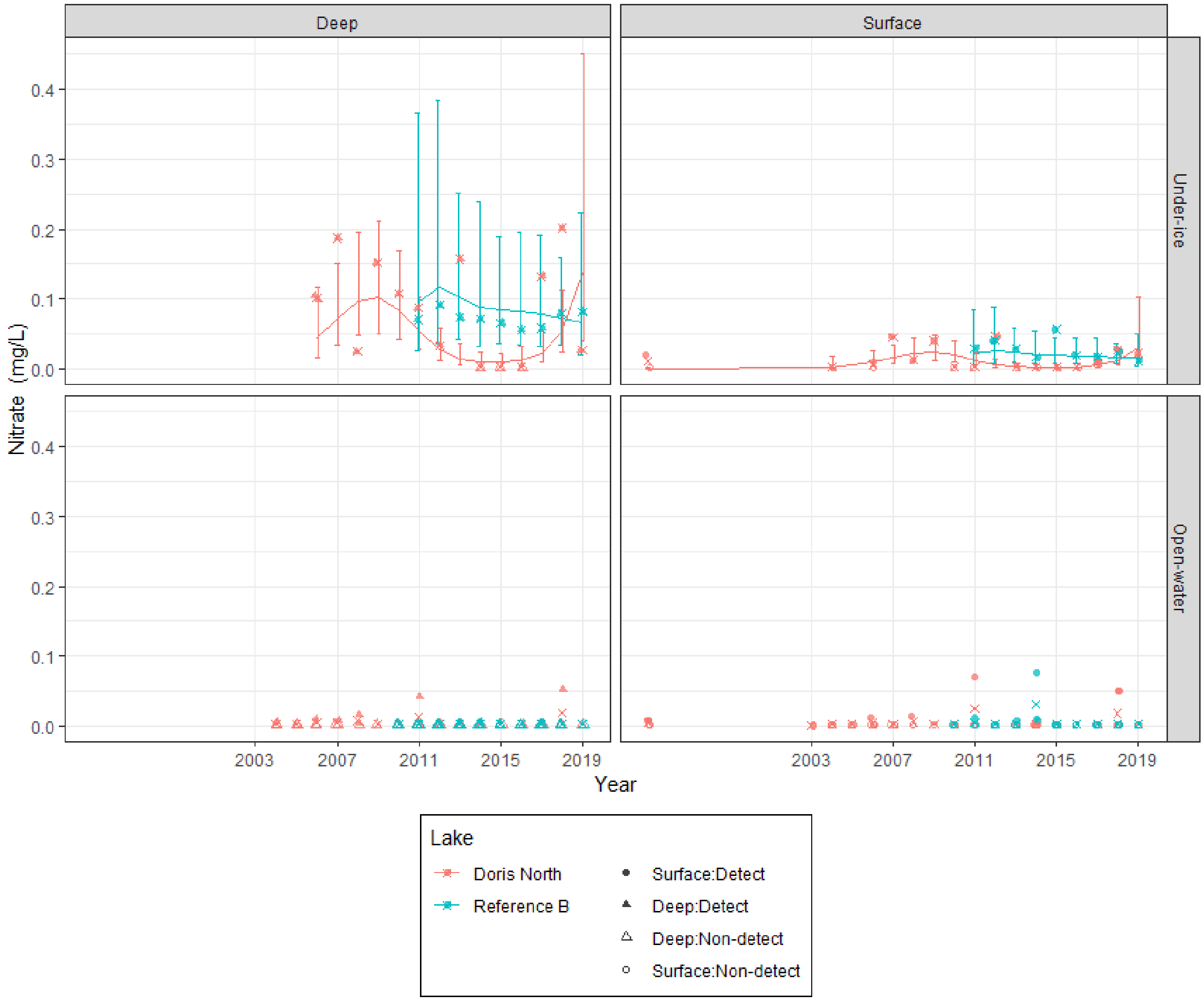
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.5165	1.383	4	0.3735	0.7277	not sig.

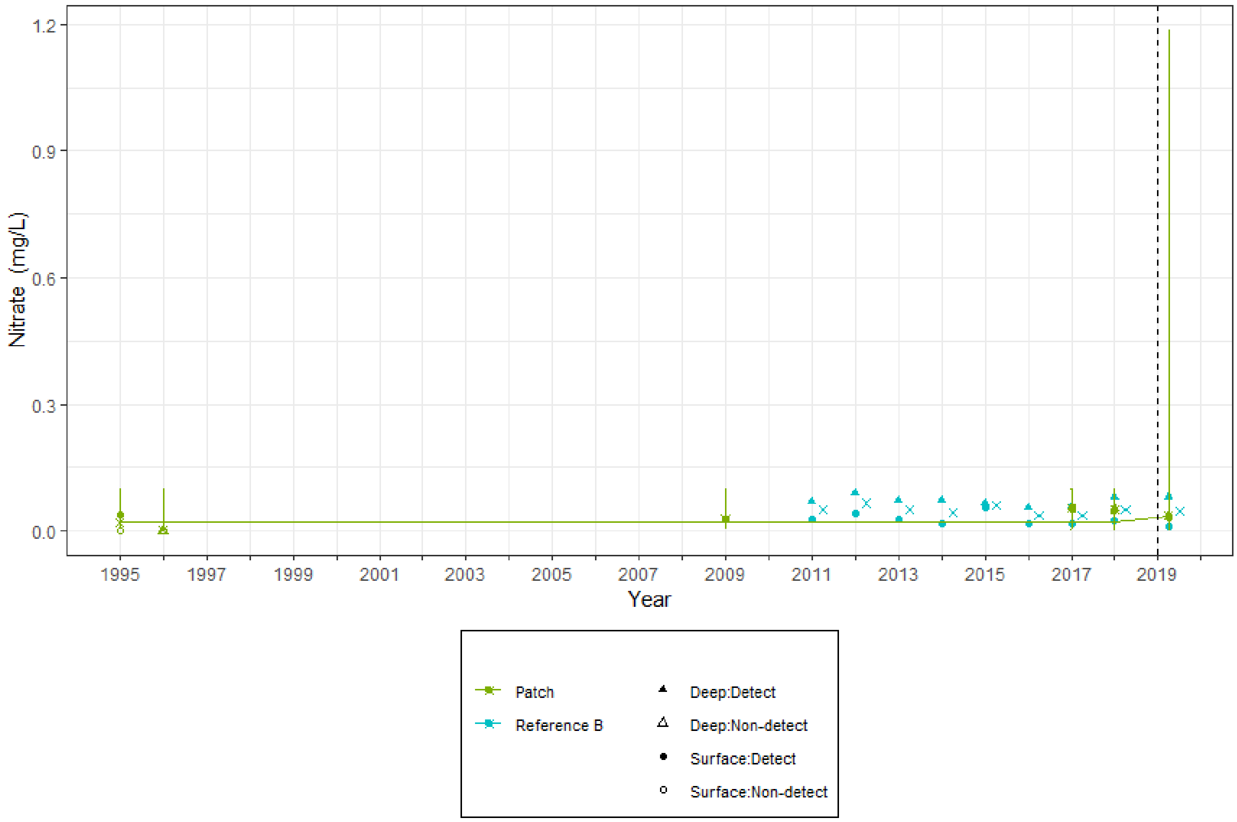
Conclusion:

The change in nitrate concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.7277) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Analysis not performed.

Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

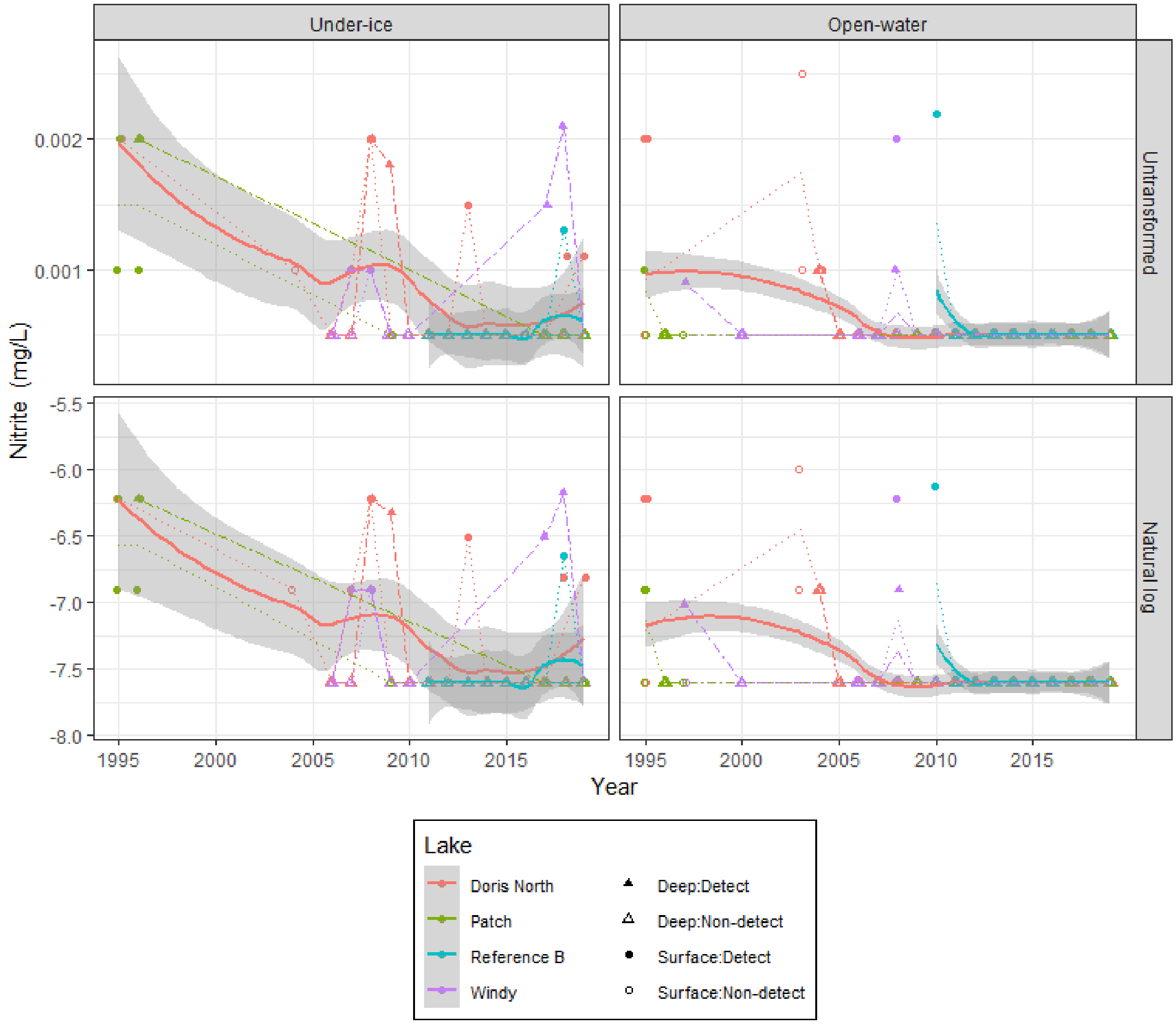
Open-water Before-vs-After Analysis

Analysis not performed.

C.3.2.8 Nitrite

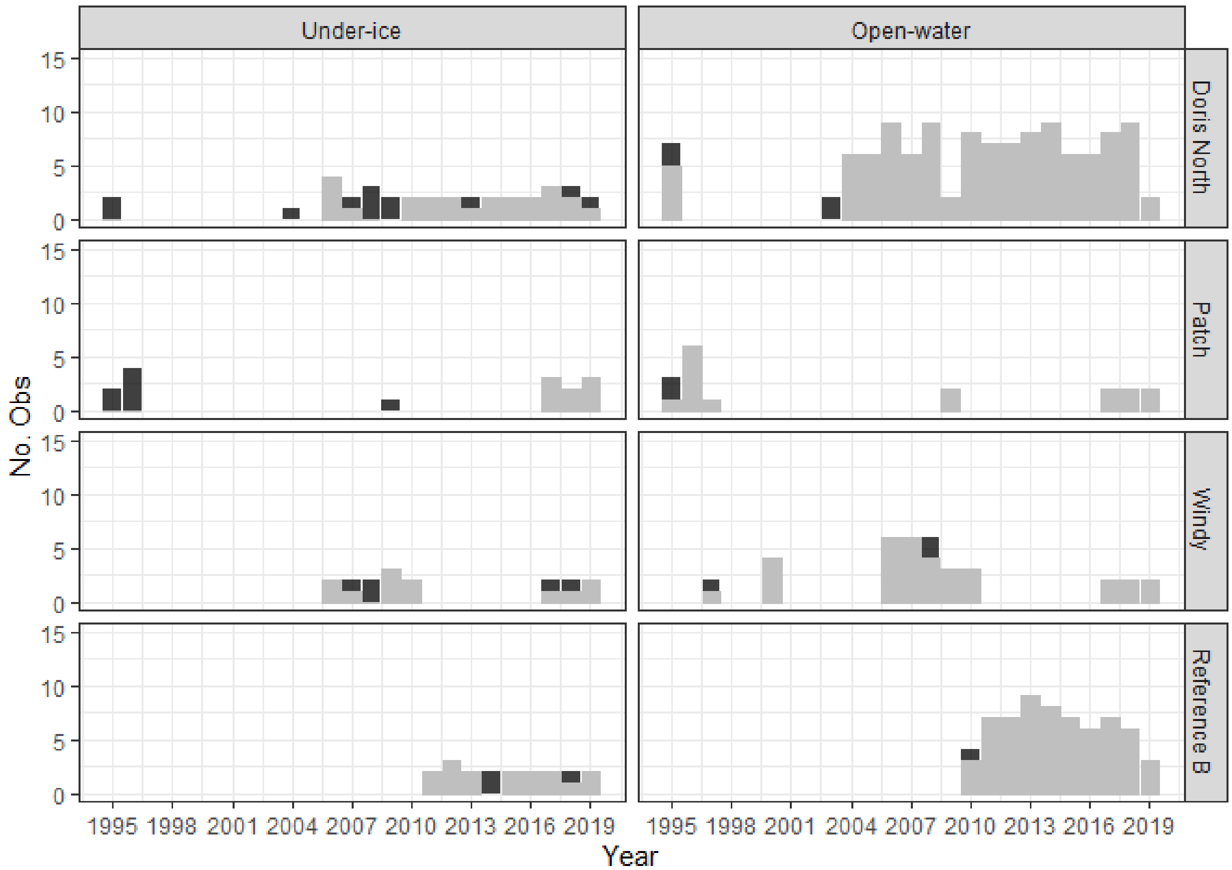
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

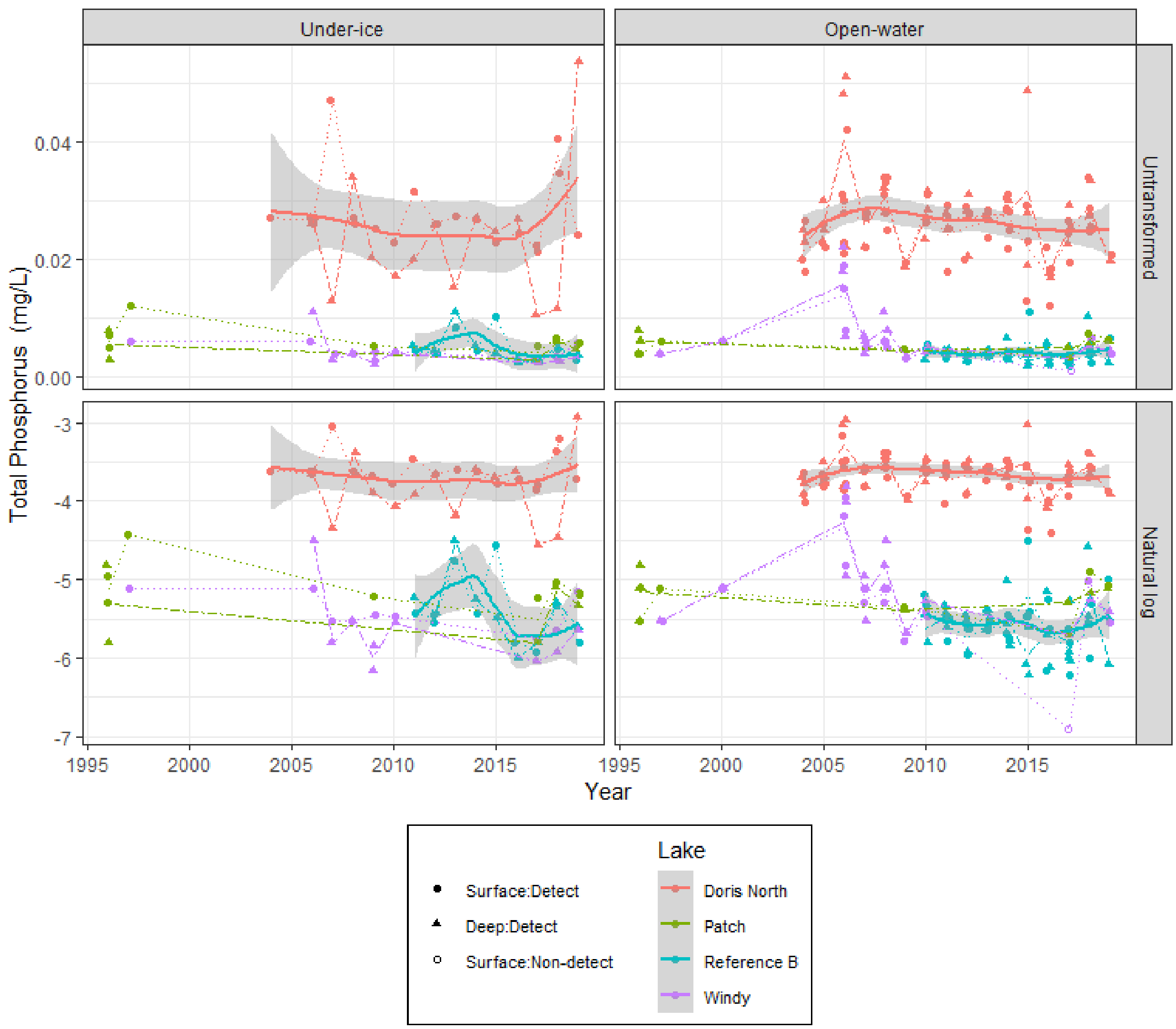
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	36	26	0.72	0.5	0.001
Doris	Open-water	117	115	0.98	1.0	0.001
Patch	Under-ice	15	9	0.60	1.0	0.001
Patch	Open-water	18	16	0.89	1.0	0.001
Reference B	Under-ice	19	18	0.95	1.0	0.001
Reference B	Open-water	64	63	0.98	1.0	0.001
Windy	Under-ice	17	12	0.71	1.0	0.001
Windy	Open-water	36	33	0.92	1.0	0.001

All data from 2019 were censored. All data removed from the analysis and no statistical analyses were performed.

C.3.2.9 Total Phosphorus

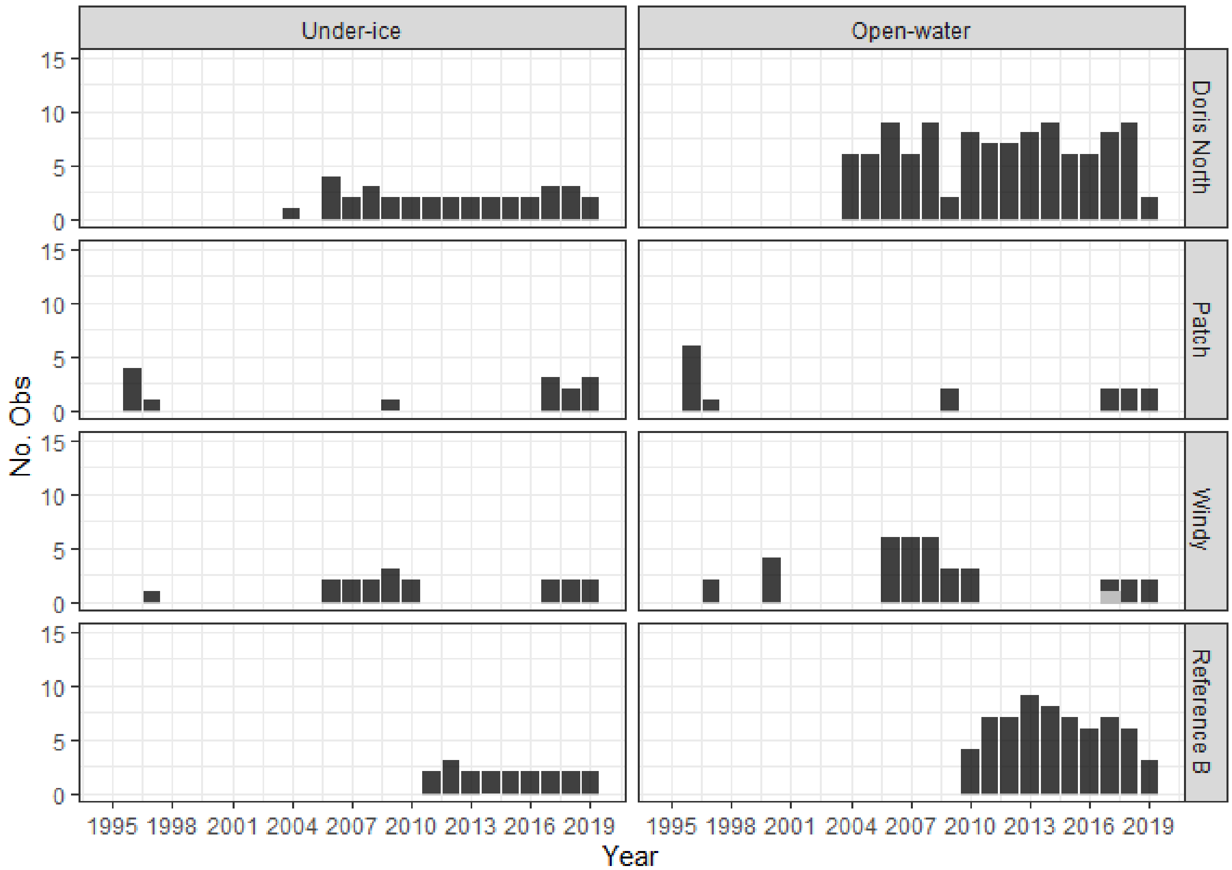
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

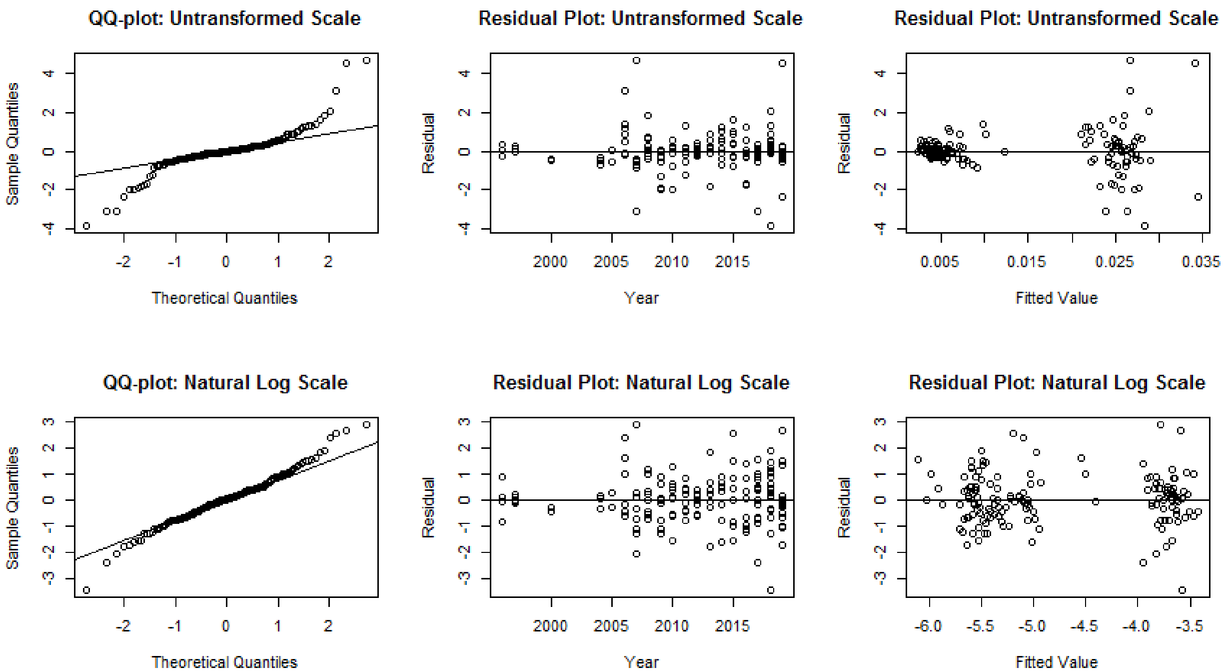
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	34	0	0.00	0	0.0260
Doris	Open-water	108	0	0.00	0	0.0268
Patch	Under-ice	14	0	0.00	0	0.0054
Patch	Open-water	15	0	0.00	0	0.0057
Reference B	Under-ice	19	0	0.00	0	0.0044
Reference B	Open-water	64	0	0.00	0	0.0038
Windy	Under-ice	18	0	0.00	0	0.0040
Windy	Open-water	36	1	0.03	0	0.0060

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.

L



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2006	Open-water	Deep	0.0403	0.027	3.147
Doris	2007	Under-ice	Deep	0.0130	0.026	-3.086
Doris	2007	Under-ice	Surface	0.0470	0.027	4.689
Doris	2017	Under-ice	Deep	0.0105	0.024	-3.092
Doris	2018	Under-ice	Deep	0.0116	0.028	-3.874
Doris	2019	Under-ice	Deep	0.0537	0.034	4.549

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2018	Under-ice	Deep	0.0116	-3.582	-3.467

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data. However, there was an outlier retained in the analysis. Results should be interpreted with caution and along with graphical results.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	3.734	4	0.4431

Doris Lake does not exhibit significant deviation from no trend.

Open-water

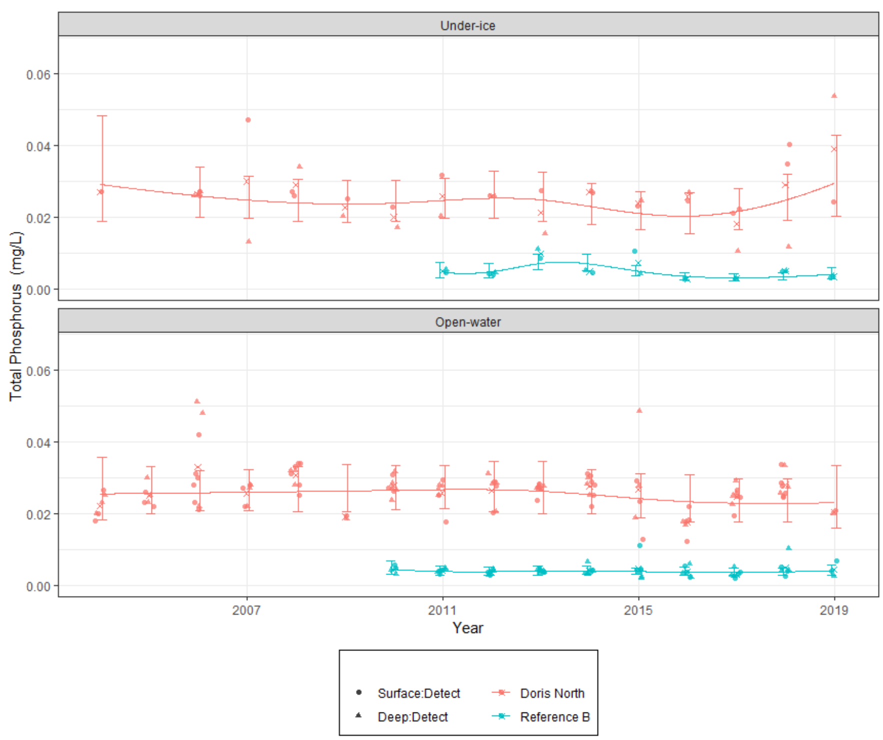
Analysis	Chi.sq	DF	P.value
Compare to slope 0	1.409	4	0.8427

Doris Lake does not exhibit significant deviation from no trend.

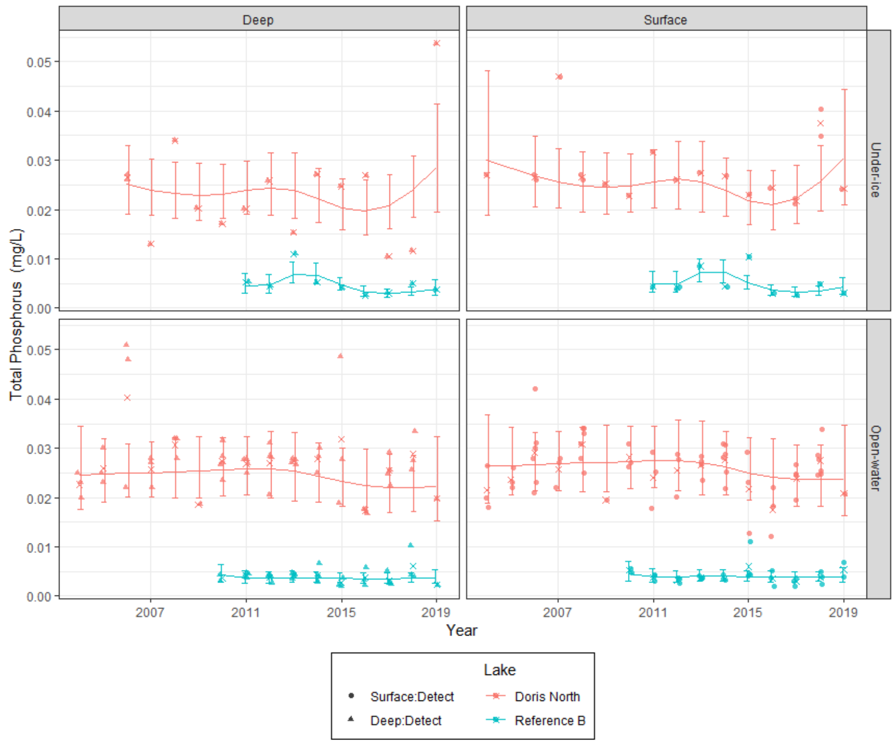
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.1244	0.4502	3.893	-0.2764	0.7963	not sig.

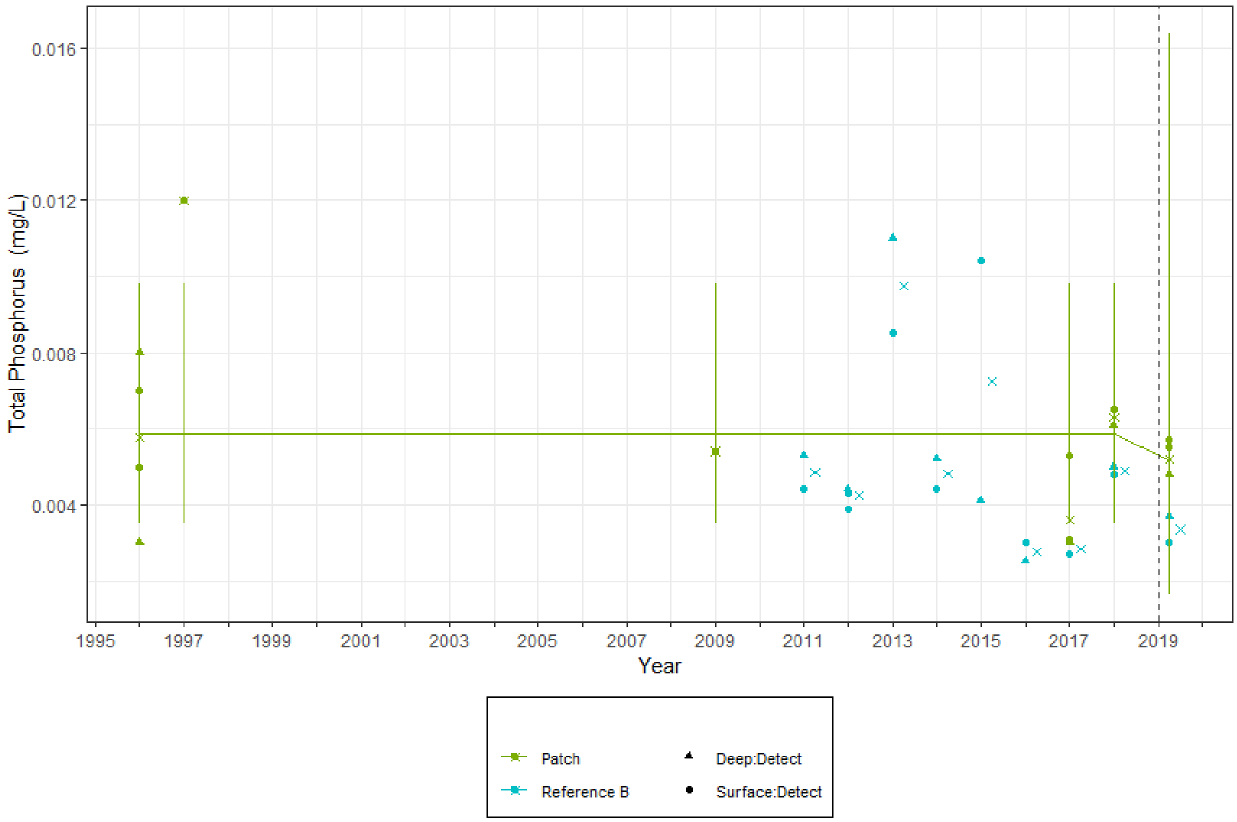
Conclusion:

The change in total phosphorus concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.7963) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.1816	0.2104	3.588	0.8632	0.4419	not sig.

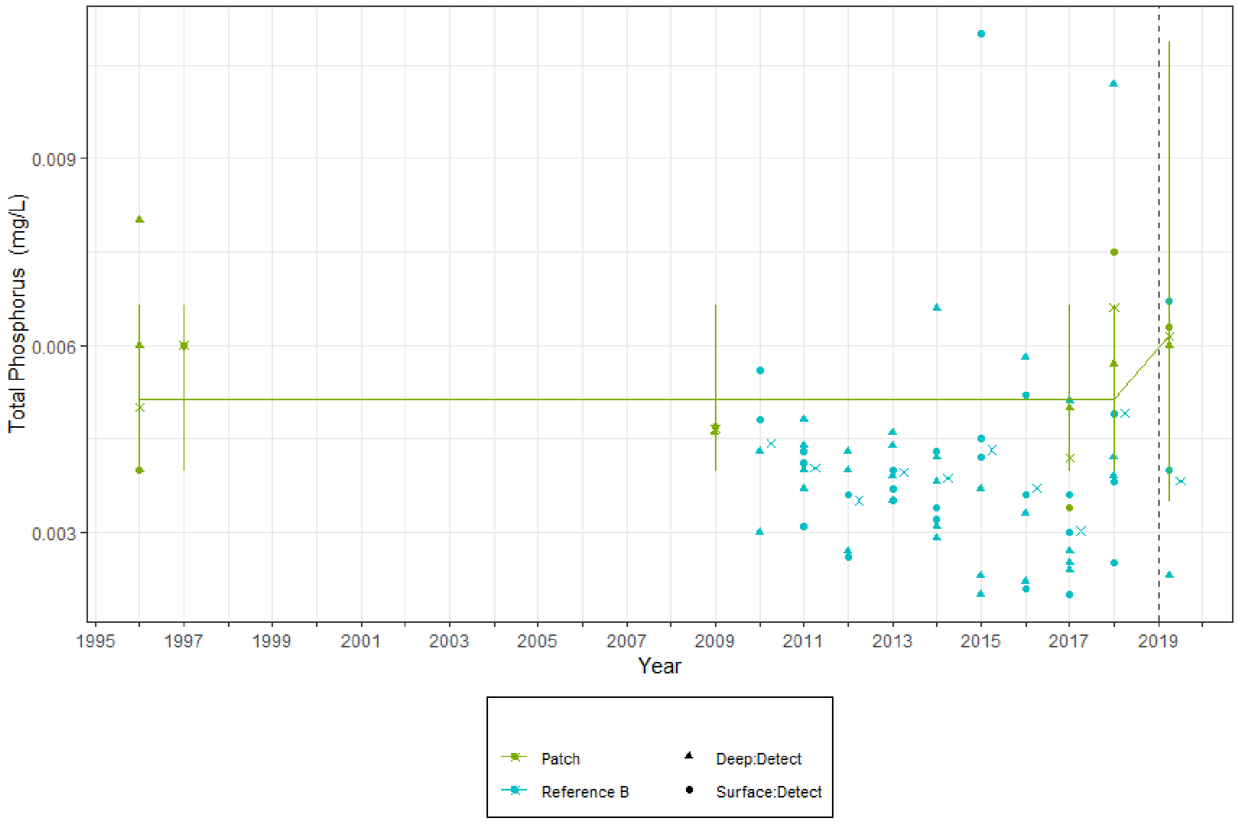
Conclusion:

The change in total phosphorus concentrations in Patch Lake from *before* to *after* was not significantly ($p = 0.4419$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.1198	0.3708	6.751	0.3232	0.7563	not sig.

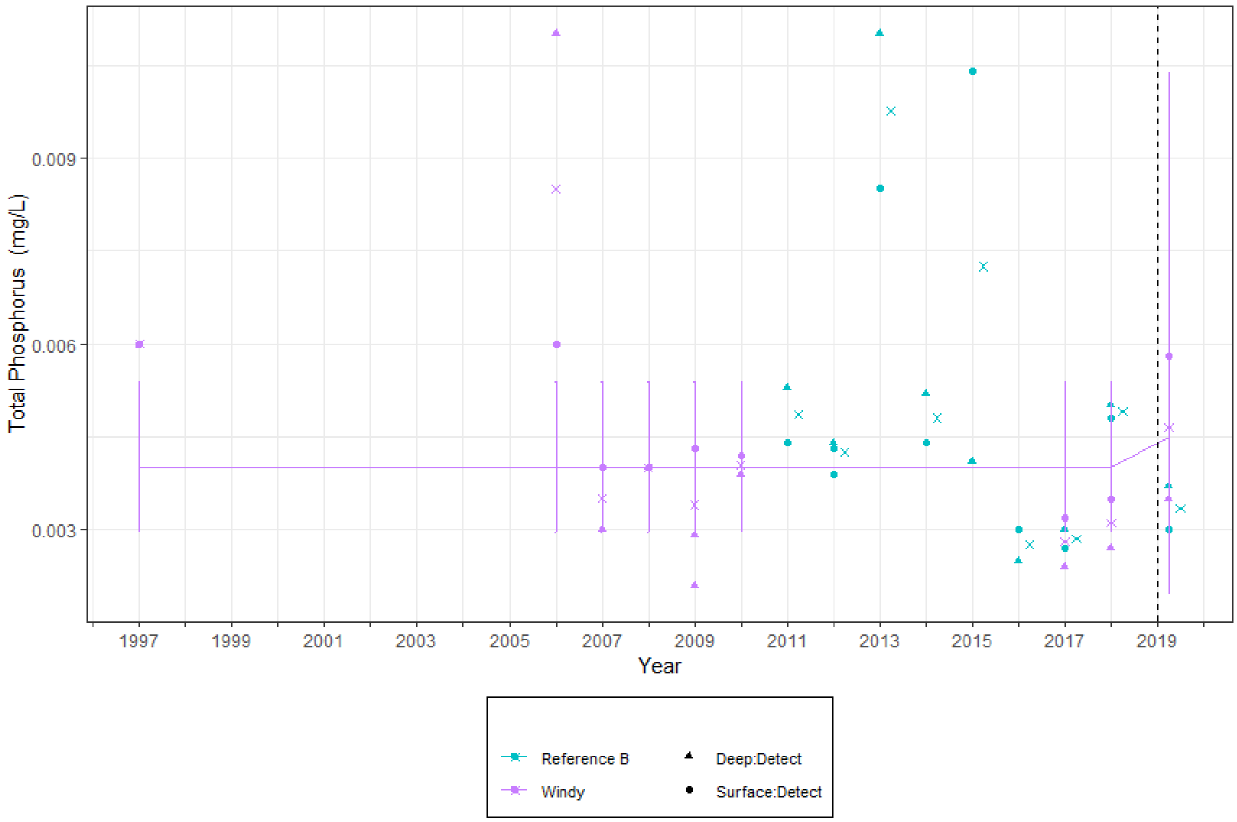
Conclusion:

The change in total phosphorus concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.7563) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.1894	0.6022	8	-0.3145	0.7612	not sig.

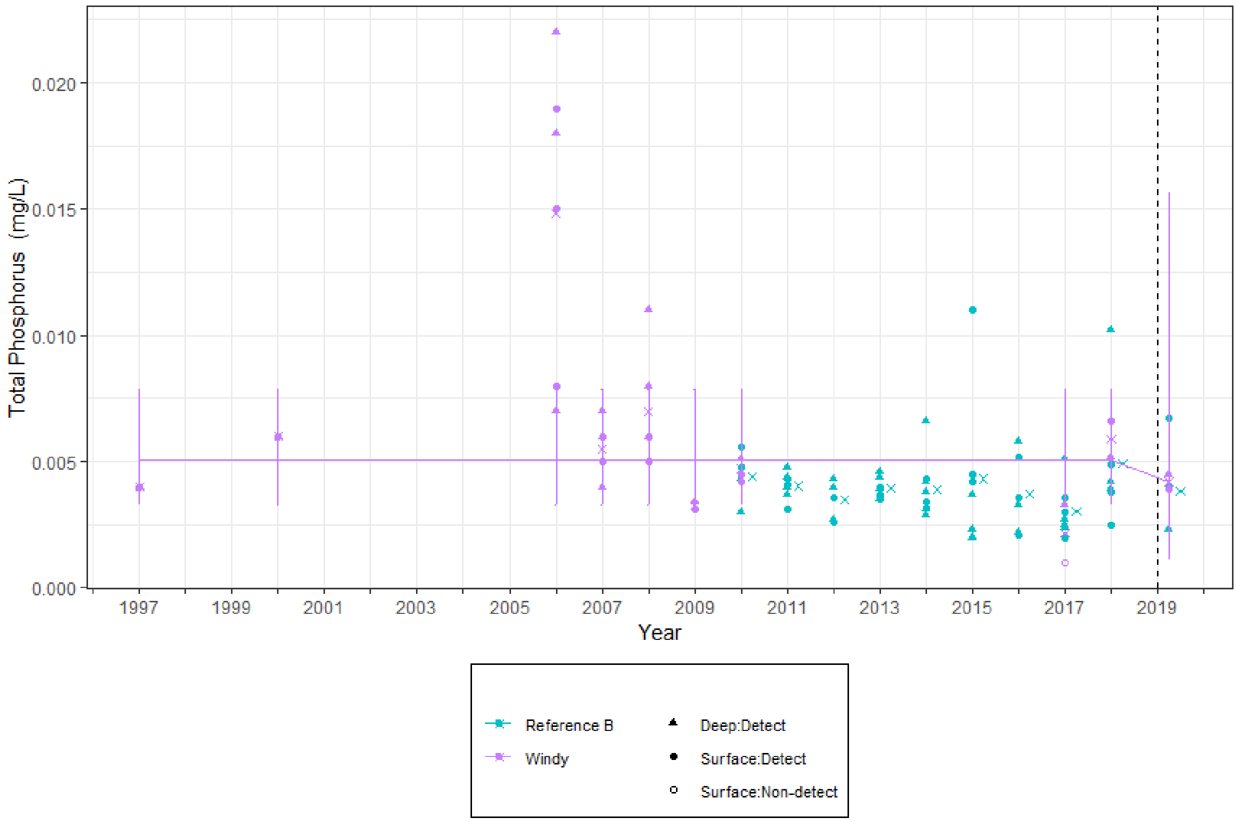
Conclusion:

The change in total phosphorus concentrations in Windy Lake from *before* to *after* was not significantly ($p = 0.7612$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

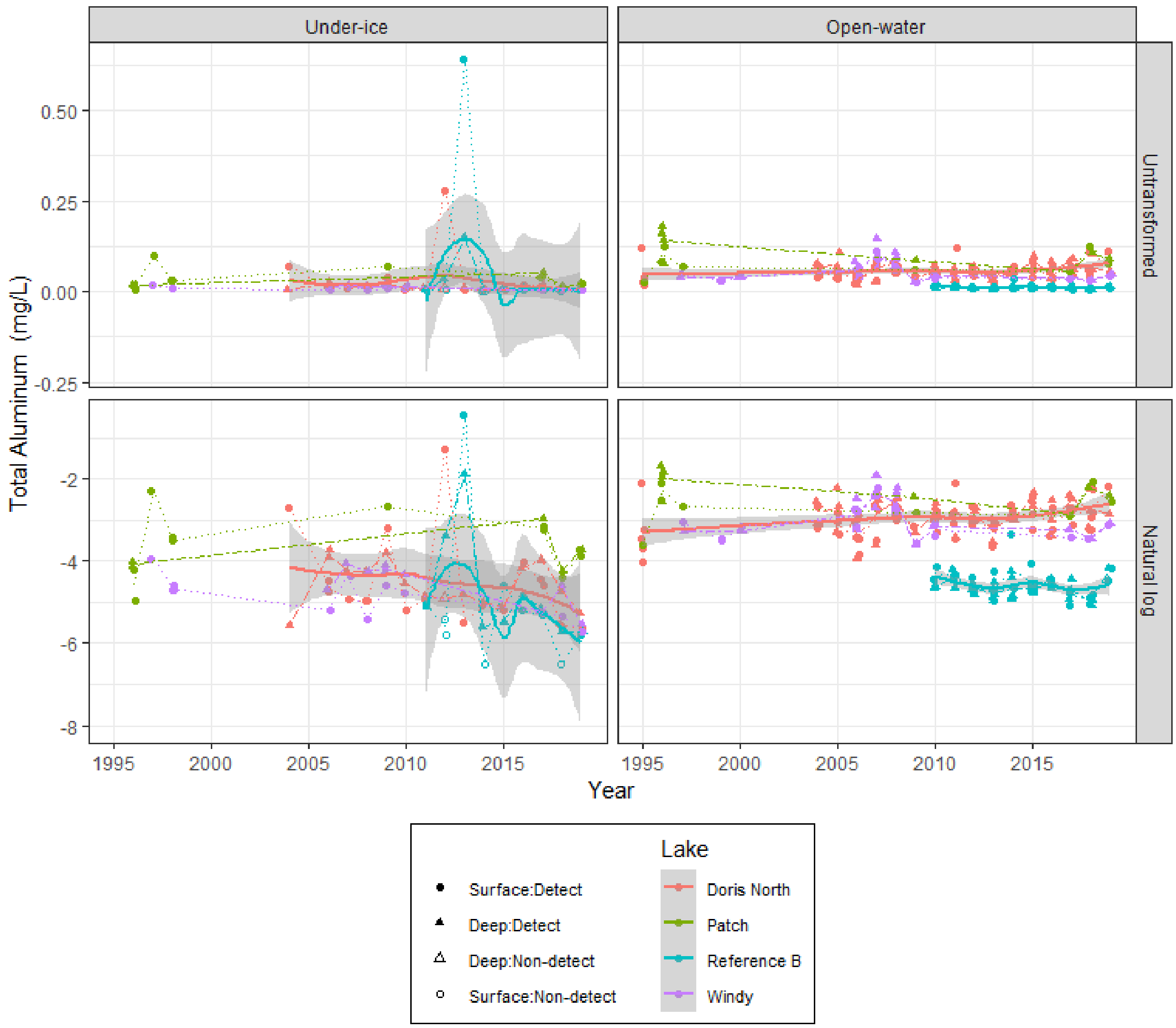
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.10 Total Aluminum

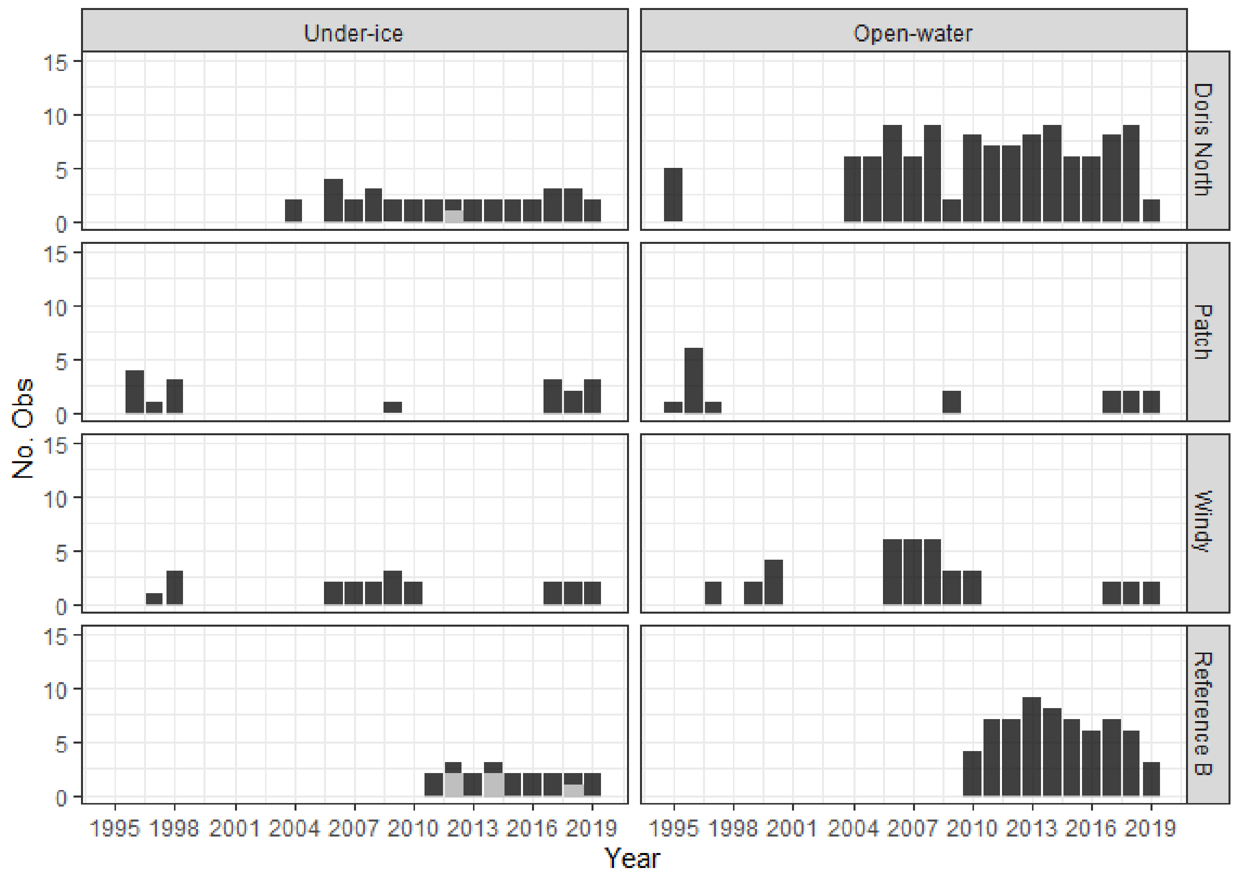
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

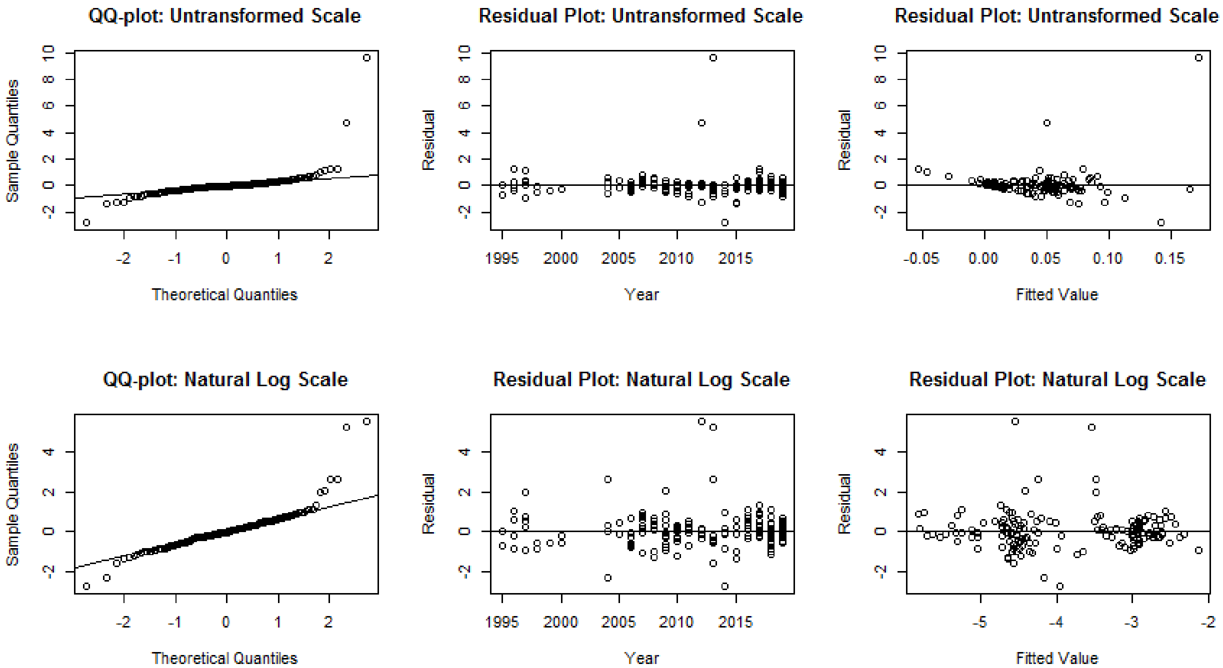
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	1	0.03	0	0.0087
Doris	Open-water	113	0	0.00	0	0.0538
Patch	Under-ice	17	0	0.00	0	0.0240
Patch	Open-water	16	0	0.00	0	0.0834
Reference B	Under-ice	20	5	0.25	0	0.0056
Reference B	Open-water	64	0	0.00	0	0.0096
Windy	Under-ice	21	0	0.00	0	0.0092
Windy	Open-water	38	0	0.00	0	0.0448

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2012	Under-ice	Surface	0.280	0.050	4.698
Reference B	2013	Under-ice	Surface	0.644	0.173	9.632

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2012	Under-ice	Surface	0.280	-4.546	5.519
Reference B	2013	Under-ice	Surface	0.644	-3.540	5.228

The natural log transformed model better meets the residual assumptions. Analysis proceeds with natural log transformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	5.153	4	0.2719

Doris Lake does not exhibit significant deviation from no trend.

Open-water

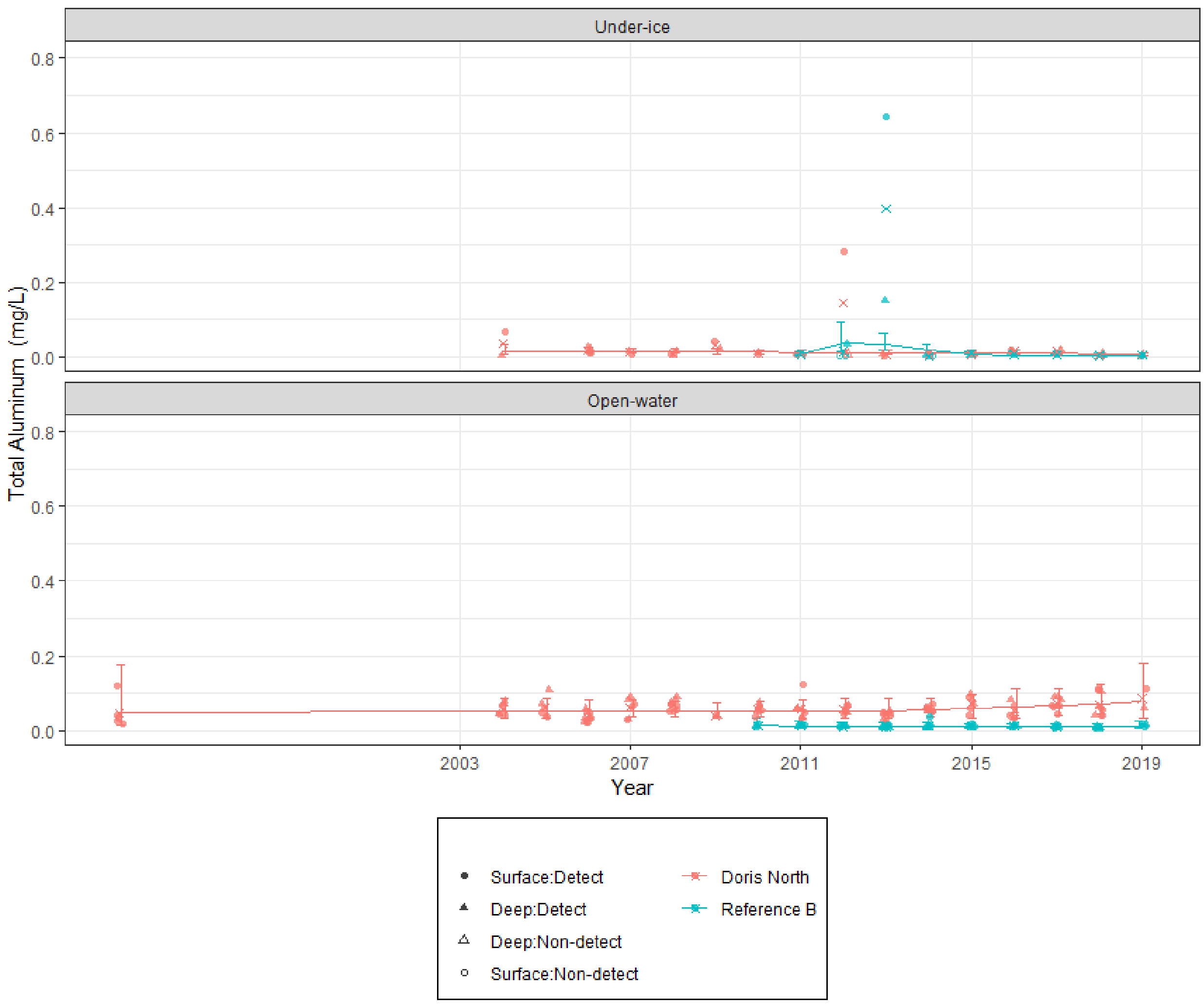
Analysis	Chi.sq	DF	P.value
Compare to slope 0	1.14	4	0.8878

Doris Lake does not exhibit significant deviation from no trend.

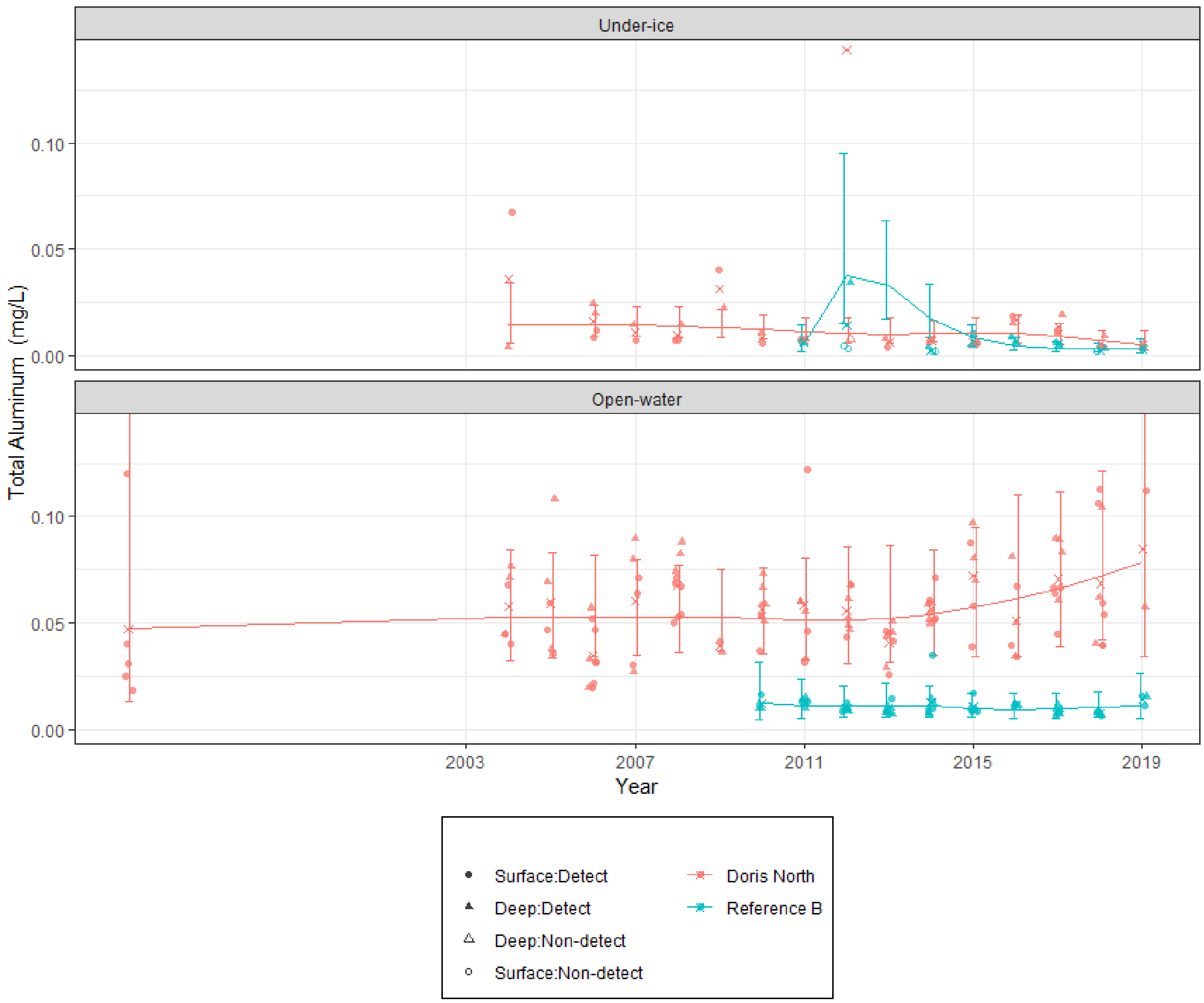
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

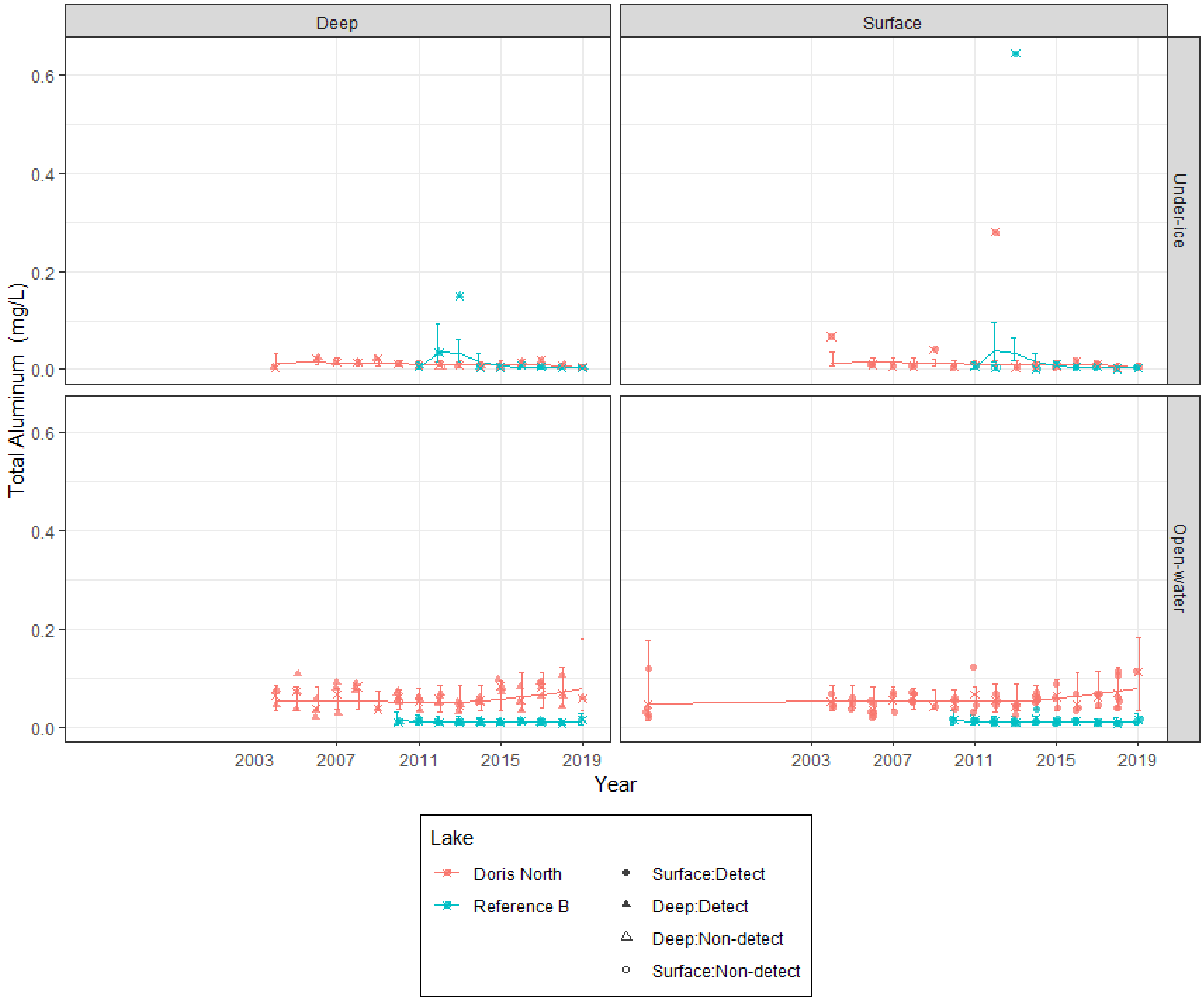
Plot of observed and fitted data averaged over depth.



Zoom-in:


Under-ice
Open-water
Total Aluminum (mg/L)
0.00
0.05
0.10
2003
2007
2011
2015
2019
Year
Surface:Detect
Deep:Detect
Deep:Non-detect
Surface:Non-detect
Doris North
Reference B

Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.4543	0.9468	4.952	-0.4798	0.6518	not sig.

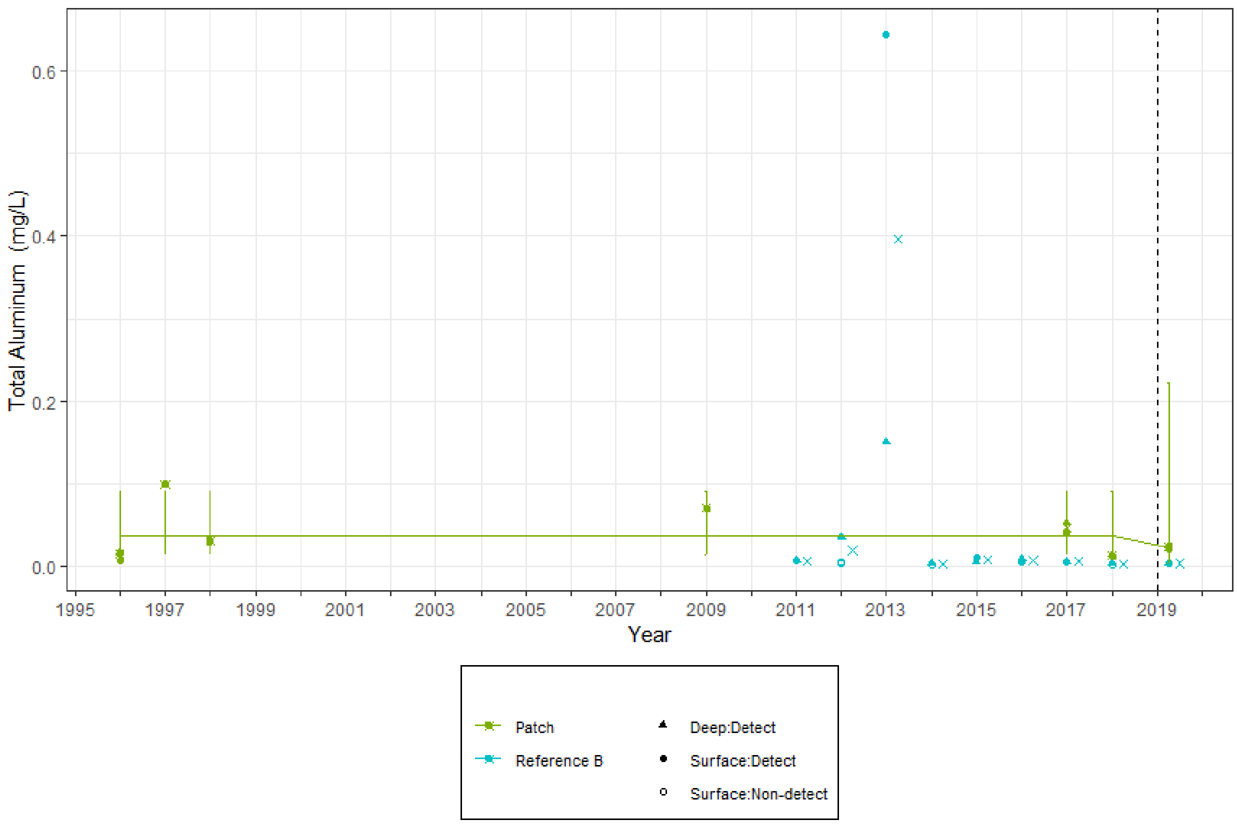
Conclusion:

The change in total aluminum concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.6518) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.1597	0.5544	4.746	0.288	0.7855	not sig.

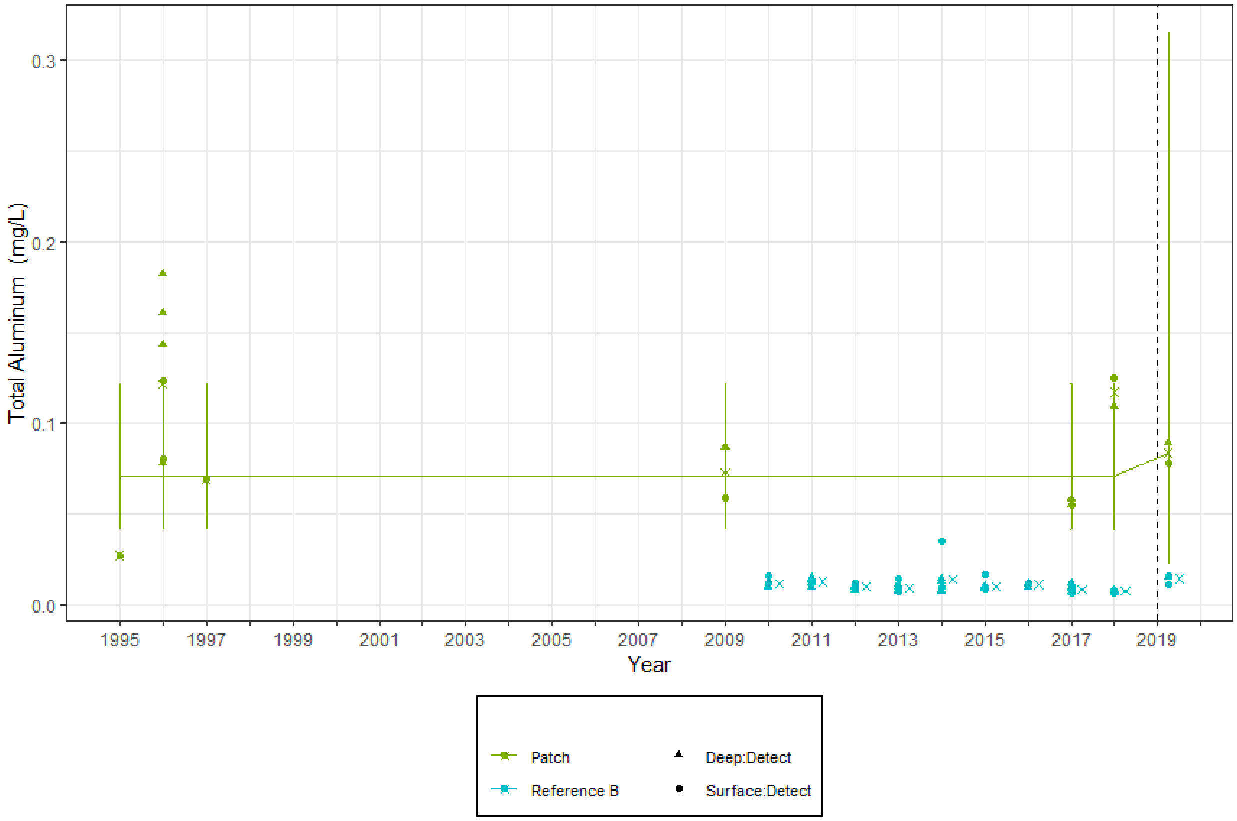
Conclusion:

The change in total aluminum concentrations in Patch Lake from *before* to *after* was not significantly ($p = 0.7855$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-1.02	0.4637	6.966	-2.2	0.064	not sig.

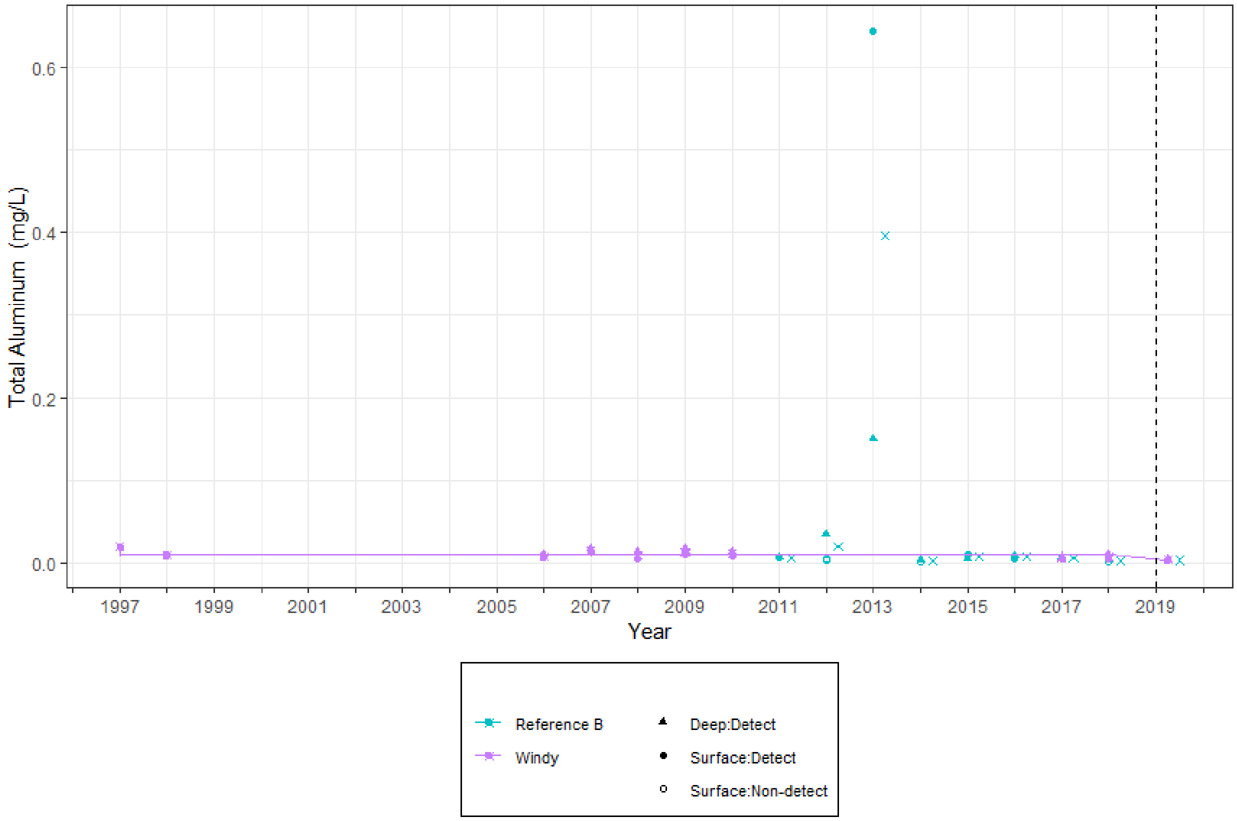
Conclusion:

The change in total aluminum concentrations in Windy Lake from *before* to *after* was not significantly ($p = 0.064$) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.0085	0.4354	8.971	0.0194	0.9849	not sig.

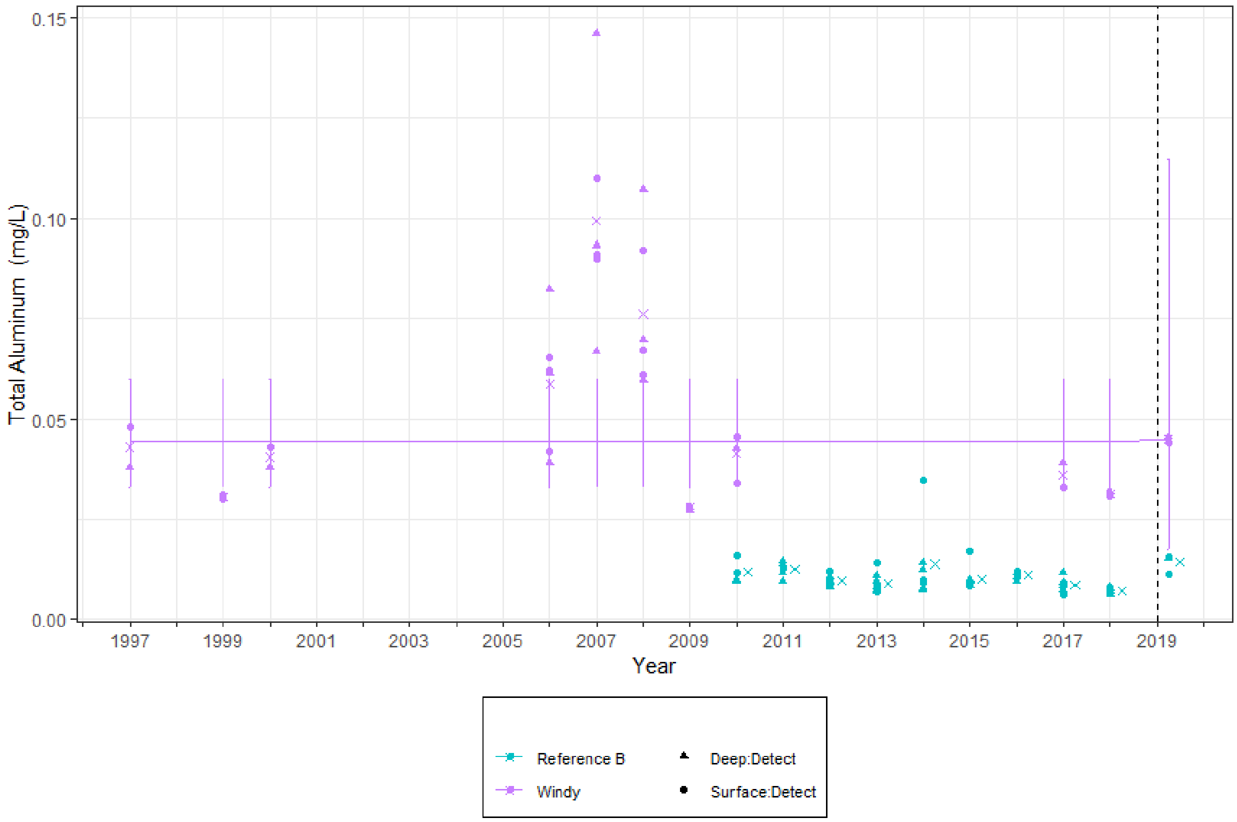
Conclusion:

The change in total aluminum concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.9849) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

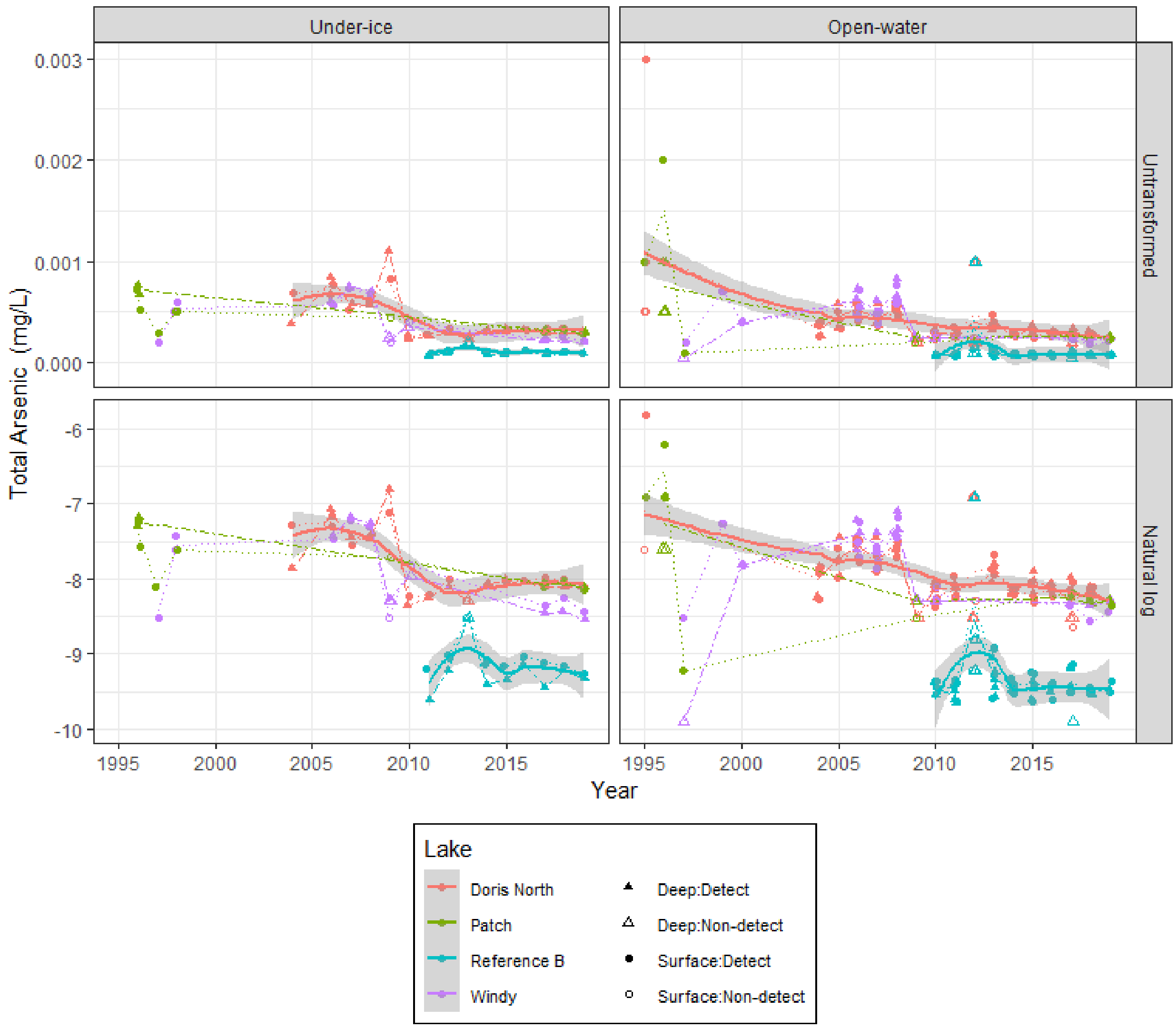
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.11 Total Arsenic

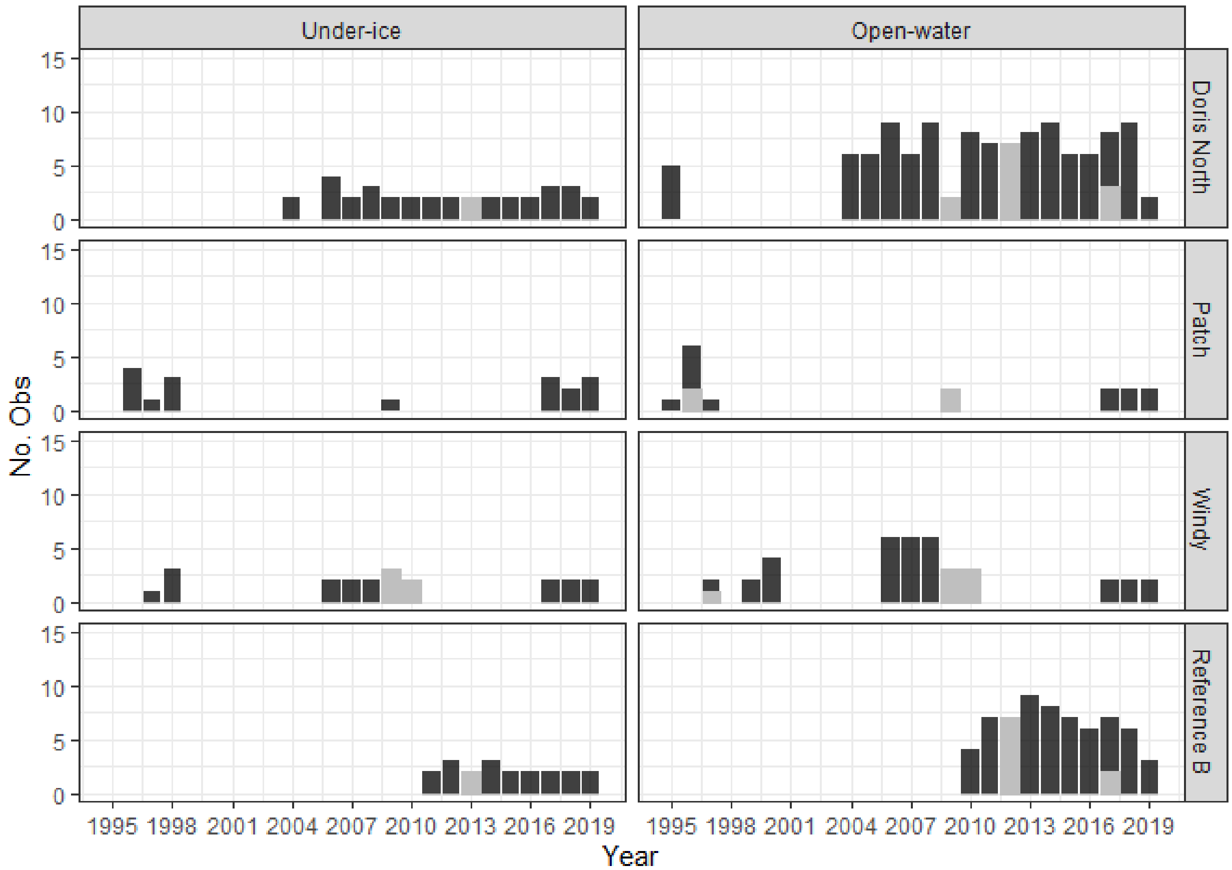
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

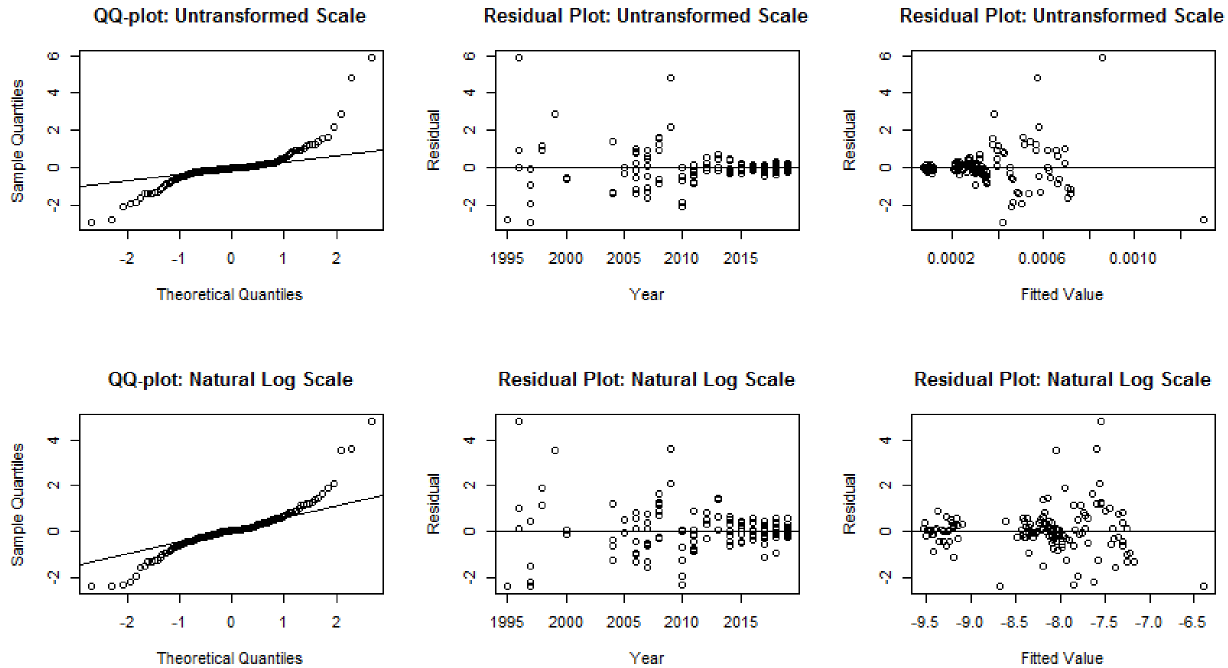
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	2	0.06	0	0.0003
Doris	Open-water	113	15	0.13	0	0.0004
Patch	Under-ice	17	1	0.06	0	0.0003
Patch	Open-water	16	4	0.25	0	0.0004
Reference B	Under-ice	20	2	0.10	0	0.0001
Reference B	Open-water	64	9	0.14	0	0.0001
Windy	Under-ice	21	5	0.24	0	0.0005
Windy	Open-water	38	7	0.18	0	0.0005

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. Doris open-water, Patch open-water, Reference B open-water, Windy under-ice, and Windy open-water exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2009	Under-ice	Deep	0.0011	0.001	4.796
Patch	1996	Open-water	Surface	0.0015	0.001	5.891

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2009	Under-ice	Deep	0.0011	-7.599	3.601
Patch	1996	Open-water	Surface	0.0015	-7.548	4.787
Windy	1999	Open-water	Surface	0.0007	-8.040	3.552

There were outliers retained in the analysis. Results should be interpreted with caution and along with graphical results. The untransformed data better meets the residual assumptions. Analysis proceeds with untransformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	84.781	4	0.0000
Compare to Reference B	5.854	4	0.2104

Doris Lake appears to show significant deviation from no trend. Doris Lake does not exhibit significant deviation from the trend of Reference B lake.

Open-water

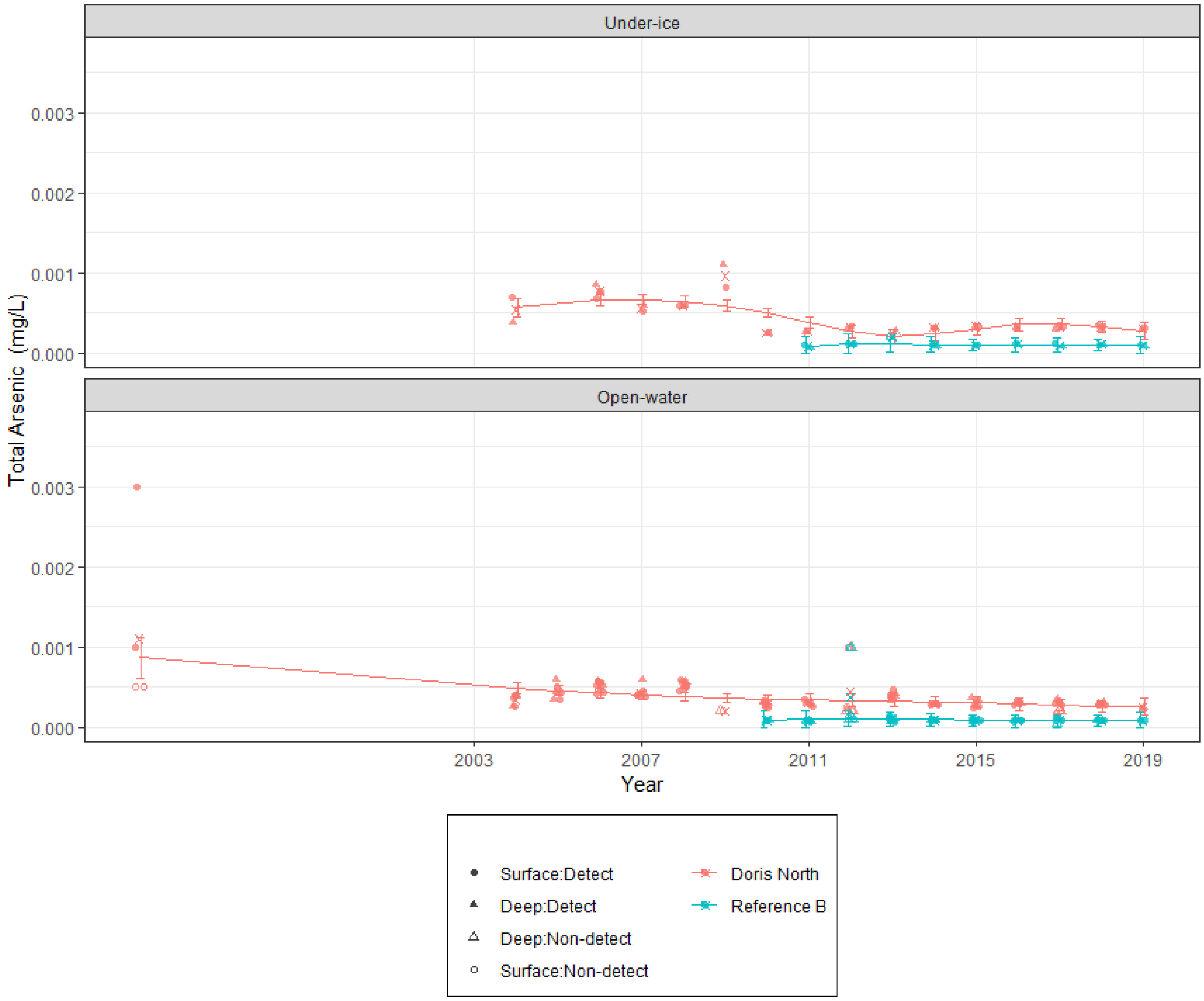
Analysis	Chi.sq	DF	P.value
Compare to slope 0	31.192	4	0.0000
Compare to Reference B	1.094	4	0.8952

Doris Lake appears to show significant deviation from no trend. Doris Lake does not exhibit significant deviation from the trend of Reference B lake.

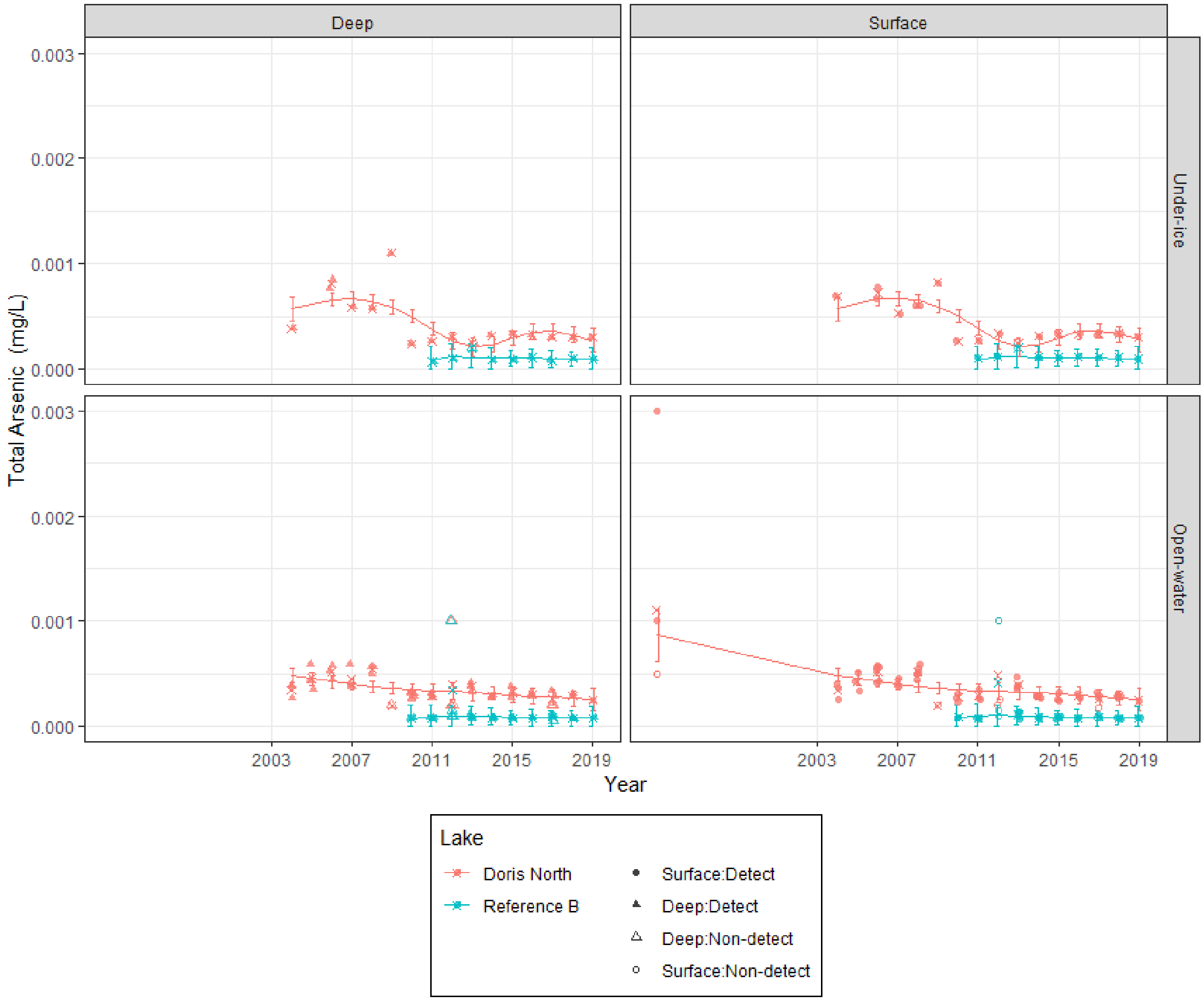
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-1e-04	2e-04	4.975	-0.8745	0.4221	not sig.

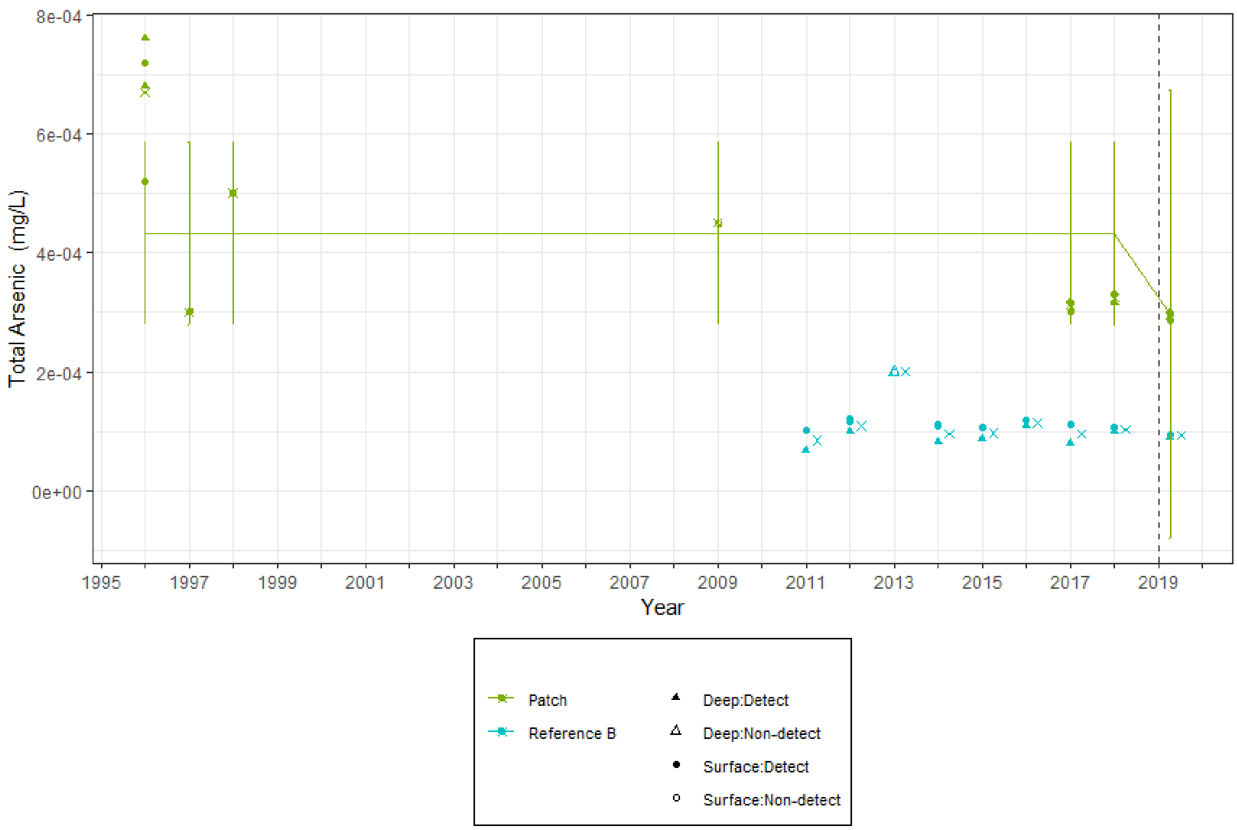
Conclusion:

The change in total arsenic concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.4221) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-2e-04	5e-04	4.59	-0.4814	0.6523	not sig.

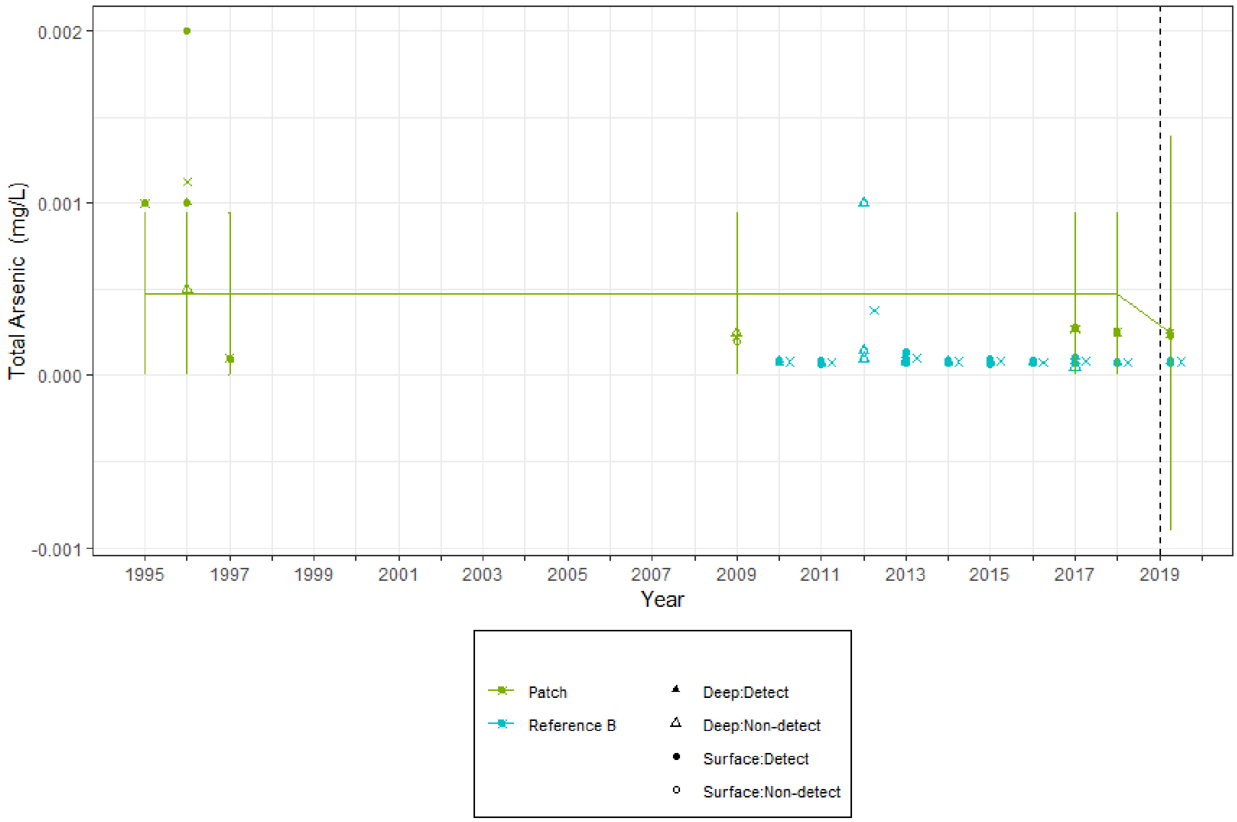
Conclusion:

The change in total arsenic concentrations at the Patch site from *before* to *after* was not significantly ($p = 0.6523$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-2e-04	2e-04	7.983	-0.9466	0.3716	not sig.

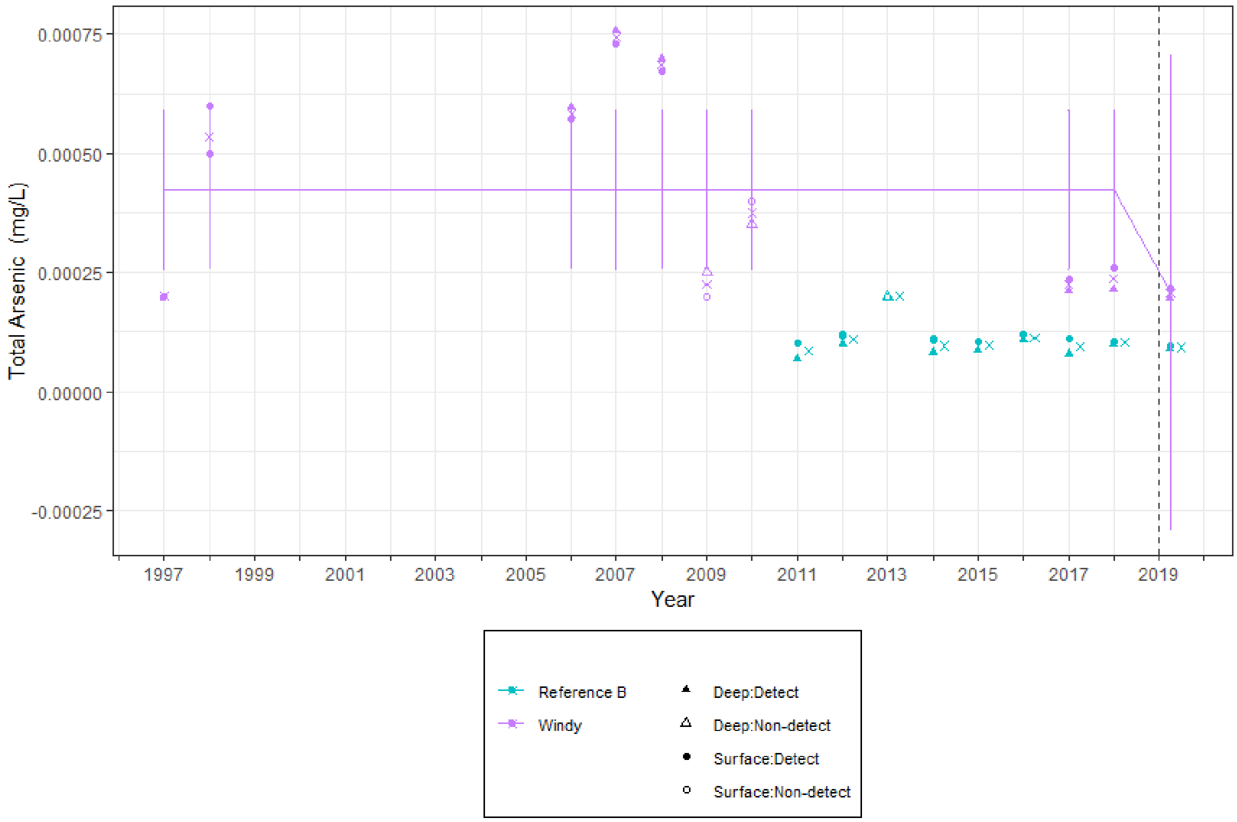
Conclusion:

The change in total arsenic concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.3716) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-2e-04	2e-04	8.894	-0.7448	0.4756	not sig.

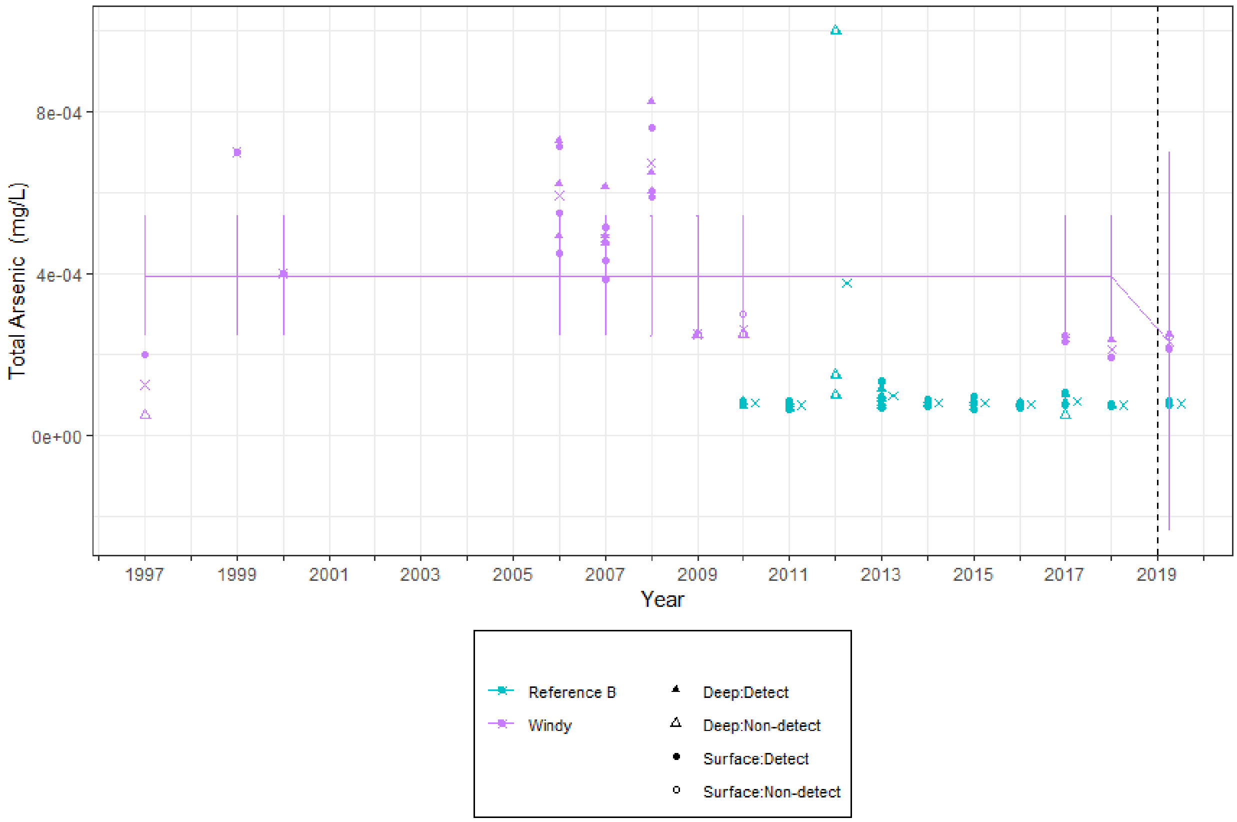
Conclusion:

The change in total arsenic concentrations in Windy Lake from *before* to *after* was not significantly ($p = 0.4756$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

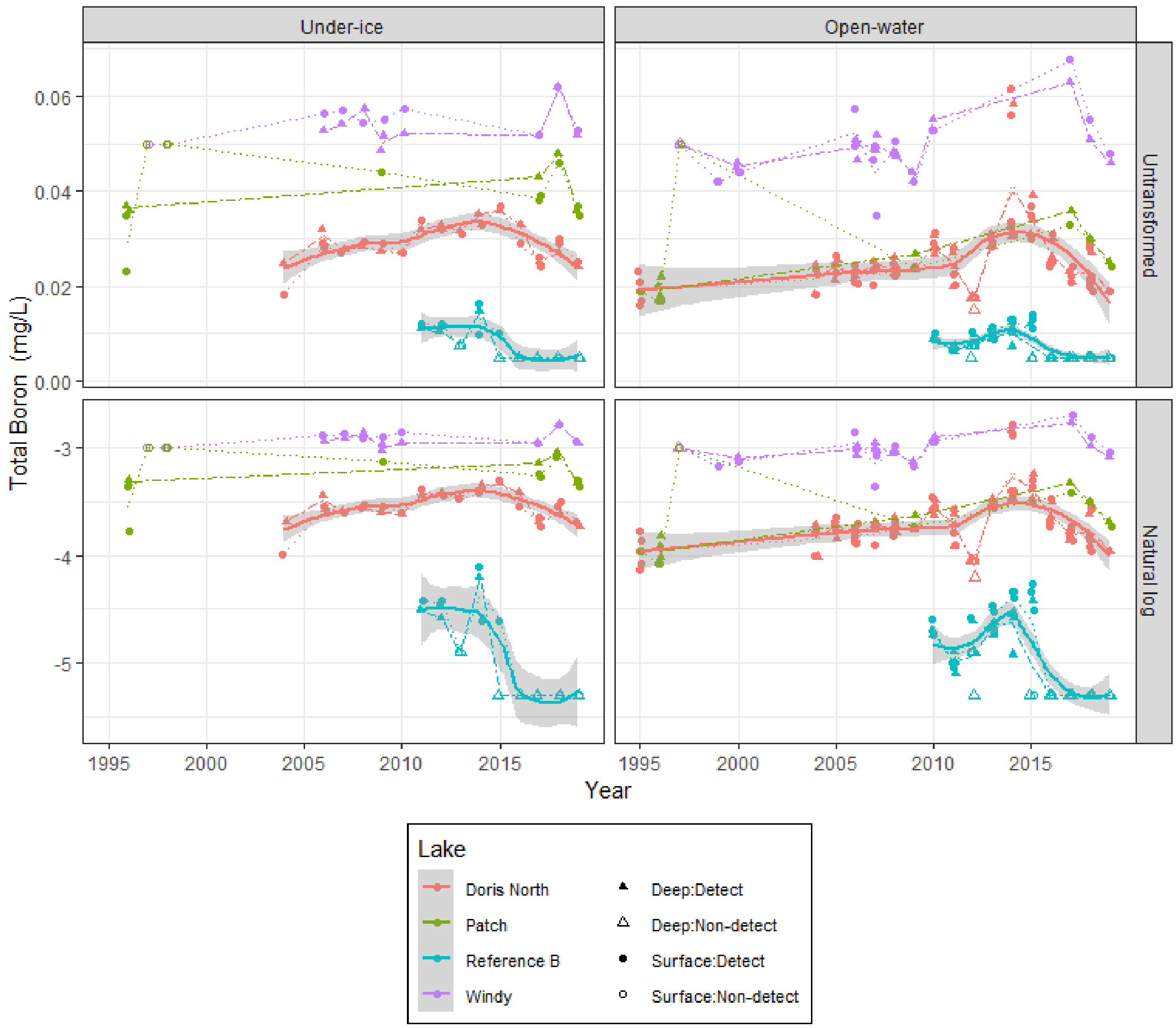
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.12 Total Boron

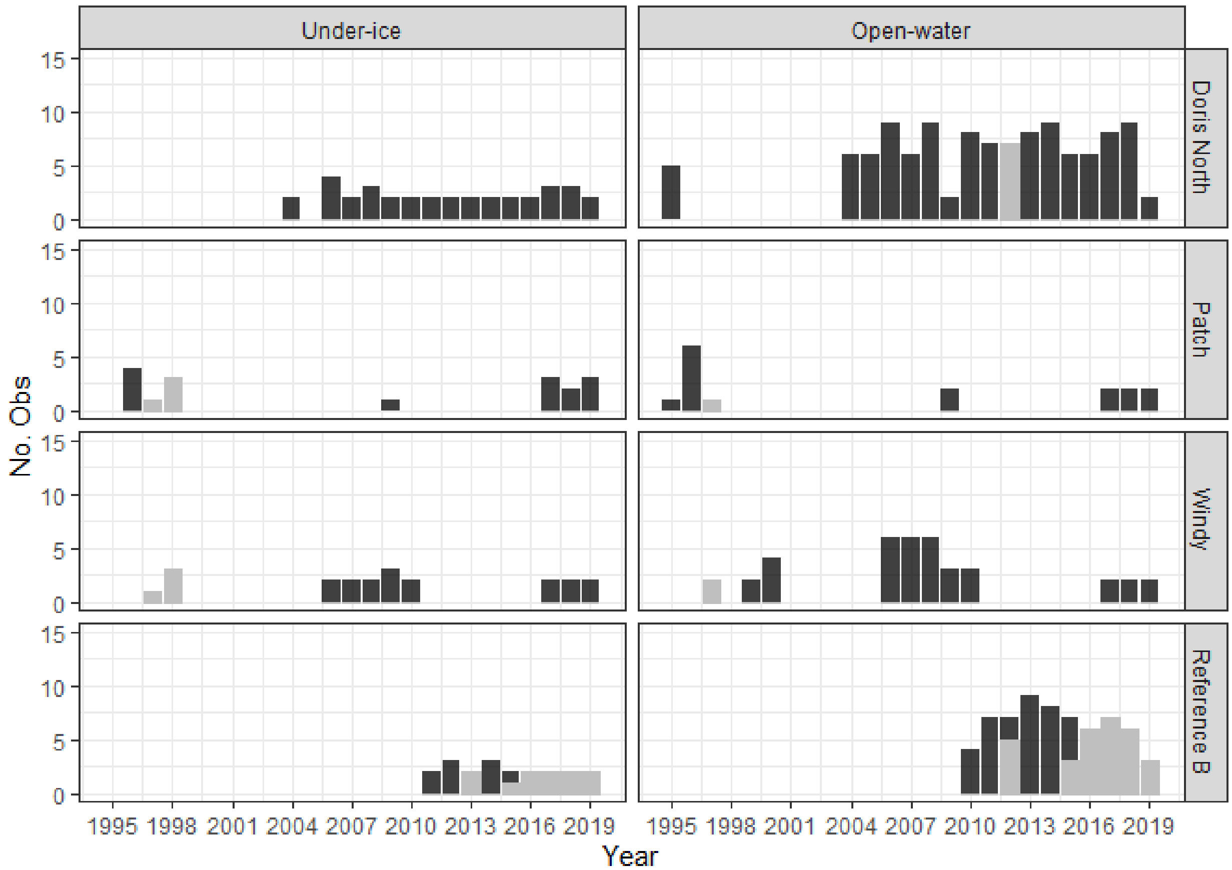
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

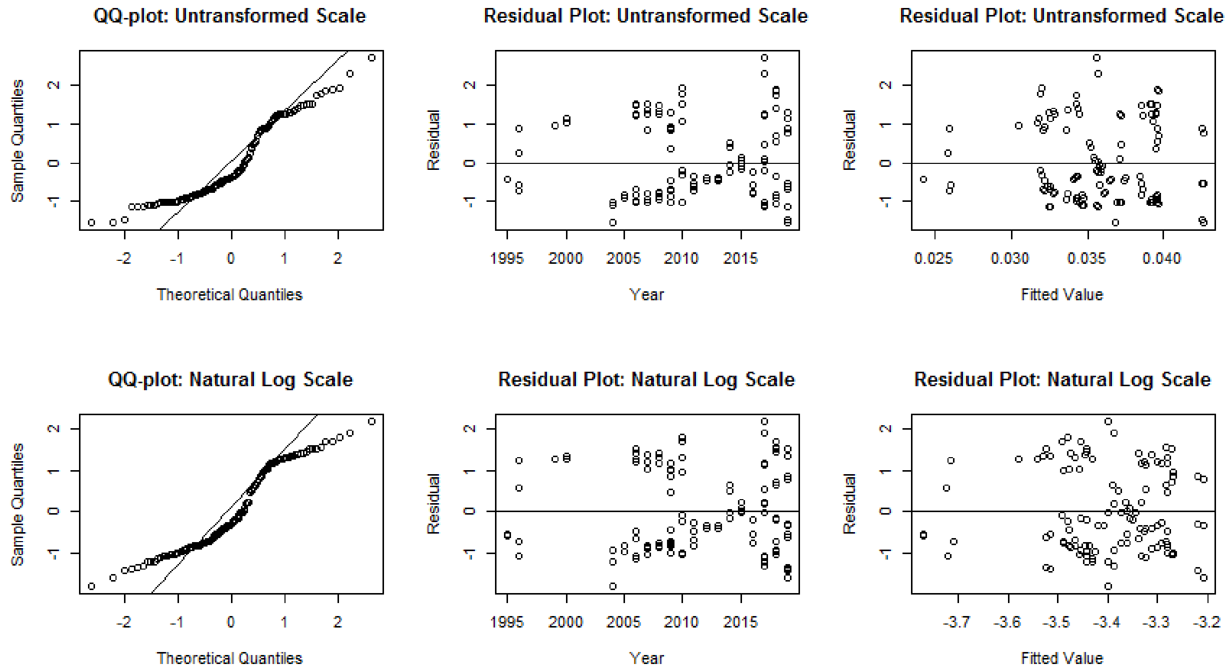
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	0	0.00	0	0.0290
Doris	Open-water	113	7	0.06	0	0.0243
Patch	Under-ice	17	4	0.24	0	0.0390
Patch	Open-water	16	1	0.06	0	0.0240
Reference B	Under-ice	20	11	0.55	1	0.0100
Reference B	Open-water	64	30	0.47	1	0.0100
Windy	Under-ice	21	4	0.19	0	0.0551
Windy	Open-water	38	2	0.05	0	0.0485

More than 50% of data under detection limit in Reference B under-ice and Reference B open-water. Data from those site-season groupings will be removed from the analysis. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	46.53	4	0.0000

Doris Lake appears to show significant deviation from no trend.

Open-water

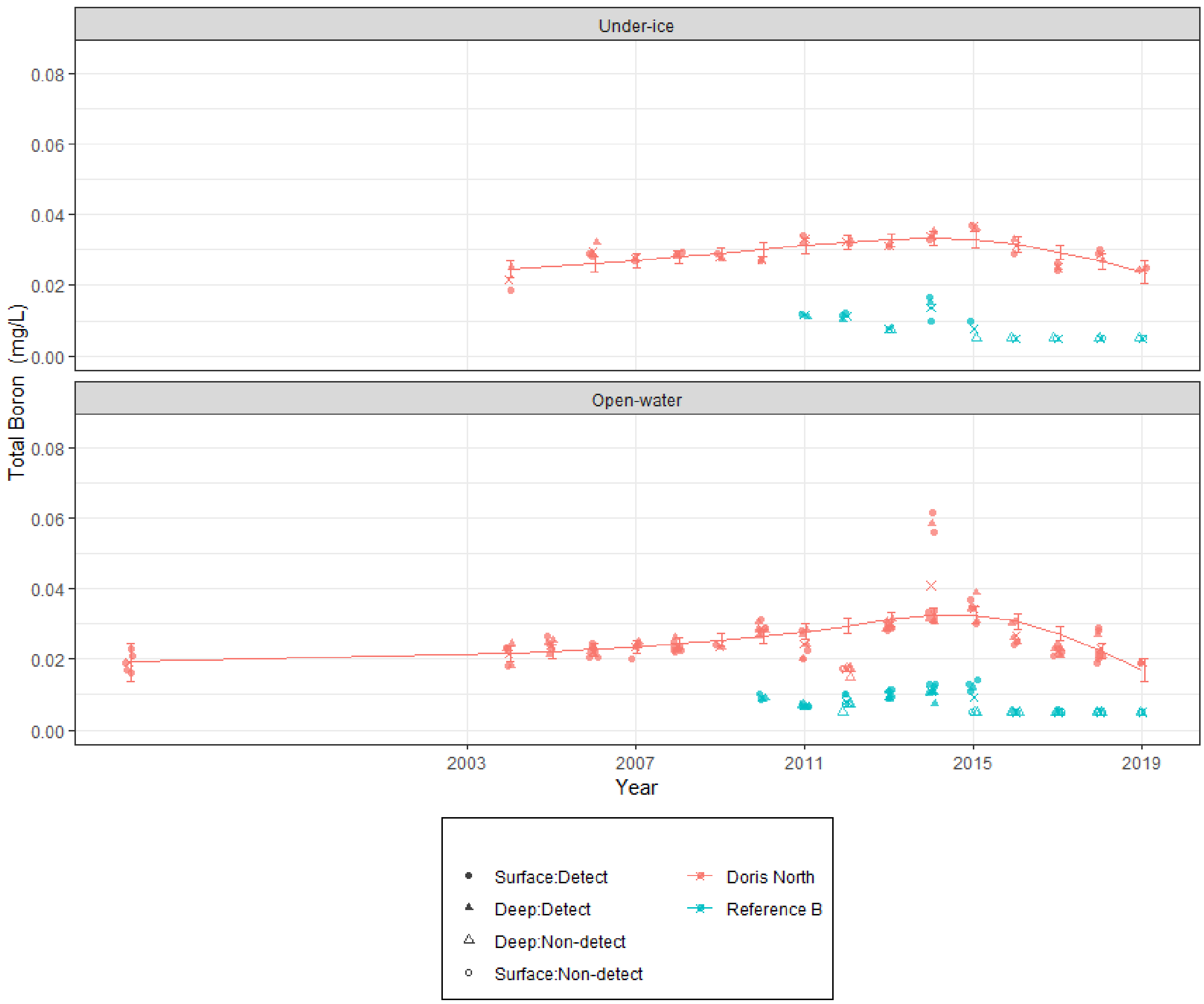
Analysis	Chi.sq	DF	P.value
Compare to slope 0	78.26	4	0.0000

Doris Lake appears to show significant deviation from no trend.

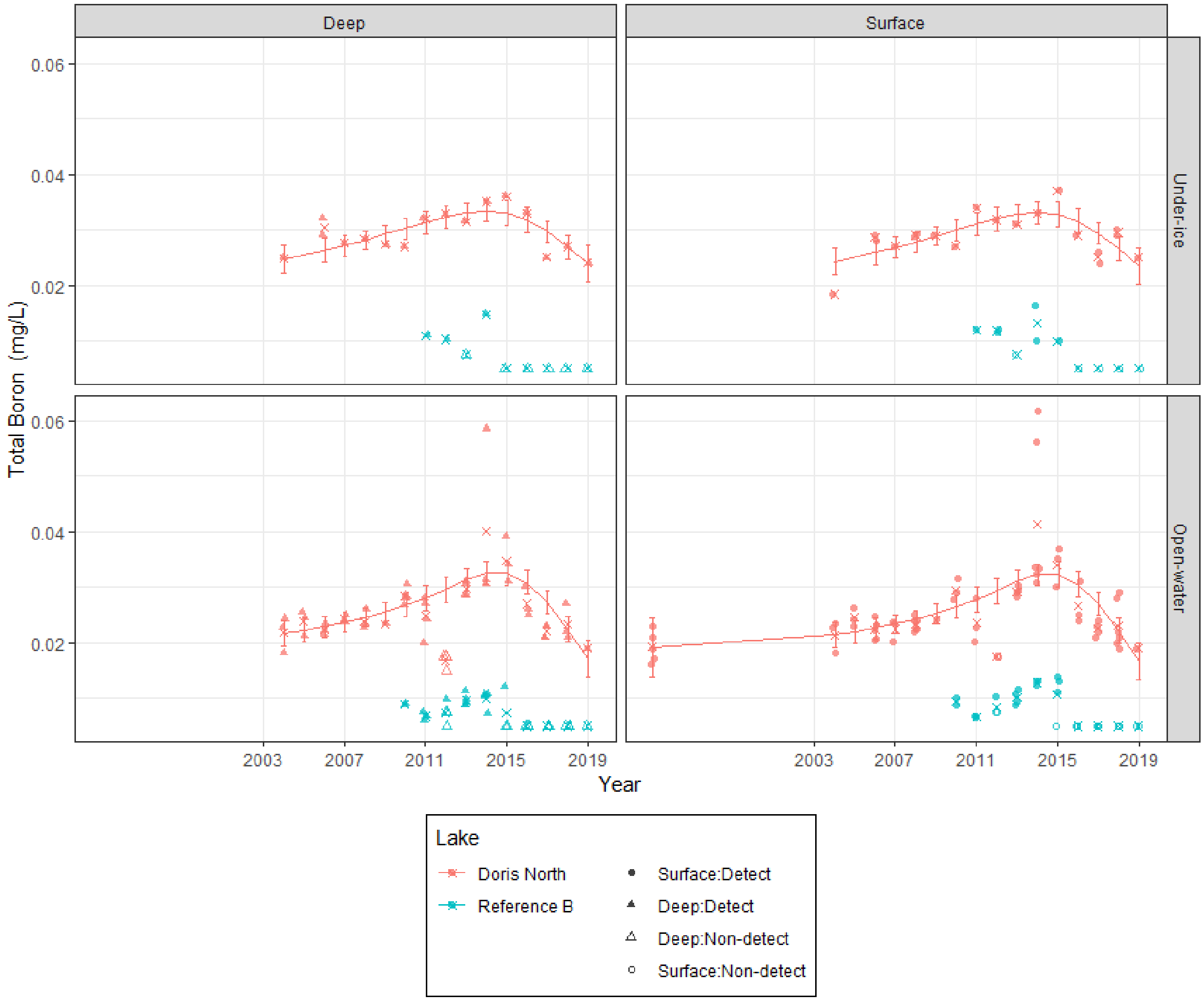
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0087	0.0078	4.796	-1.125	0.3138	not sig.

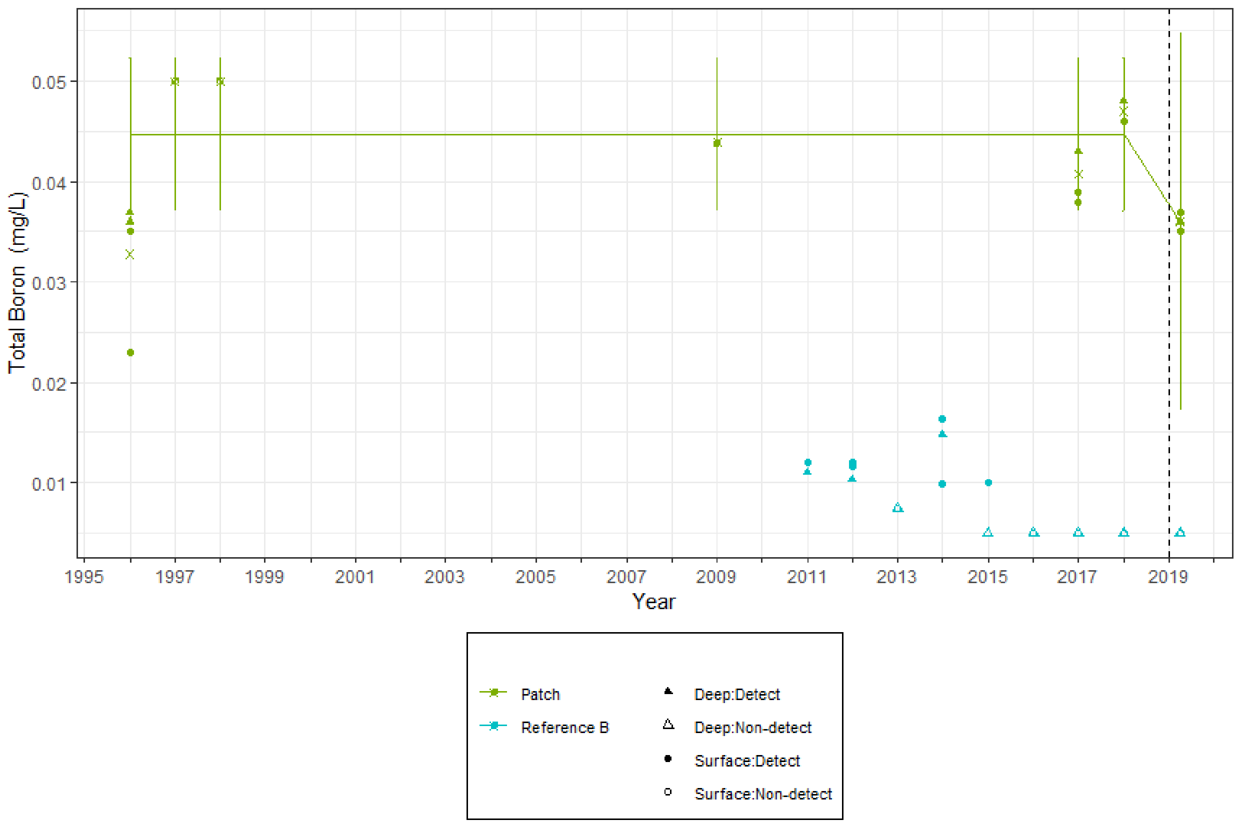
Conclusion:

The change in total boron concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.3138) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0053	0.013	4.981	-0.4066	0.7012	not sig.

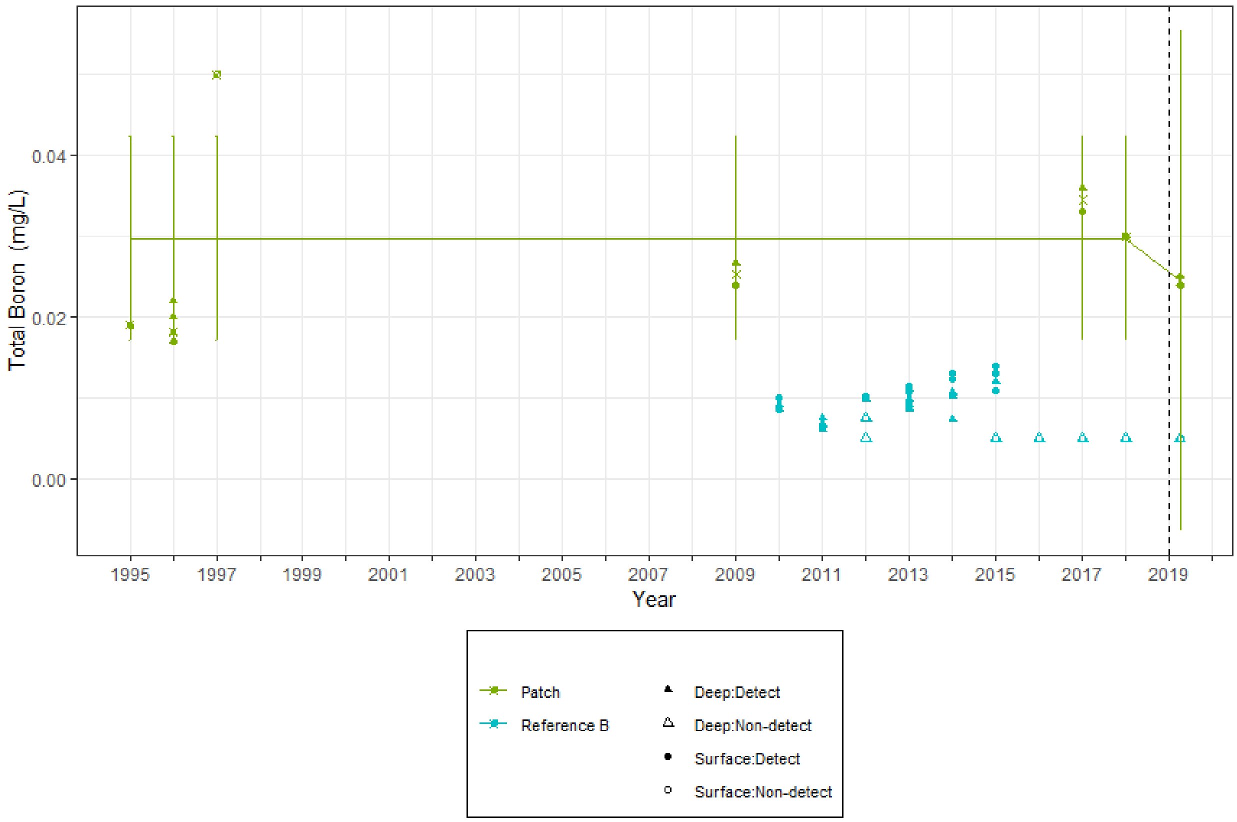
Conclusion:

The change in total boron concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.7012) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0016	0.004	7.166	-0.4115	0.6927	not sig.

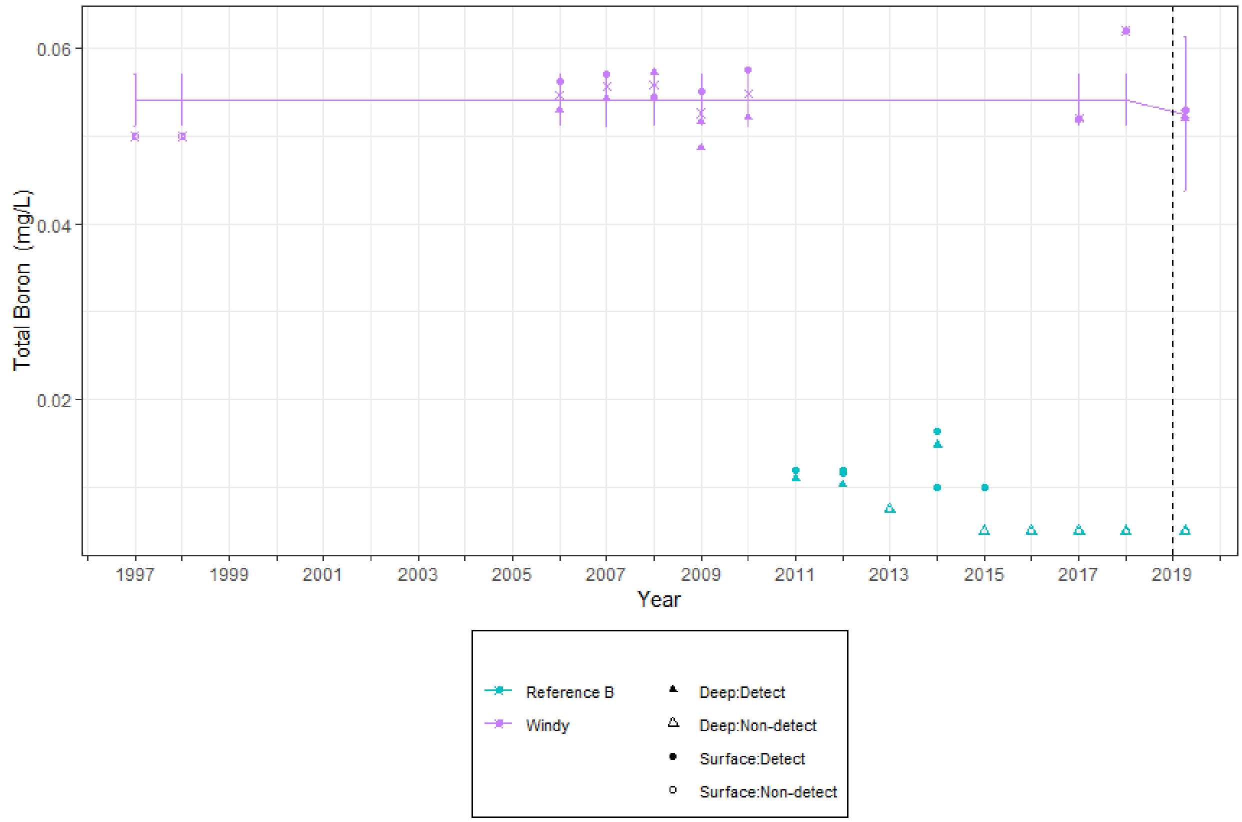
Conclusion:

The change in total boron concentrations in Windy ake from *before* to *after* was not significantly (p = 0.6927) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0028	0.0072	8.855	-0.3923	0.7041	not sig.

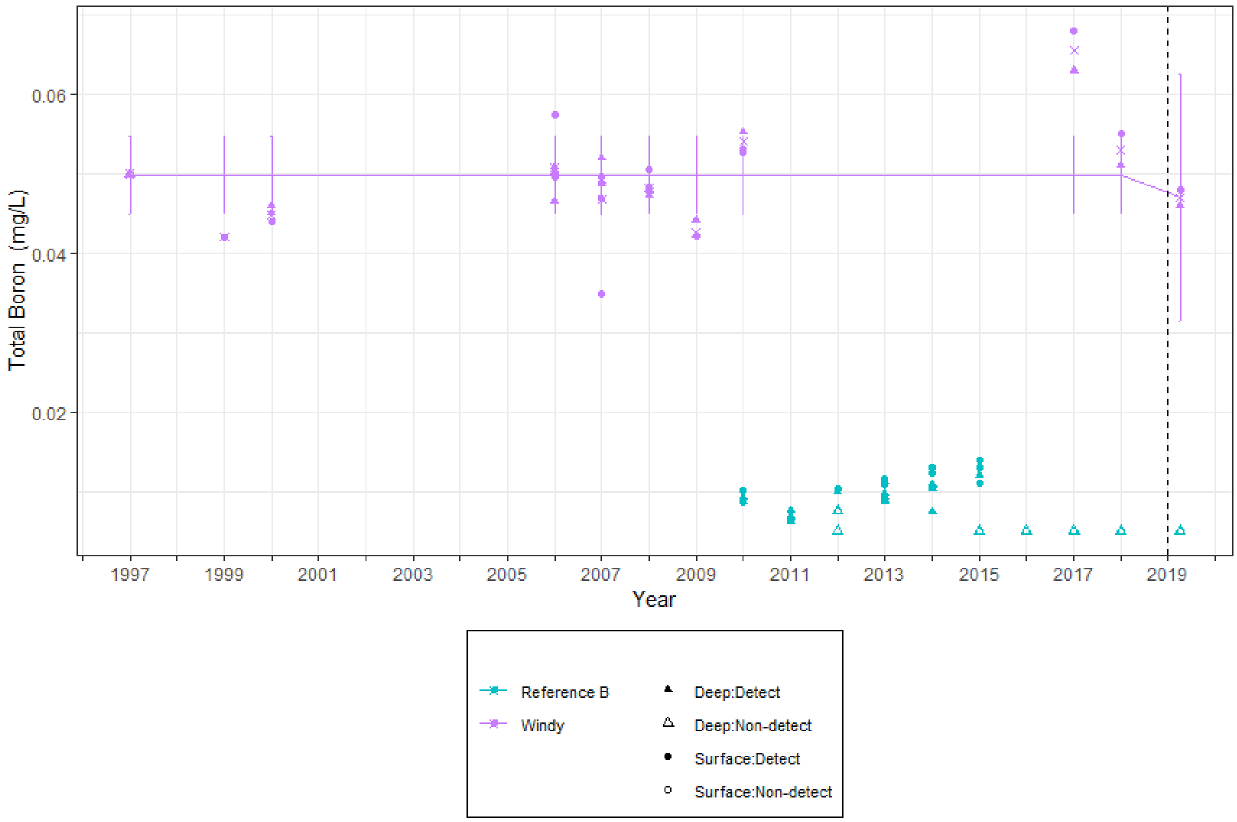
Conclusion:

The change in total boron concentrations in Windy Lake from *before* to *after* was not significantly ($p = 0.7041$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

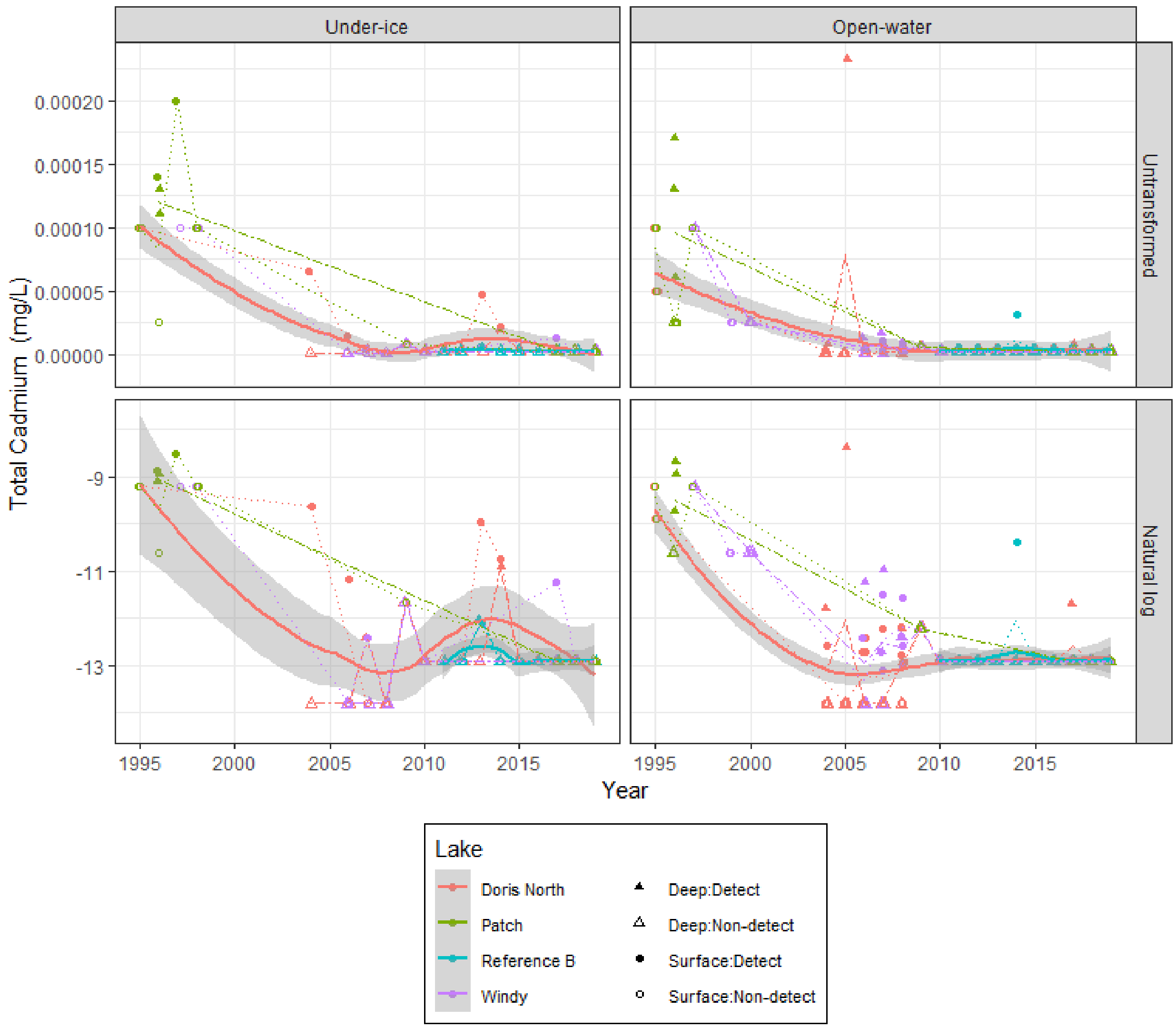
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.13 Total Cadmium

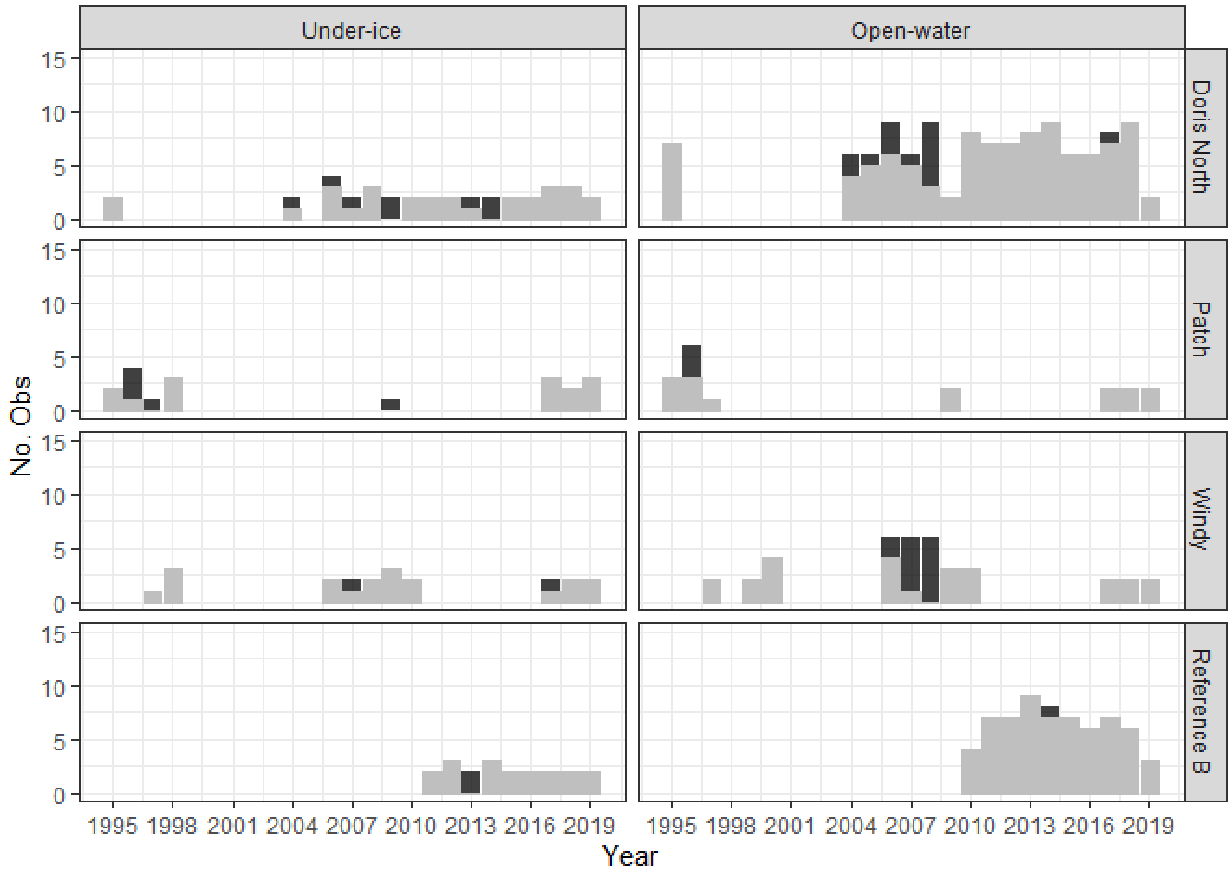
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

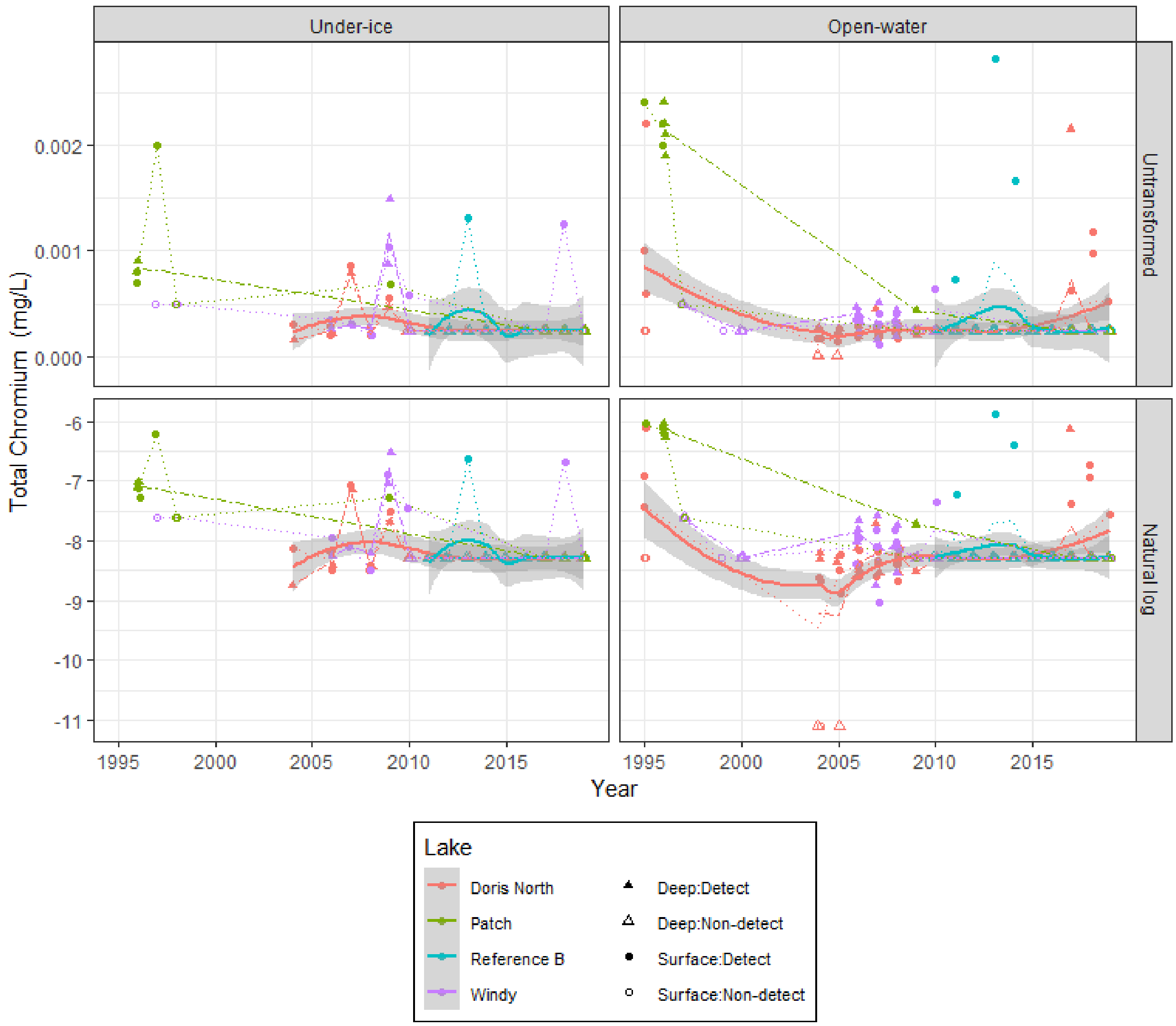
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	37	31	0.84	1	0
Doris	Open-water	115	101	0.88	1	0
Patch	Under-ice	19	15	0.79	1	0
Patch	Open-water	18	15	0.83	1	0
Reference B	Under-ice	20	18	0.90	1	0
Reference B	Open-water	64	63	0.98	1	0
Windy	Under-ice	21	19	0.90	1	0
Windy	Open-water	38	25	0.66	1	0

All data from 2019 were censored. All data removed from the analysis and no statistical analyses were performed.

C.3.2.14 Total Chromium

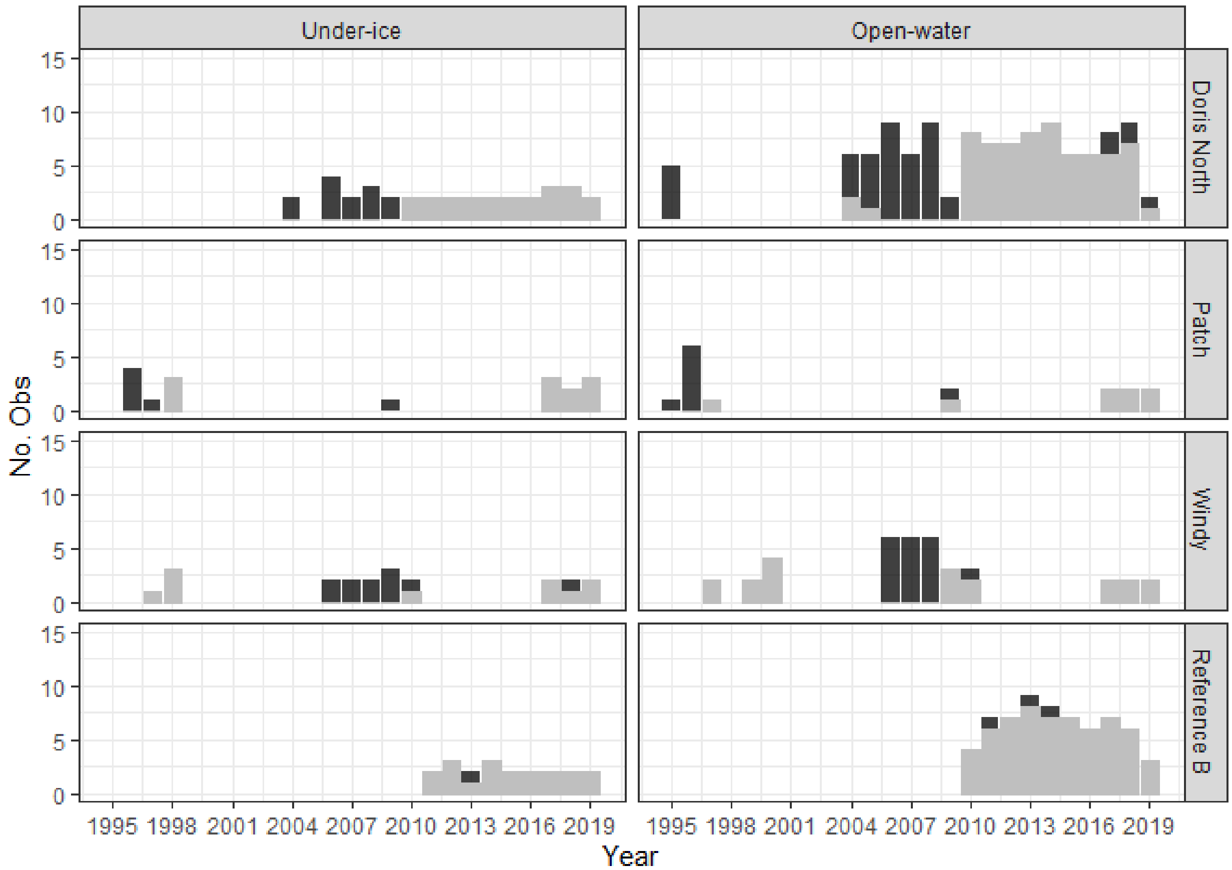
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

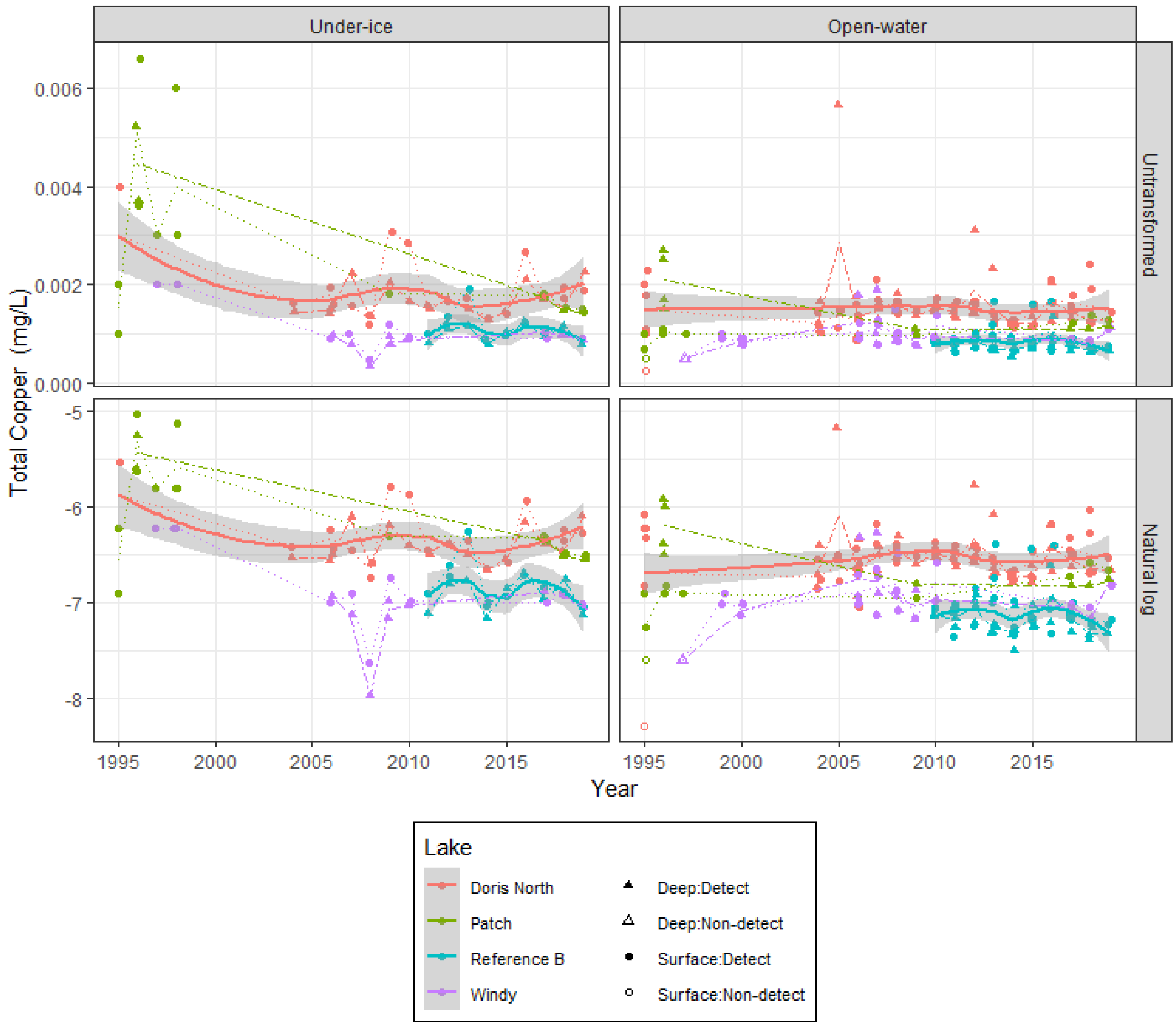
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	22	0.63	1.0	0.0005
Doris	Open-water	113	70	0.62	0.5	0.0005
Patch	Under-ice	17	11	0.65	1.0	0.0007
Patch	Open-water	16	8	0.50	1.0	0.0008
Reference B	Under-ice	20	19	0.95	1.0	0.0005
Reference B	Open-water	64	61	0.95	1.0	0.0005
Windy	Under-ice	21	10	0.48	1.0	0.0005
Windy	Open-water	38	19	0.50	1.0	0.0005

All data from 2019 were censored. All data removed from the analysis and no statistical analyses were performed.

C.3.2.15 Total Copper

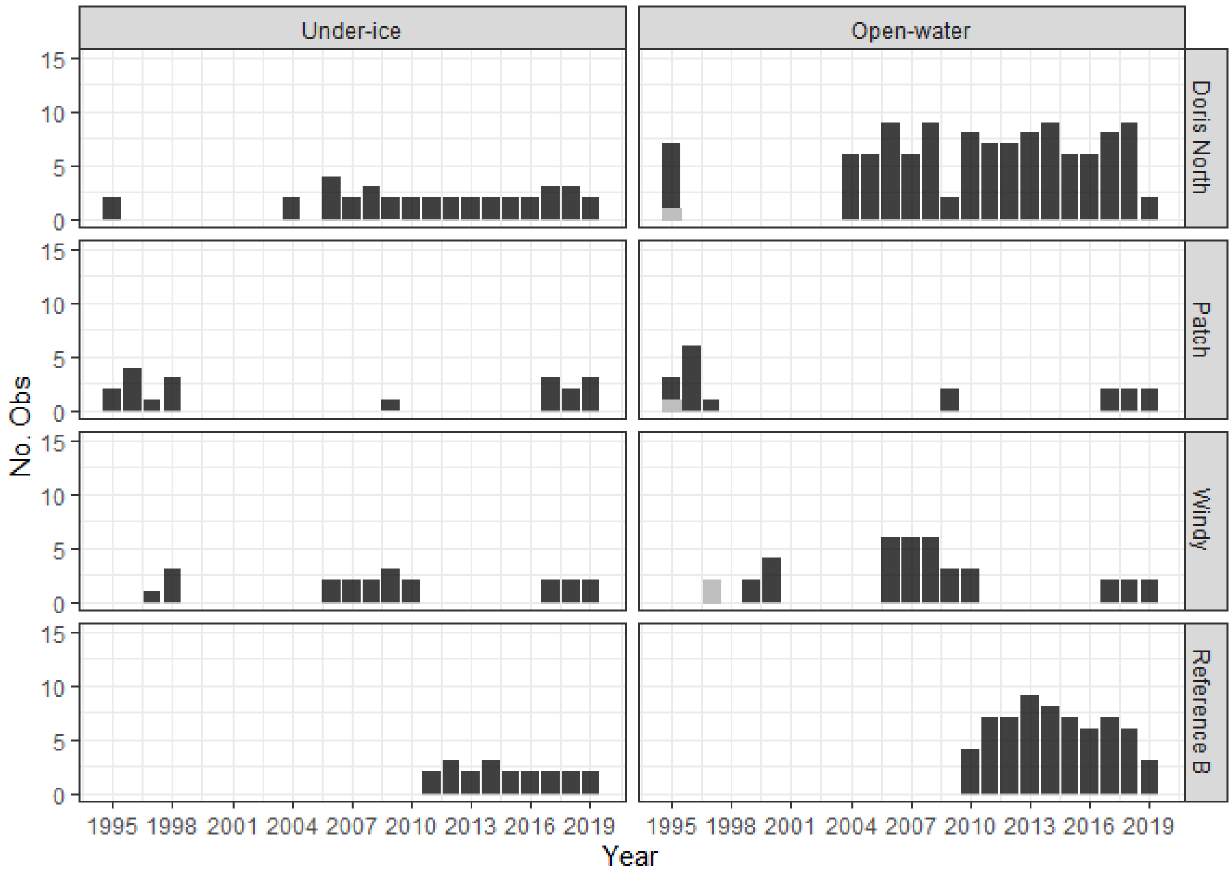
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

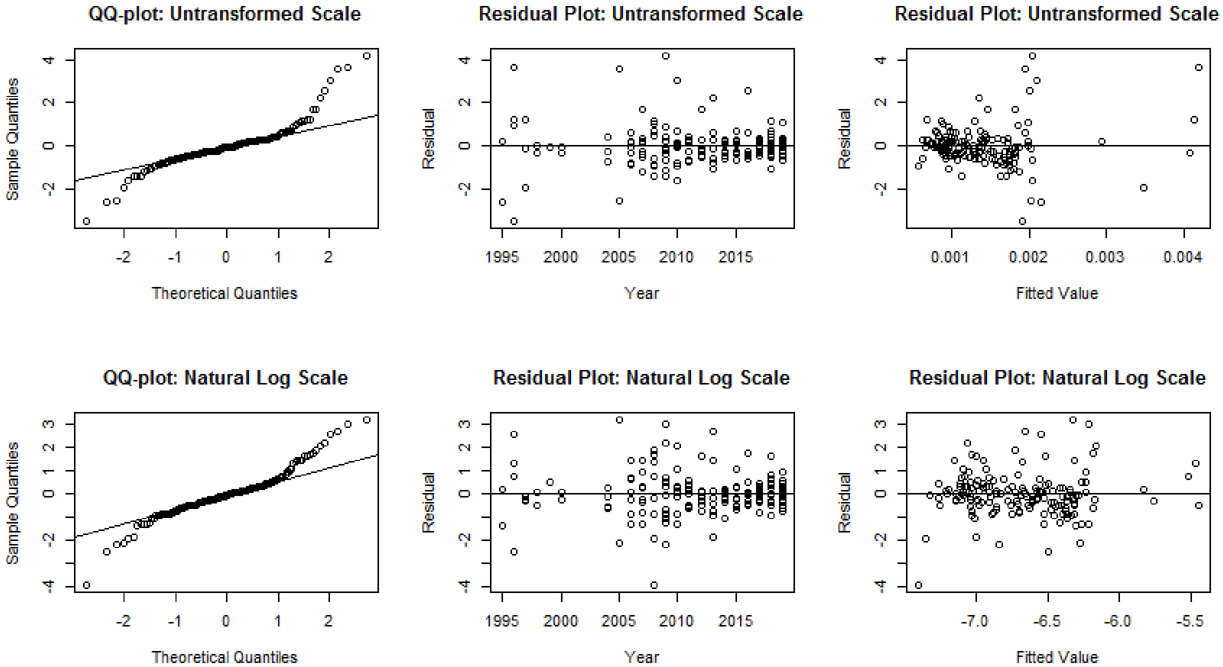
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	37	0	0.00	0	0.0017
Doris	Open-water	115	1	0.01	0	0.0014
Patch	Under-ice	19	0	0.00	0	0.0018
Patch	Open-water	18	1	0.06	0	0.0011
Reference B	Under-ice	20	0	0.00	0	0.0010
Reference B	Open-water	64	0	0.00	0	0.0008
Windy	Under-ice	21	0	0.00	0	0.0009
Windy	Open-water	38	2	0.05	0	0.0009

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.

L



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2005	Open-water	Deep	0.0029	0.002	3.584
Doris	2009	Under-ice	Surface	0.0031	0.002	4.175
Doris	2010	Under-ice	Surface	0.0028	0.002	3.015
Patch	1996	Under-ice	Surface	0.0051	0.004	3.624
Patch	1996	Open-water	Surface	0.0011	0.002	-3.487

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2005	Open-water	Deep	0.0029	-6.326	3.207
Windy	2008	Under-ice	Deep	0.0003	-7.396	-3.943

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data. However, there was an outlier retained in the analysis. Results should be interpreted with caution and along with graphical results.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	7.898	4	0.0954

Doris Lake does not exhibit significant deviation from no trend.

Open-water

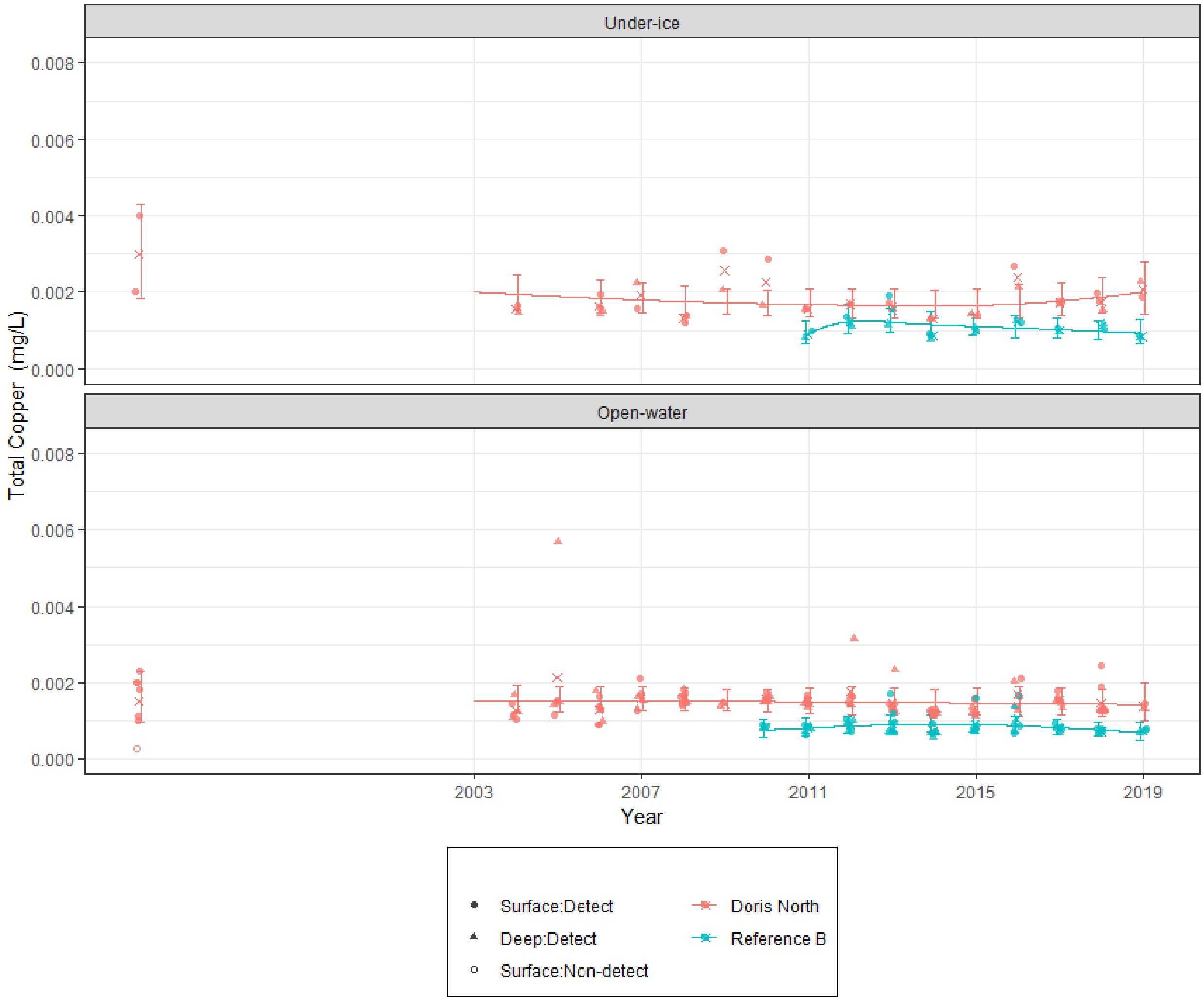
Analysis	Chi.sq	DF	P.value
Compare to slope 0	0.438	4	0.9793

Doris Lake does not exhibit significant deviation from no trend.

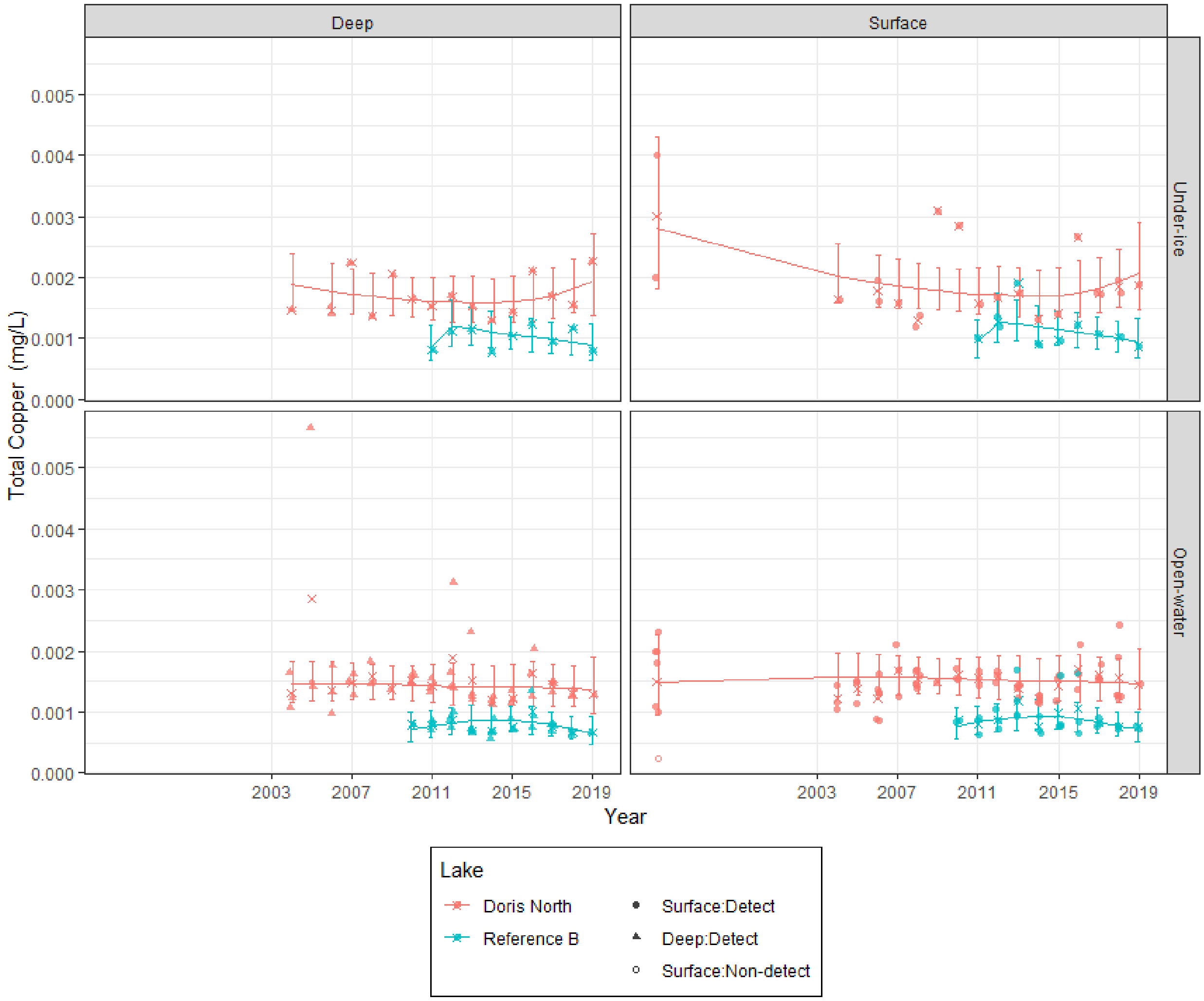
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.


Under-ice
Open-water
0.008
0.006
0.004
0.002
0.000
Total Copper (mg/L)
2003
2007
2011
2015
2019
Year
Surface:Detect
Deep:Detect
Surface:Non-detect
Doris North
Reference B

Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.4667	0.5134	5.989	-0.909	0.3985	not sig.

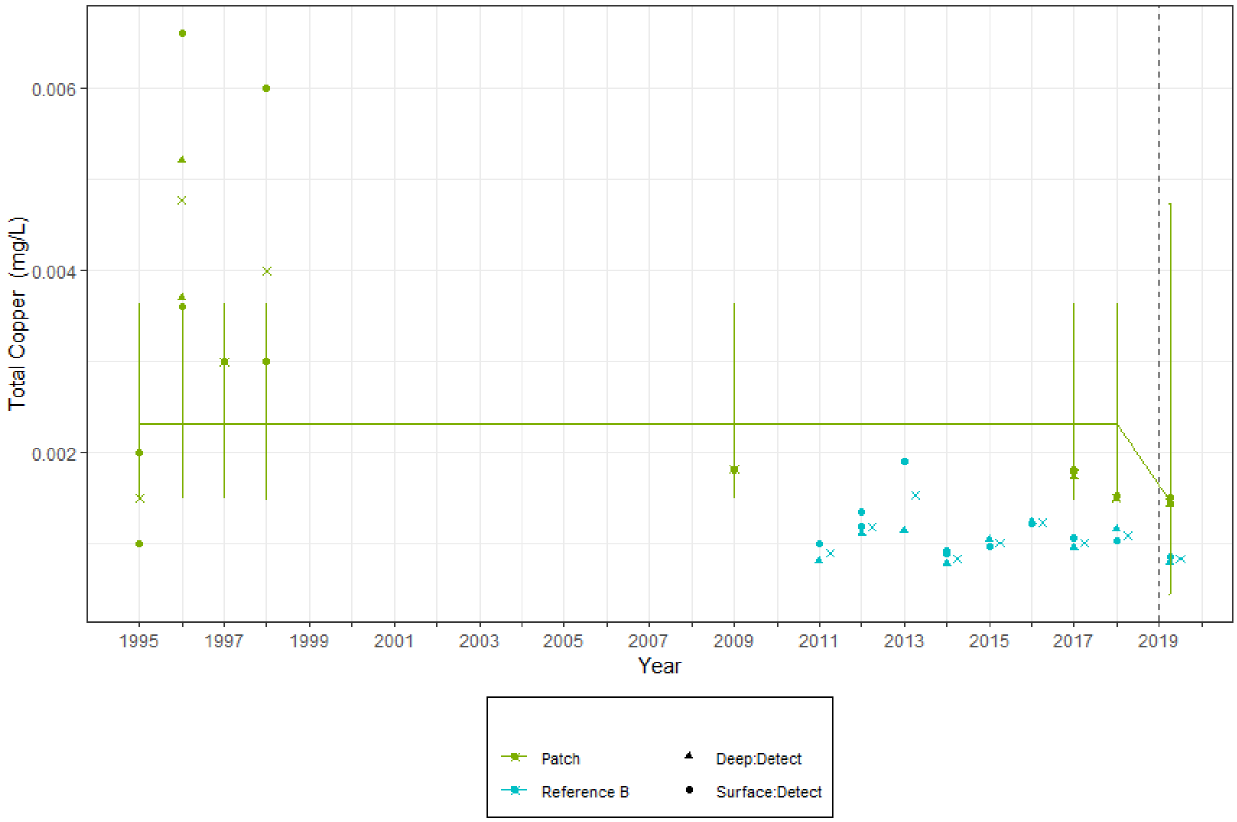
Conclusion:

The change in total copper concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.3985) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.0623	0.1995	9	0.3121	0.7621	not sig.

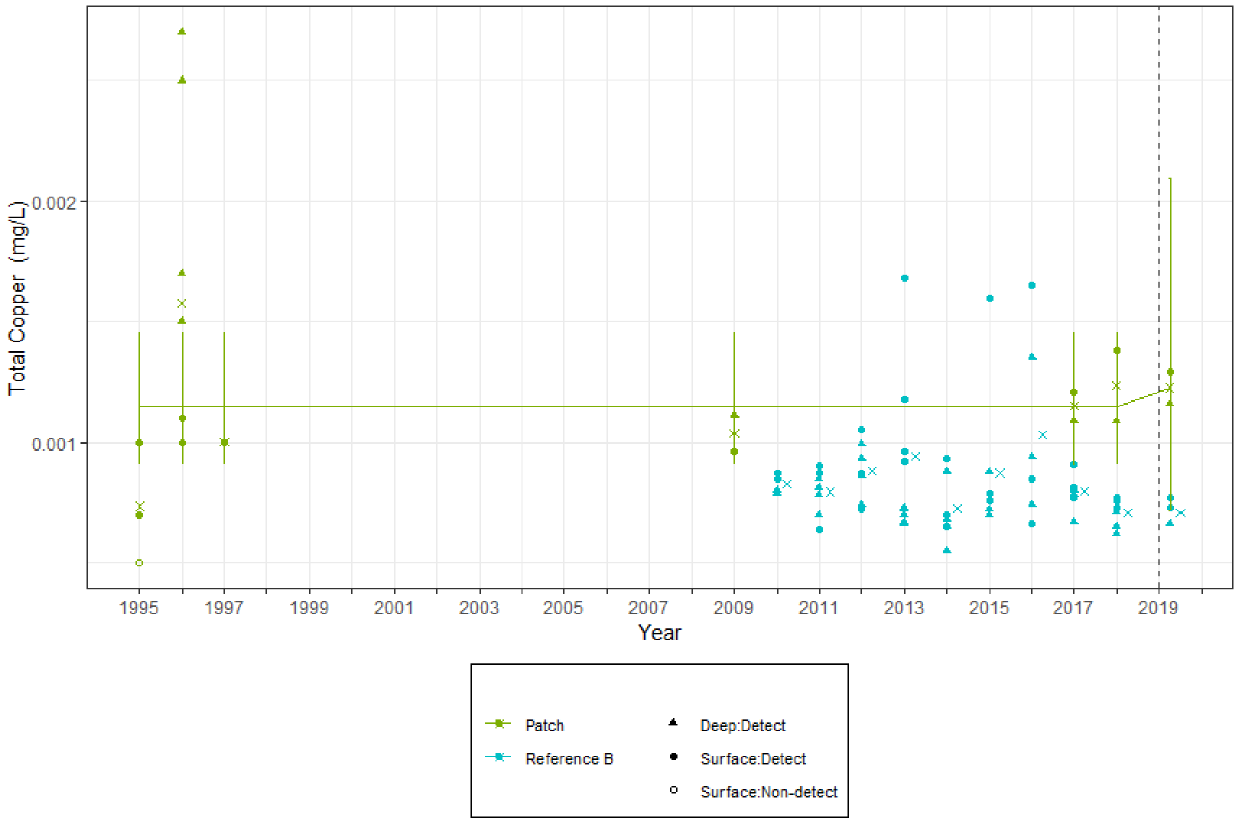
Conclusion:

The change in total copper concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.7621) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.1262	0.4692	7.665	-0.2689	0.7951	not sig.

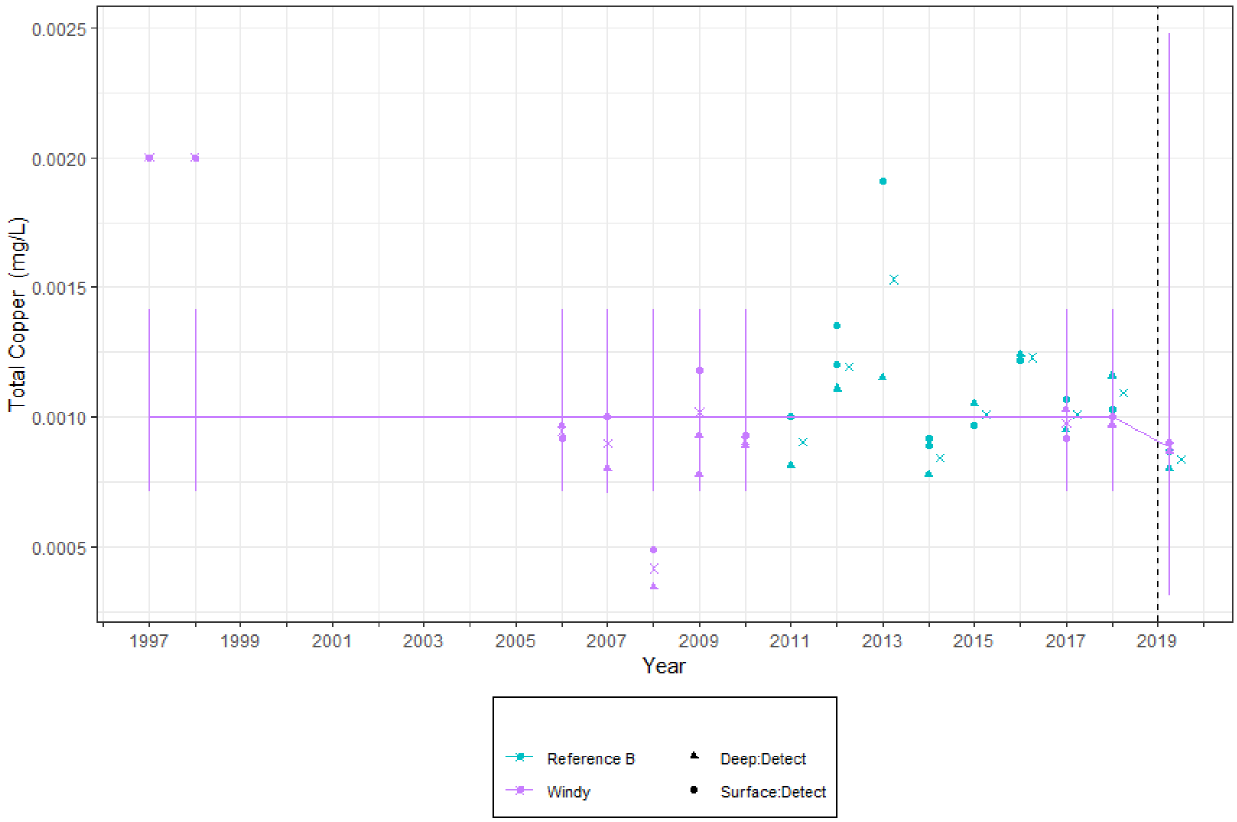
Conclusion:

The change in total copper concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.7951) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.2056	0.2536	9.001	0.8108	0.4384	not sig.

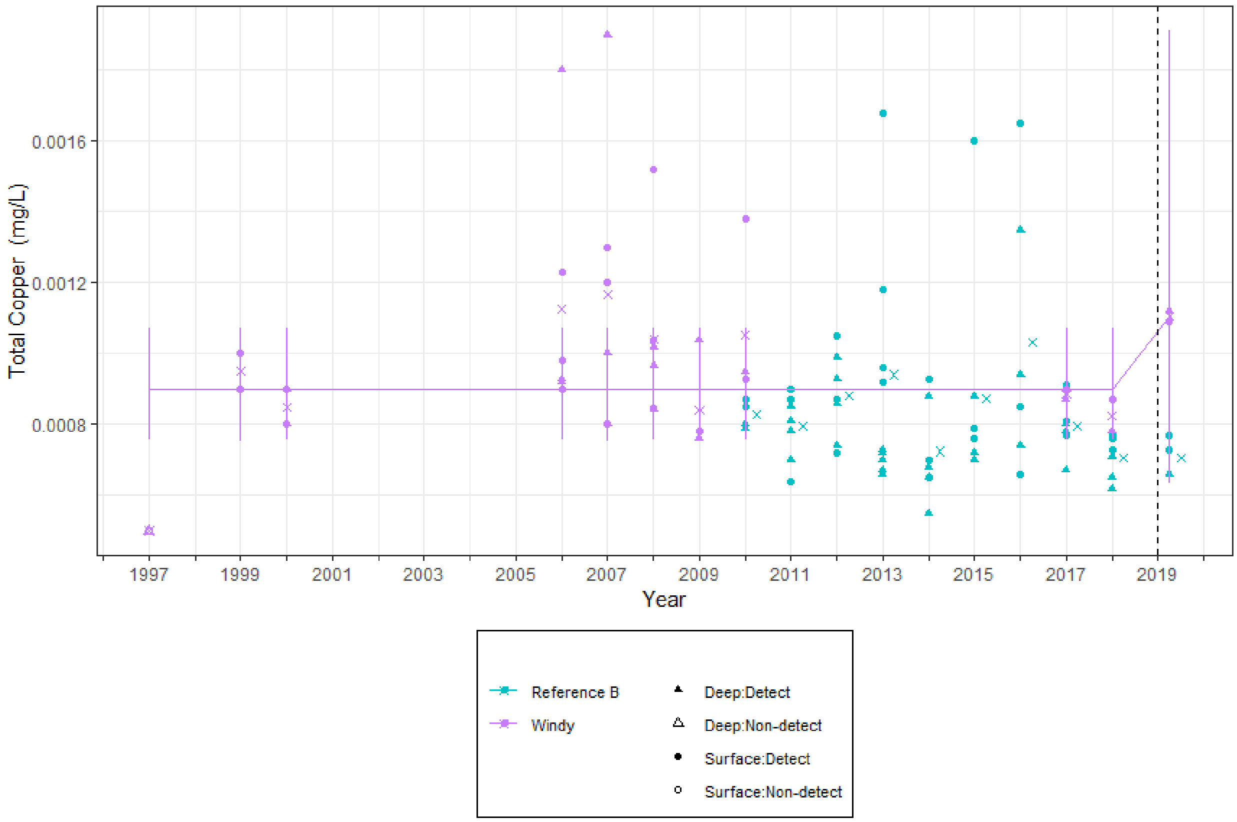
Conclusion:

The change in total copper concentrations in Windy Lake from *before* to *after* was not significantly ($p = 0.4384$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

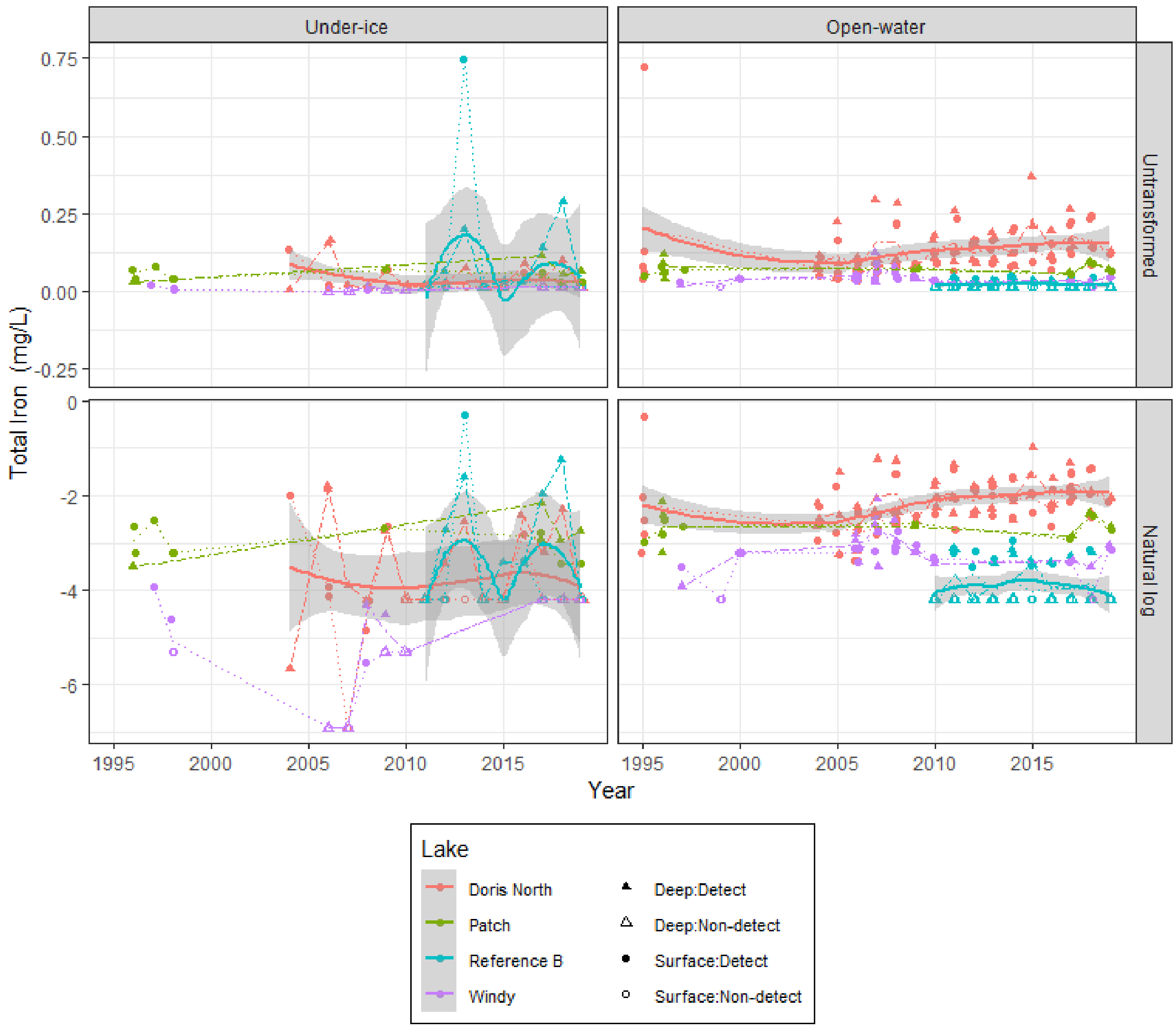
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.16 Total Iron

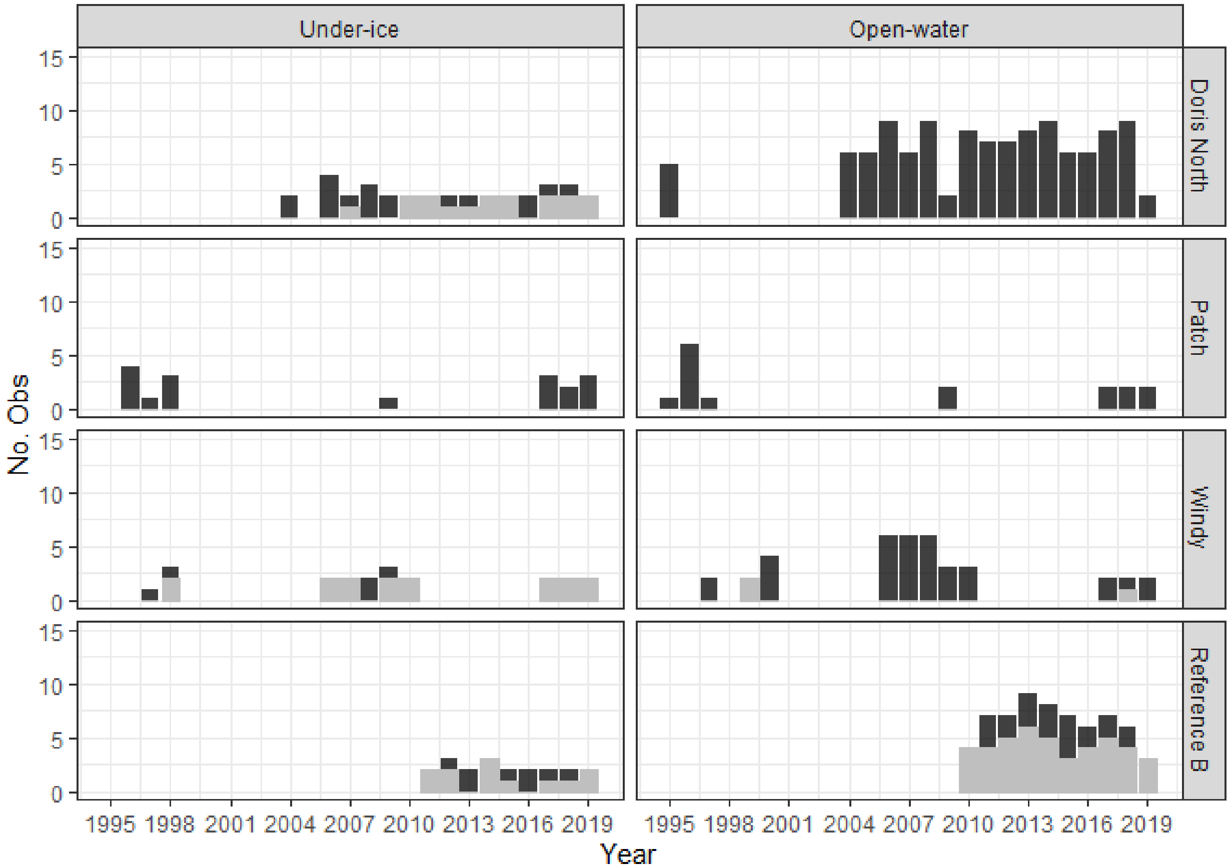
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

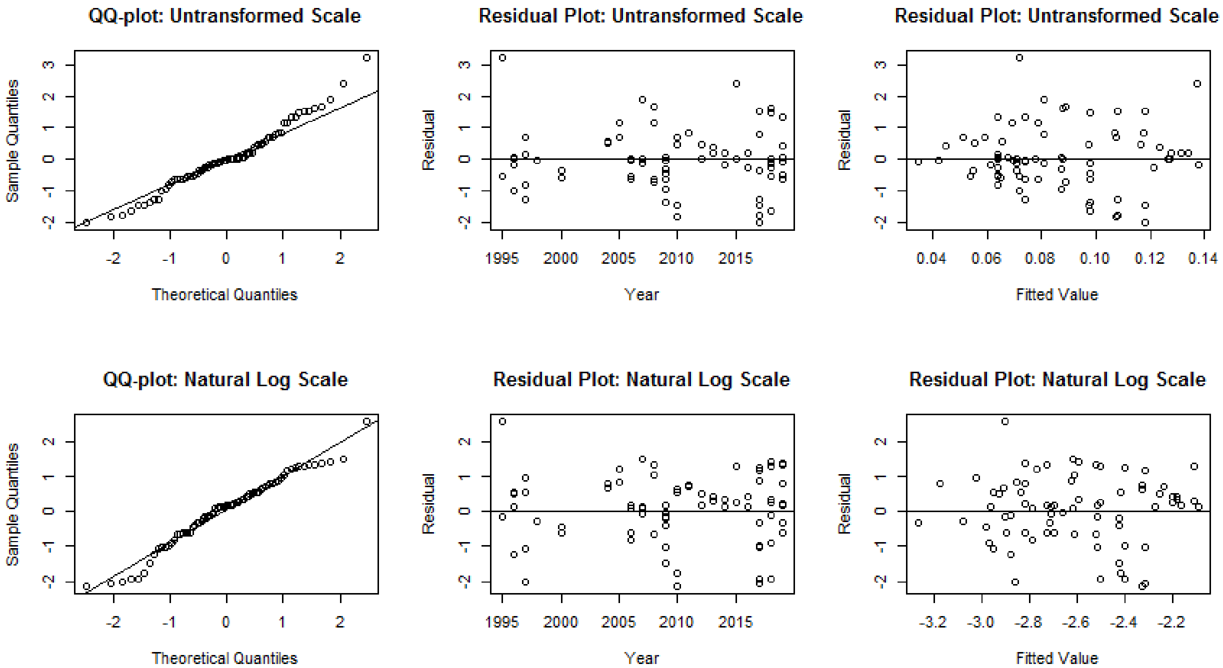
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	17	0.49	1	0.0300
Doris	Open-water	113	0	0.00	0	0.1140
Patch	Under-ice	17	0	0.00	0	0.0400
Patch	Open-water	16	0	0.00	0	0.0705
Reference B	Under-ice	20	12	0.60	1	0.0300
Reference B	Open-water	64	43	0.67	1	0.0300
Windy	Under-ice	21	16	0.76	1	0.0100
Windy	Open-water	38	3	0.08	0	0.0408

More than 50% of data under detection limit in Doris under-ice, Reference B under-ice, Reference B open-water, and Windy under-ice. Data from those site-season groupings will be removed from the analysis. Doris under-ice exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	1995	Open-water	Surface	0.206	0.072	3.23

Outliers on natural log scale: None

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

All data from Doris under-ice removed from the analysis. No analysis performed.

Open-water

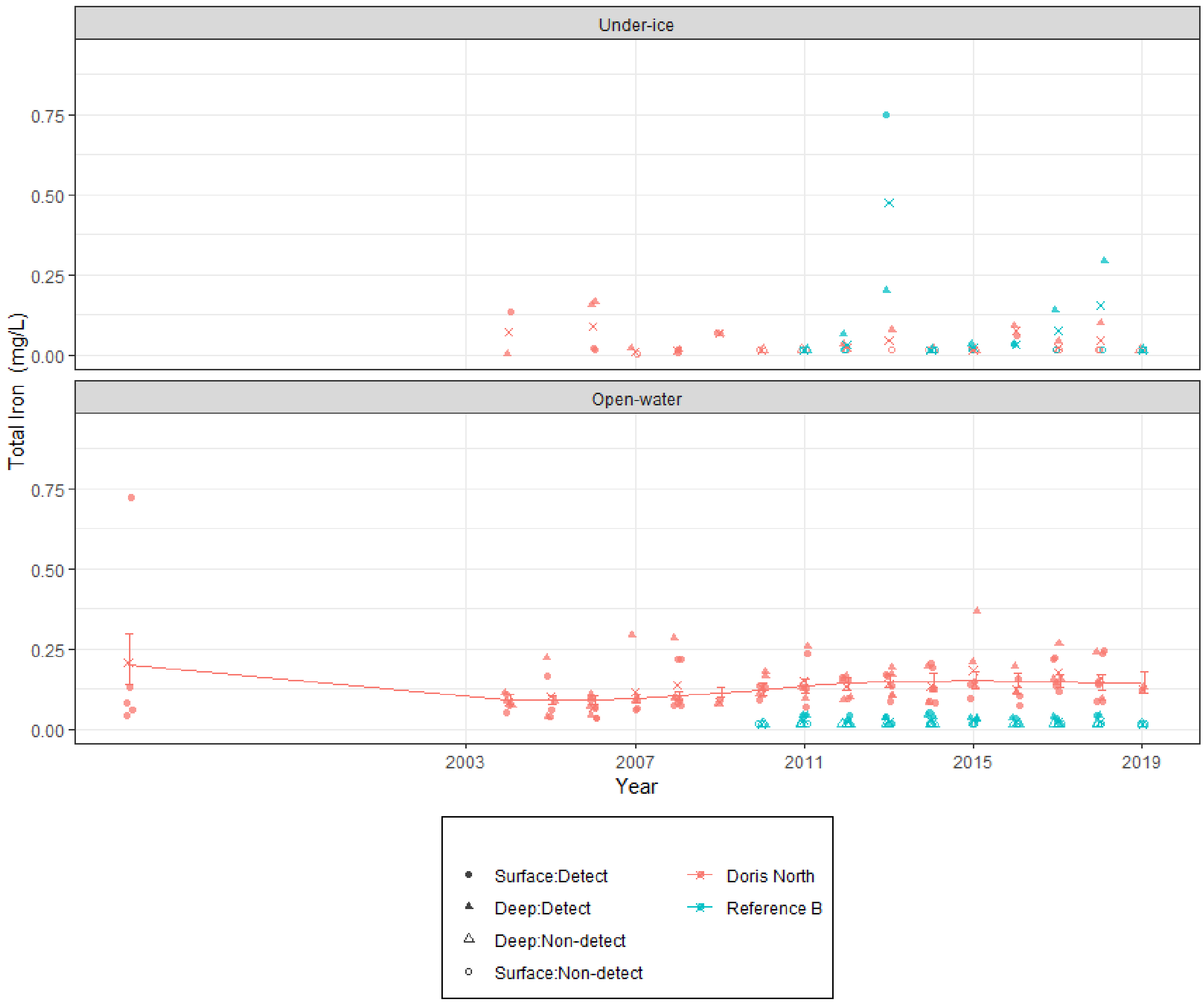
Analysis	Chi.sq	DF	P.value
Compare to slope 0	39.98	4	0.0000

Doris Lake appears to show significant deviation from no trend.

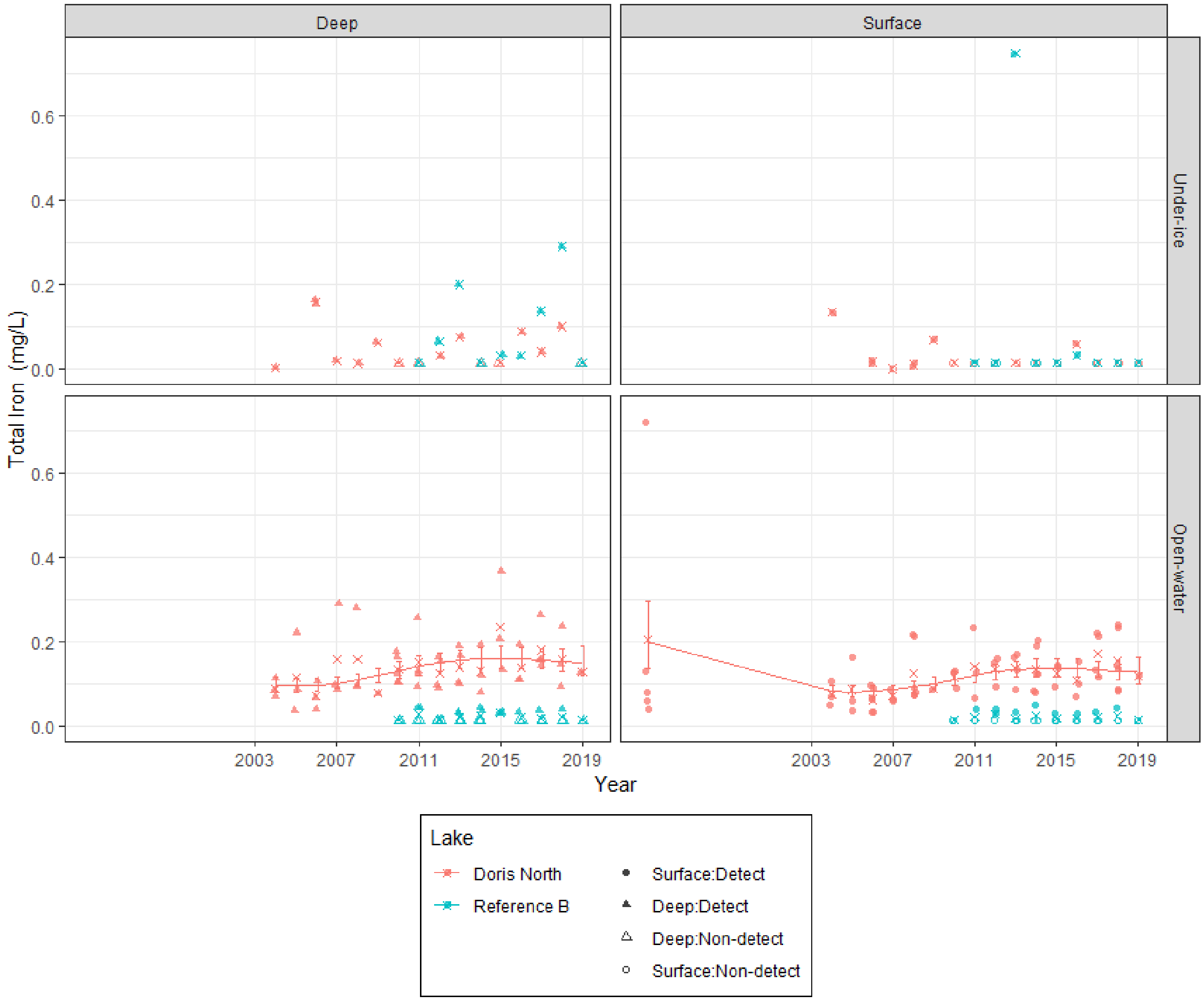
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.2312	0.3843	3.712	-0.6017	0.5822	not sig.

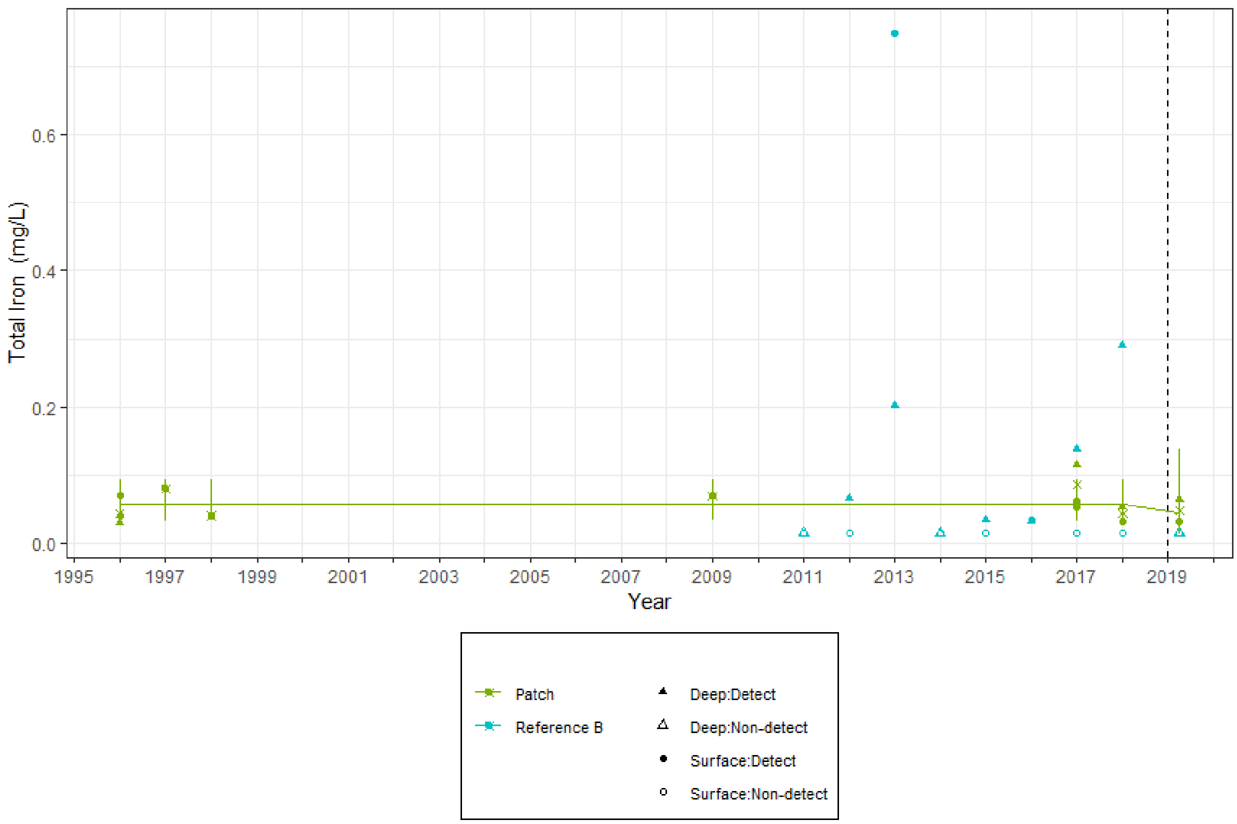
Conclusion:

The change in total iron concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.5822) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.0124	0.222	4.937	0.056	0.9575	not sig.

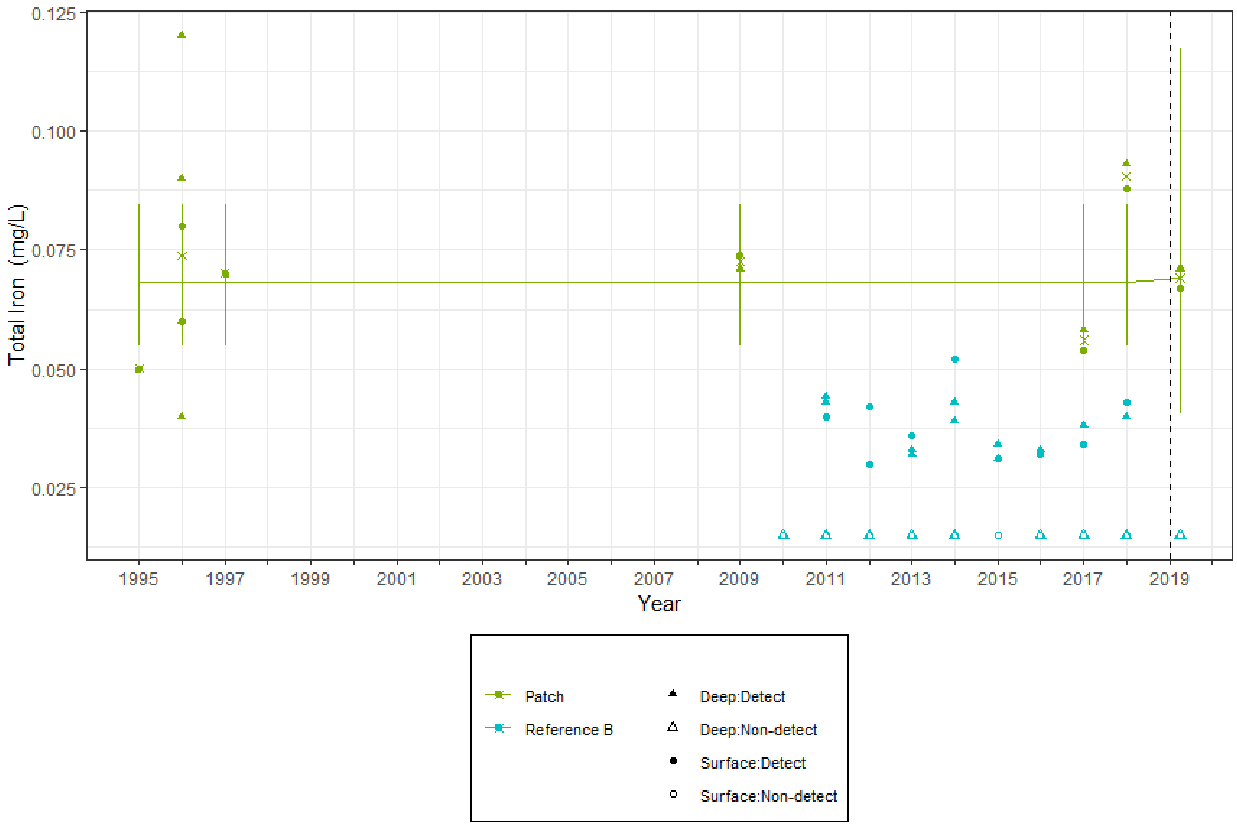
Conclusion:

The change in total iron concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.9575) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.253	0.4618	8.379	0.5477	0.5982	not sig.

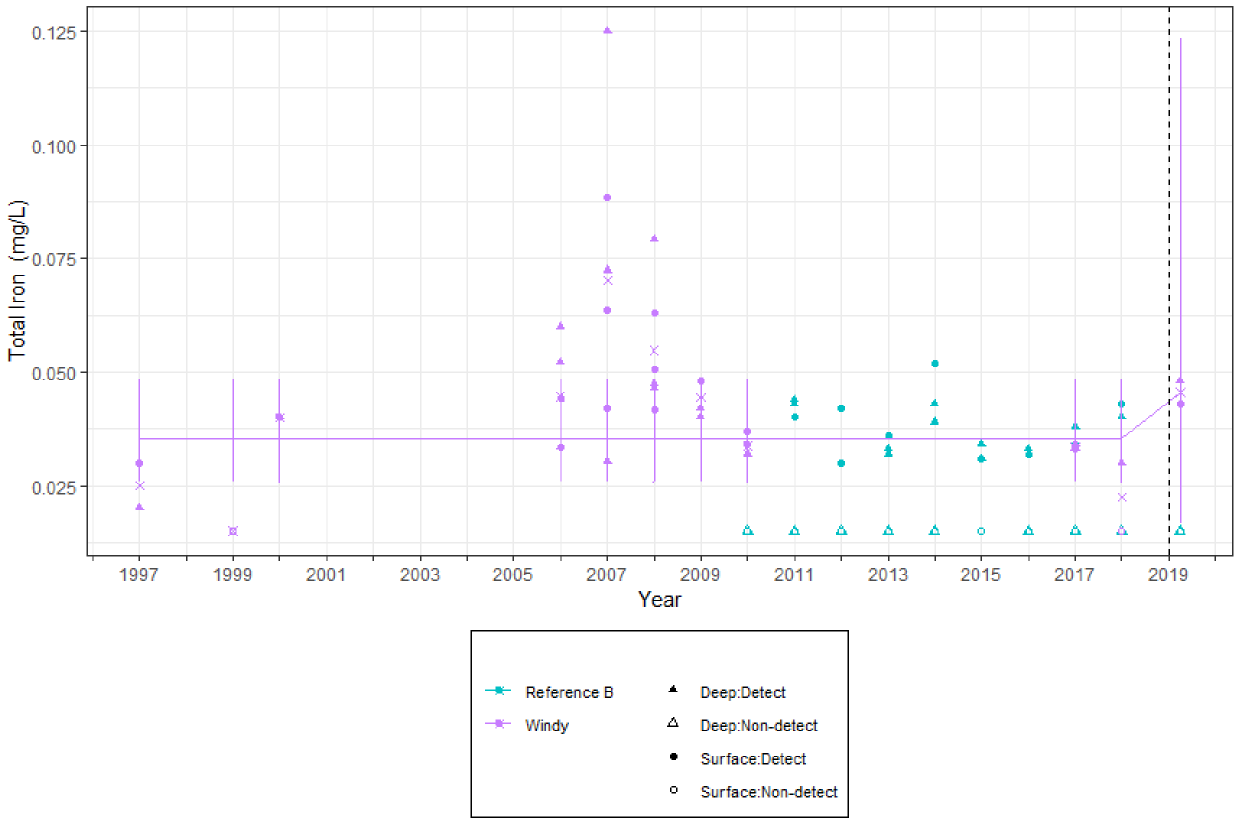
Conclusion:

The change in total iron concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.5982) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

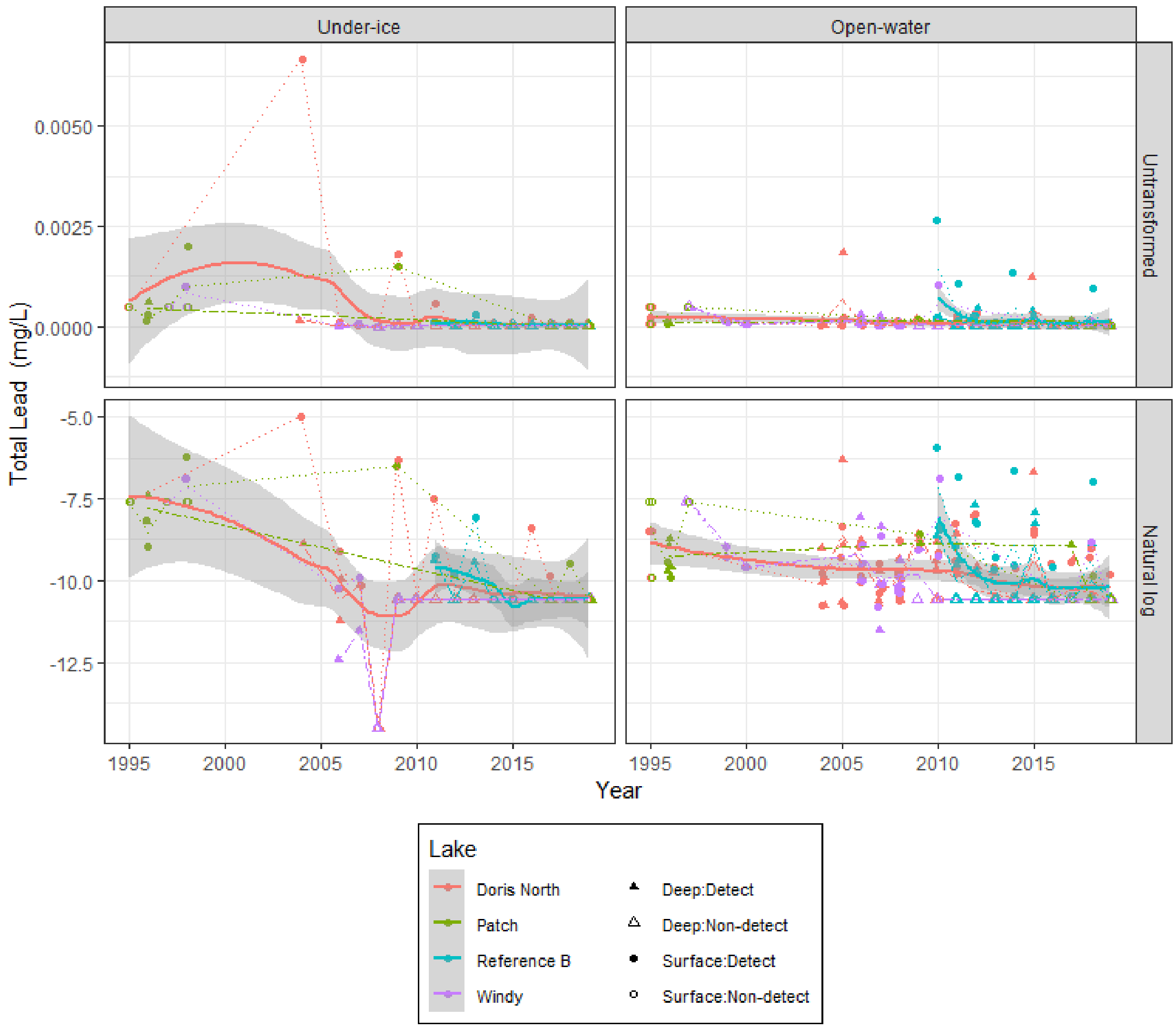
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.17 Total Lead

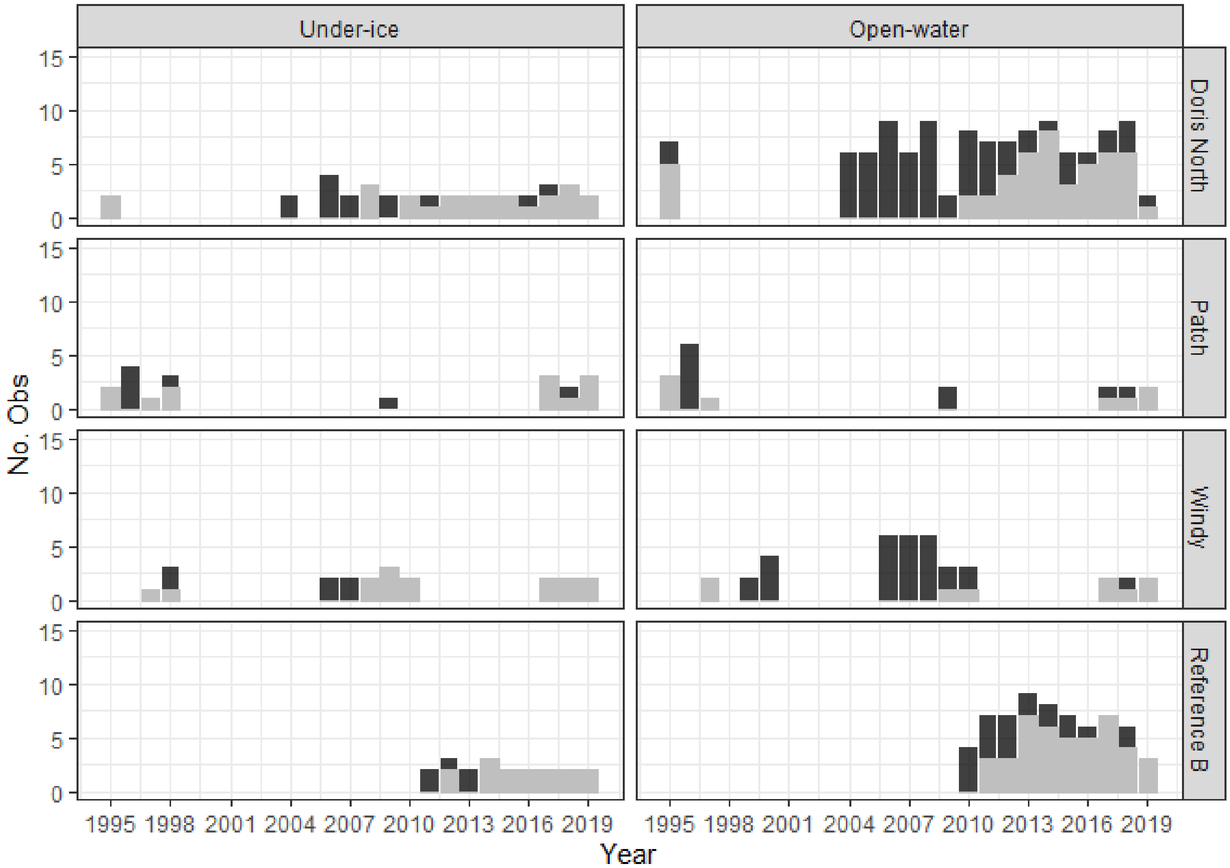
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

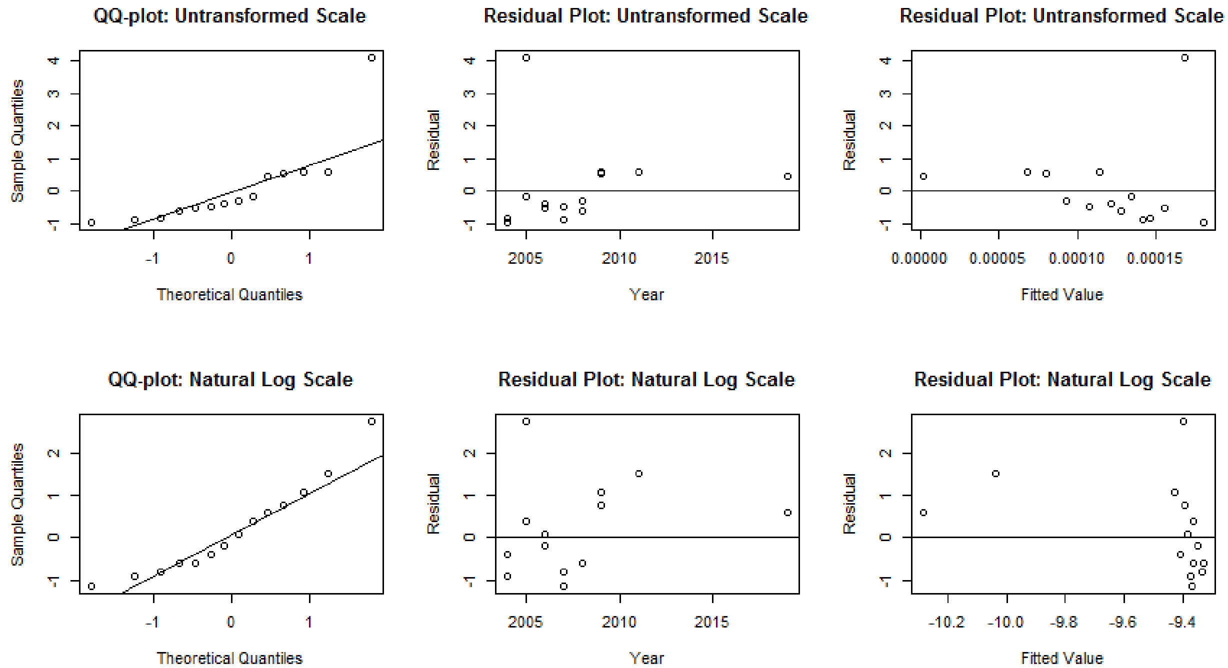
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	37	25	0.68	1.0	0.0000
Doris	Open-water	115	48	0.42	0.5	0.0000
Patch	Under-ice	19	12	0.63	1.0	0.0003
Patch	Open-water	18	8	0.44	1.0	0.0001
Reference B	Under-ice	20	15	0.75	1.0	0.0000
Reference B	Open-water	64	43	0.67	1.0	0.0000
Windy	Under-ice	21	15	0.71	1.0	0.0000
Windy	Open-water	38	9	0.24	1.0	0.0001

More than 50% of data under detection limit in Doris under-ice, Patch under-ice, Patch open-water, Reference B under-ice, Reference B open-water, Windy under-ice, and Windy open-water. Data from those site-season groupings will be removed from the analysis. Doris open-water, Patch open-water, and Windy open-water exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2005	Open-water	Deep	0.0007	0	4.091

Outliers on natural log scale: None

The natural log-transformed data better meets the residual assumptions. Analysis proceeds with natural log-transformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

All data from Doris under-ice removed from the analysis. No analysis performed.

Open-water

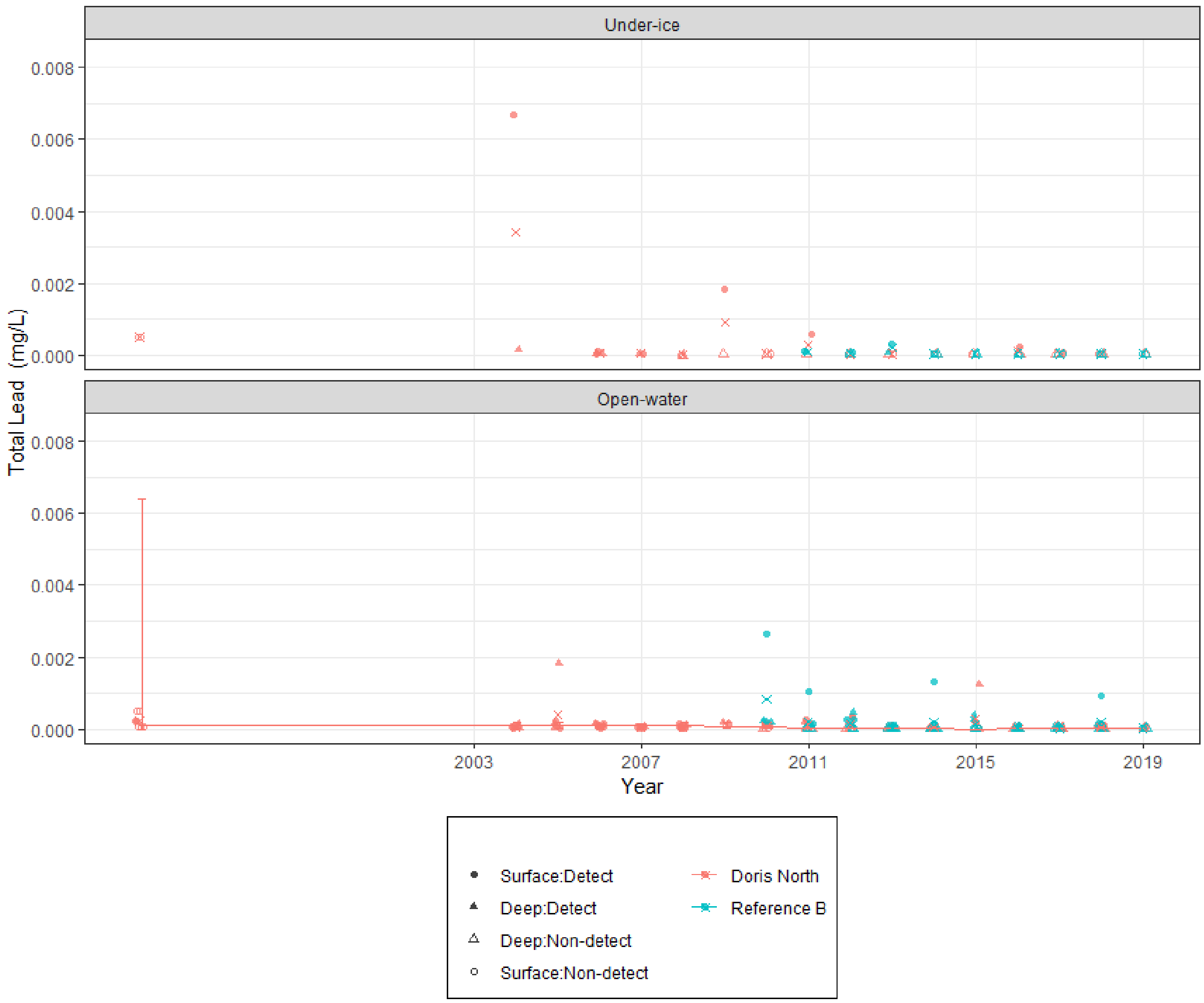
Analysis	Chi.sq	DF	P.value
Compare to slope 0	5.683	4	0.2241

Doris Lake does not exhibit significant deviation from no trend.

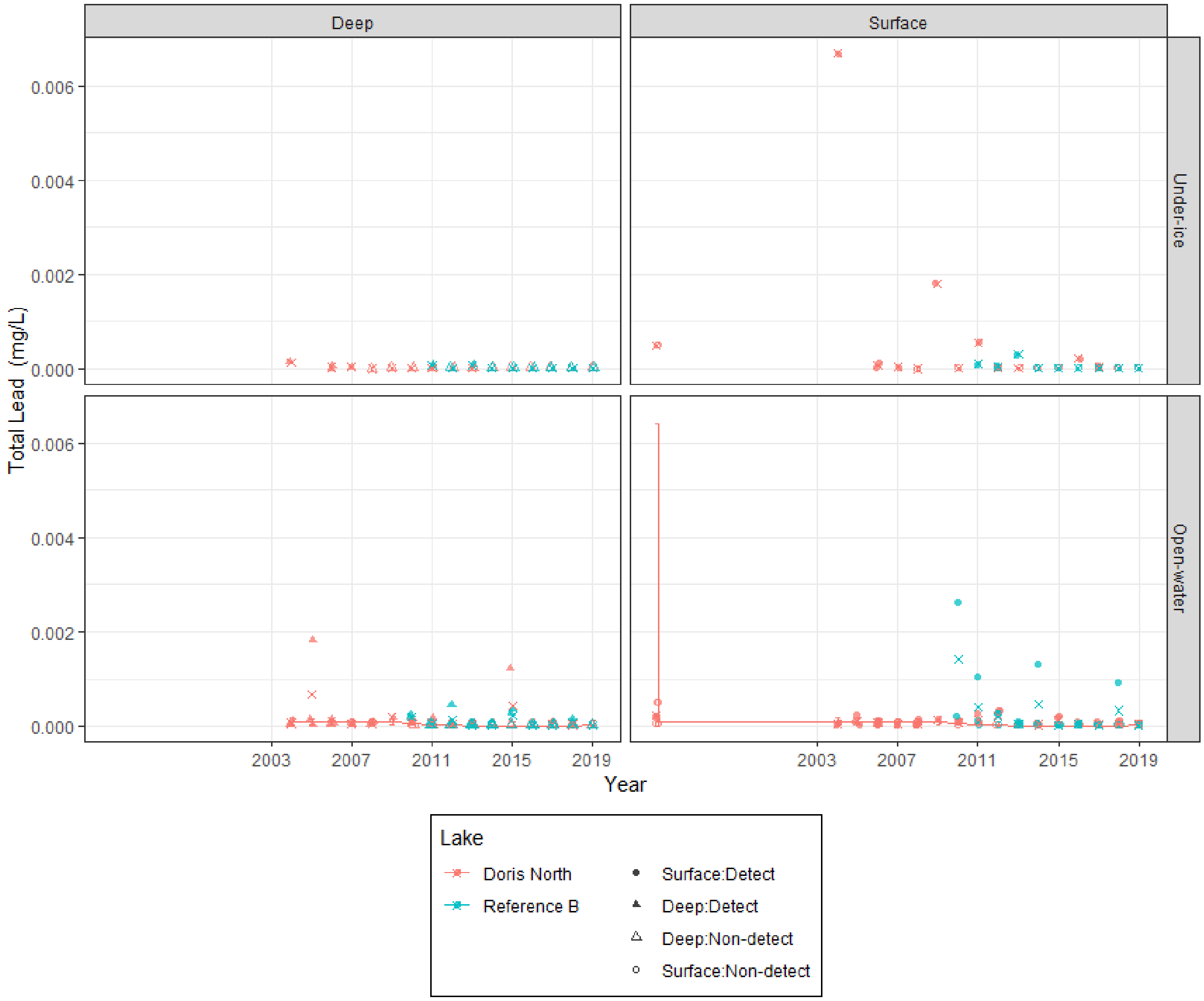
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

Open-water Before-vs-After Analysis

Analysis not performed.

Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

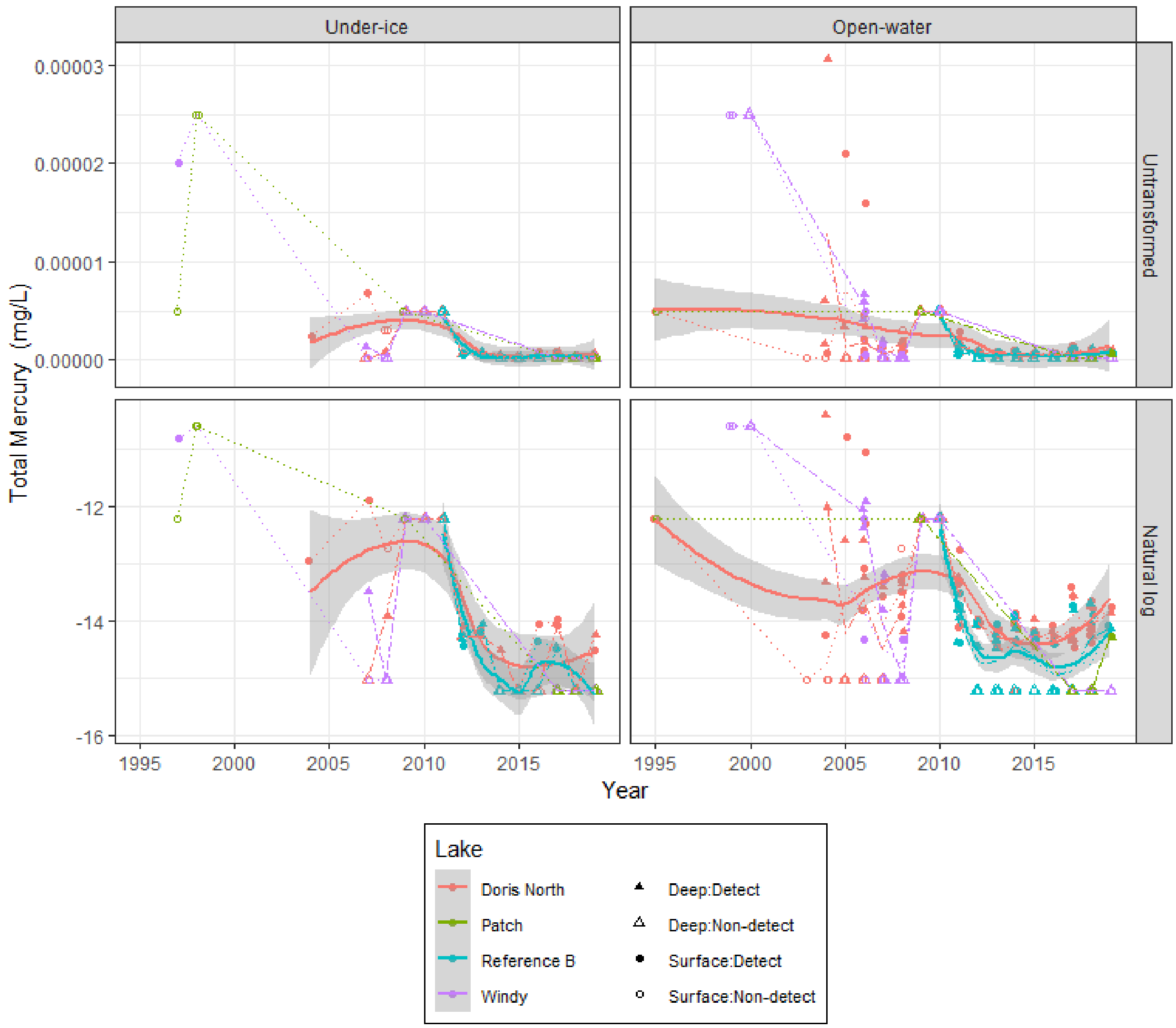
Open-water Before-vs-After Analysis

Analysis not performed.

C.3.2.18 Total Mercury

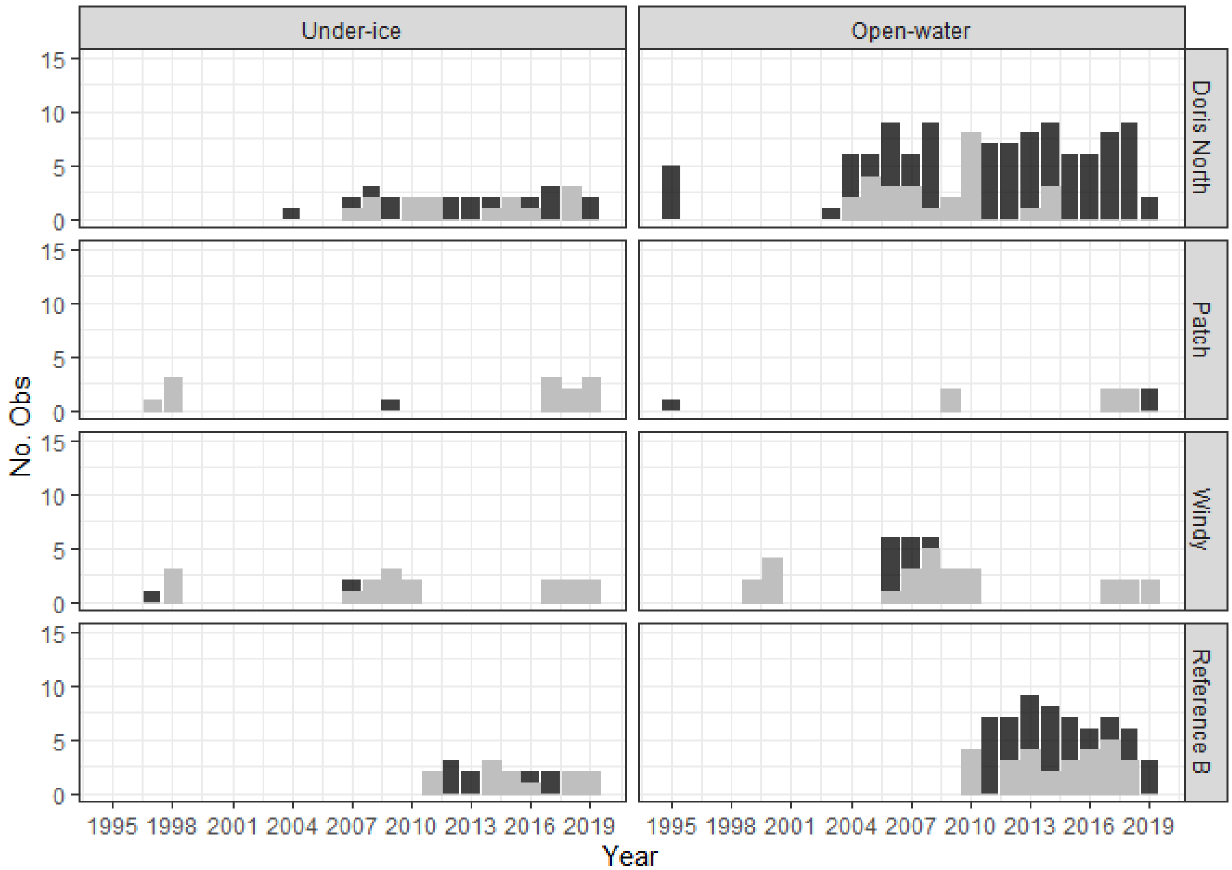
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

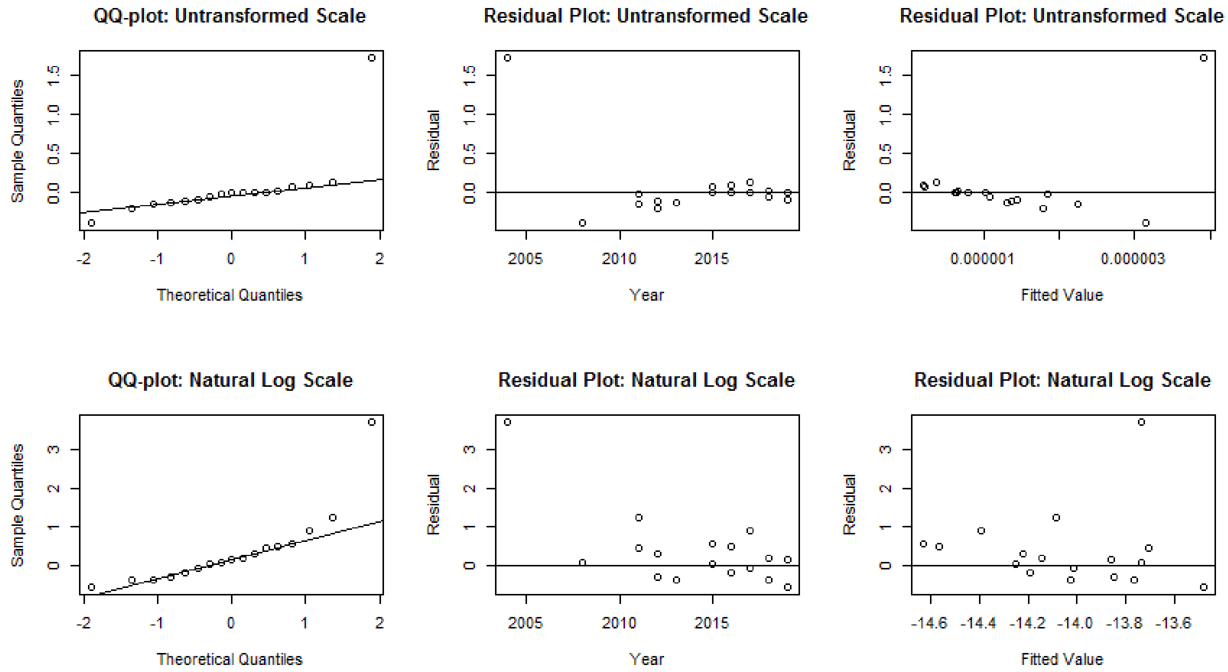
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	30	16	0.53	0	0
Doris	Open-water	114	33	0.29	0	0
Patch	Under-ice	13	13	1.00	1	0
Patch	Open-water	9	7	0.78	0	0
Reference B	Under-ice	20	12	0.60	1	0
Reference B	Open-water	64	28	0.44	0	0
Windy	Under-ice	19	17	0.89	1	0
Windy	Open-water	36	27	0.75	1	0

More than 50% of data under detection limit in Doris under-ice, Patch under-ice, Patch open-water, Reference B under-ice, Windy under-ice, Windy open-water, and Reference B open-water. Data from those site-season groupings will be removed from the analysis. Doris open-water and Reference B open-water exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. Reference B exhibited close to 50% under detection limit in the open-water season. Inclusion of Reference B lead to unstable results, hence Reference B was removed from the analysis. The analysis proceeds with tobit regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2004	Open-water	Deep	0	-13.73	3.701

There was an outlier retained in the analysis. Results should be interpreted with caution and along with graphical results. The untransformed data better meets the residual assumptions. Analysis proceeds with untransformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

All data from Doris under-ice removed from the analysis. No analysis performed.

Open-water

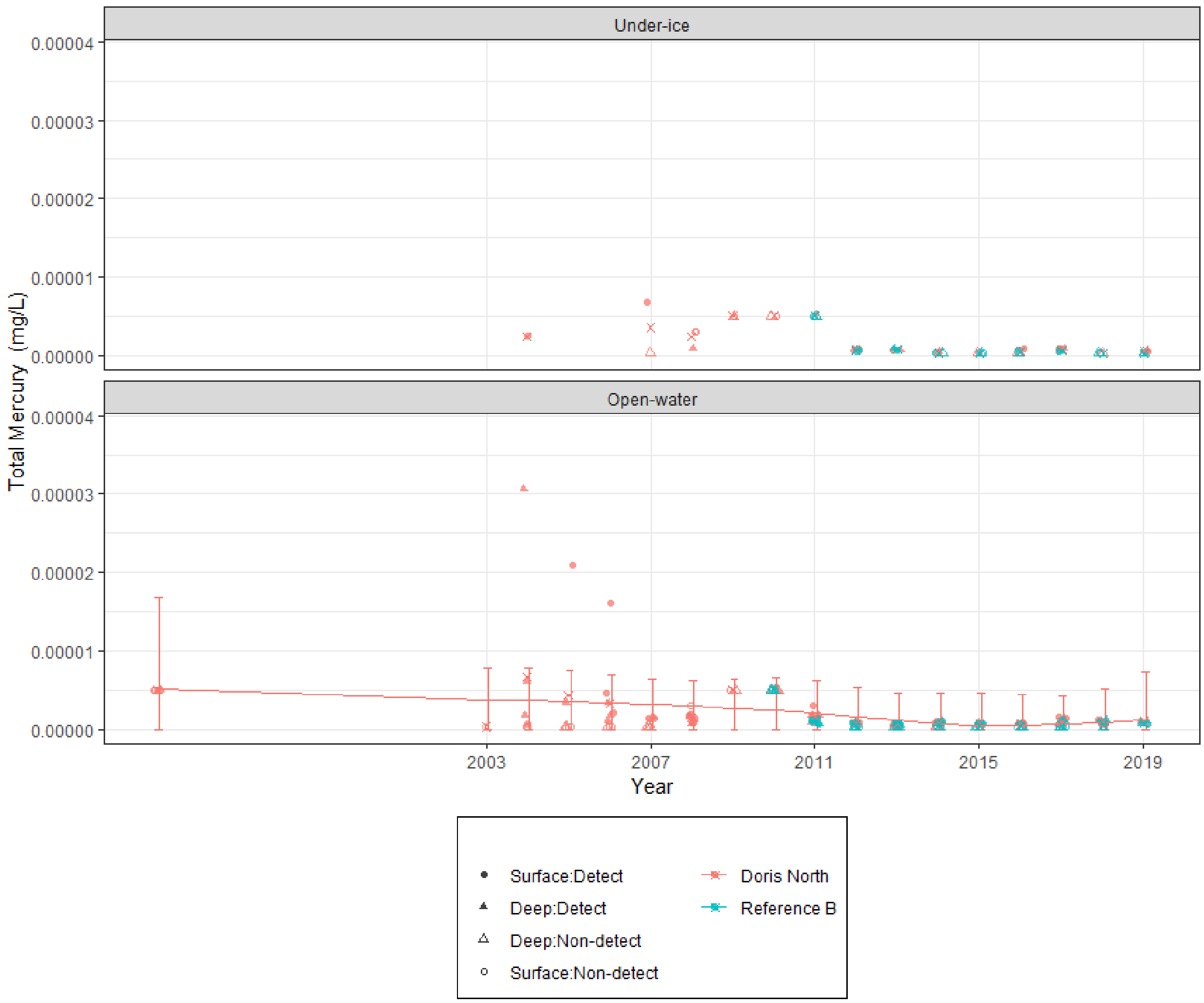
Analysis	Chi.sq	DF	P.value
Compare to slope 0	2.006	4	0.7347

Doris Lake does not exhibit significant deviation from no trend.

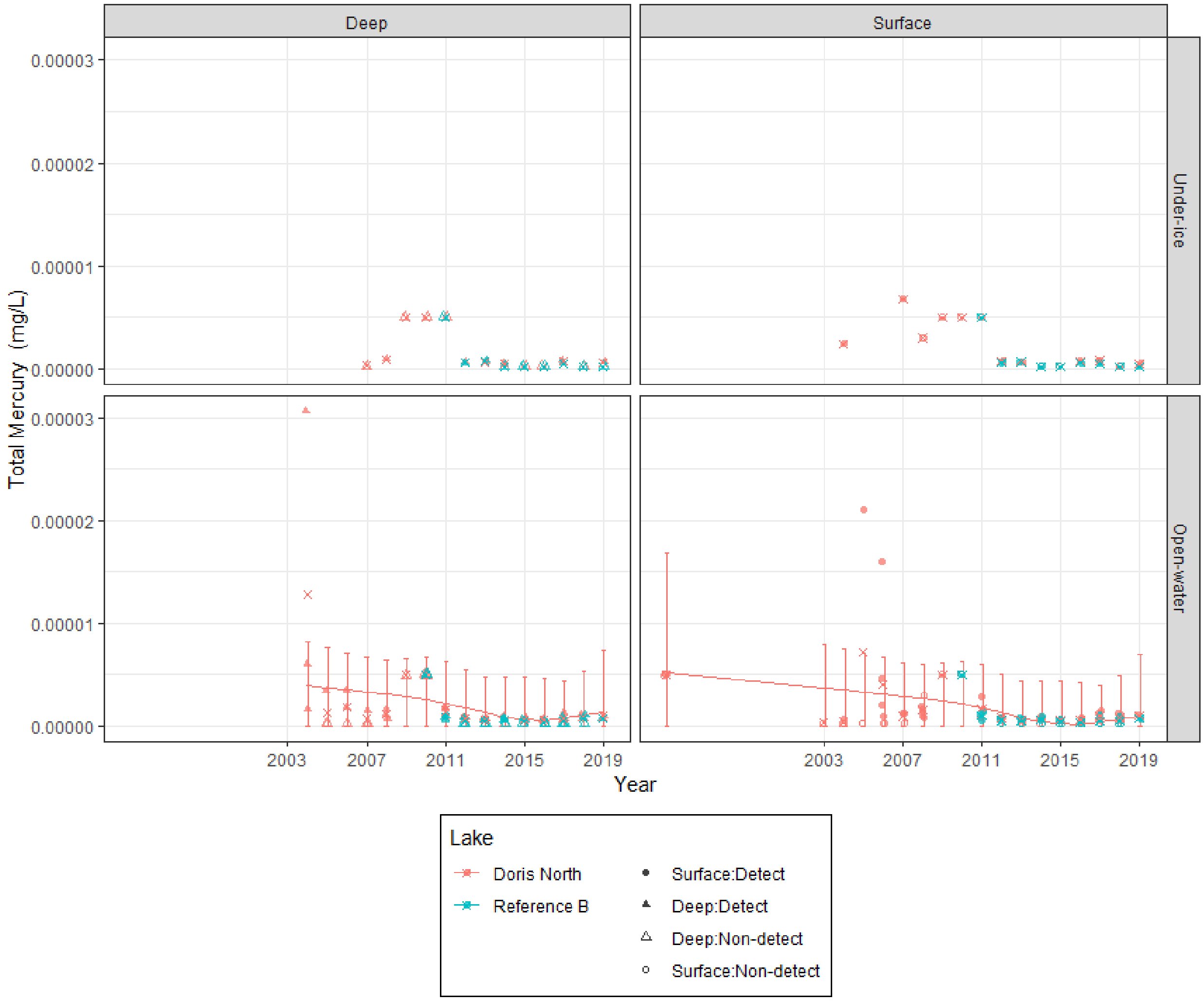
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

Open-water Before-vs-After Analysis

Analysis not performed.

Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

Open-water Before-vs-After Analysis

Analysis not performed.

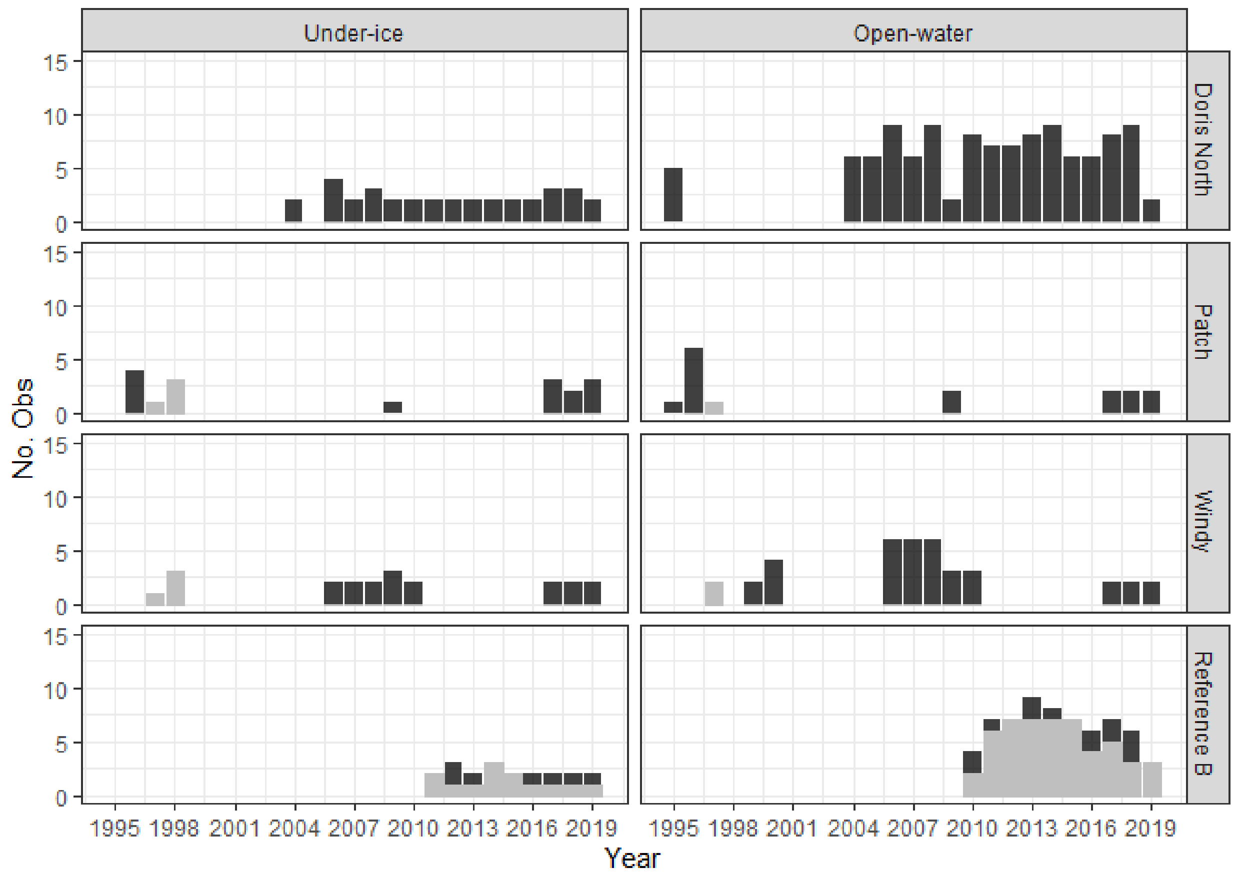
C.3.2.19 Total Molybdenum

Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.

Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

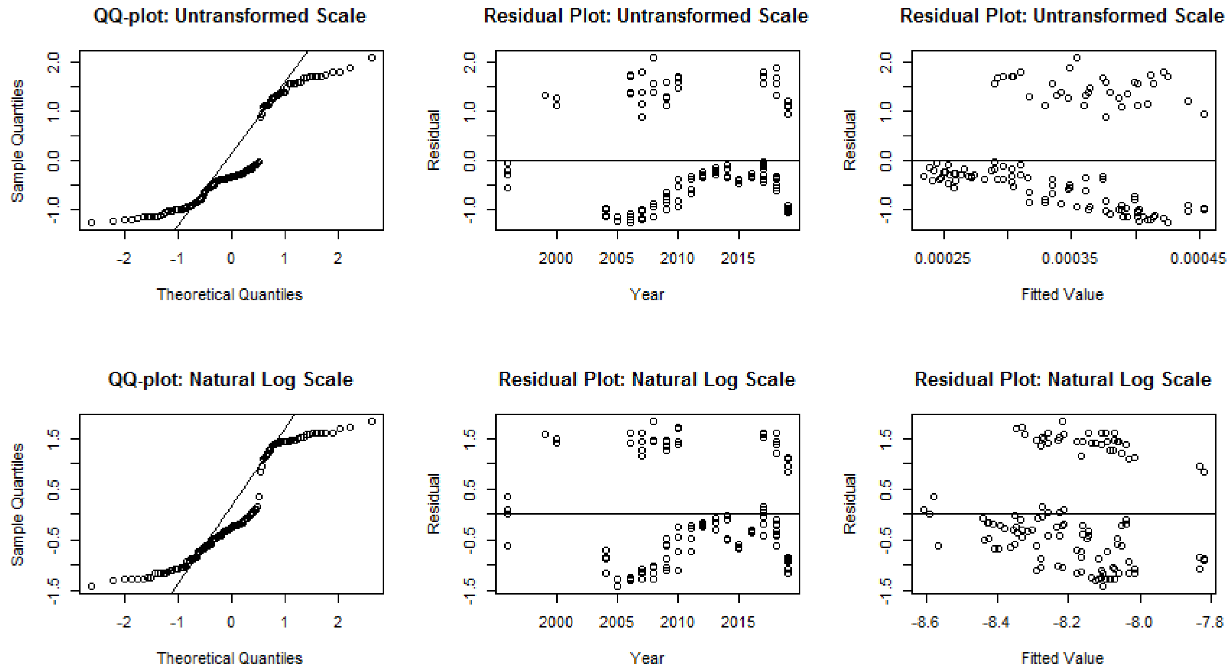
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	0	0.00	0.0	0.0002
Doris	Open-water	113	5	0.04	0.0	0.0002
Patch	Under-ice	17	4	0.24	0.0	0.0003
Patch	Open-water	16	2	0.12	0.0	0.0002
Reference B	Under-ice	20	13	0.65	0.5	0.0000
Reference B	Open-water	64	51	0.80	1.0	0.0000
Windy	Under-ice	21	4	0.19	0.0	0.0007
Windy	Open-water	38	2	0.05	0.0	0.0006

More than 50% of data under detection limit in Reference B under-ice and Reference B open-water. Data from those site-season groupings will be removed from the analysis. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	34.98	4	0.0000

Doris Lake appears to show significant deviation from no trend.

Open-water

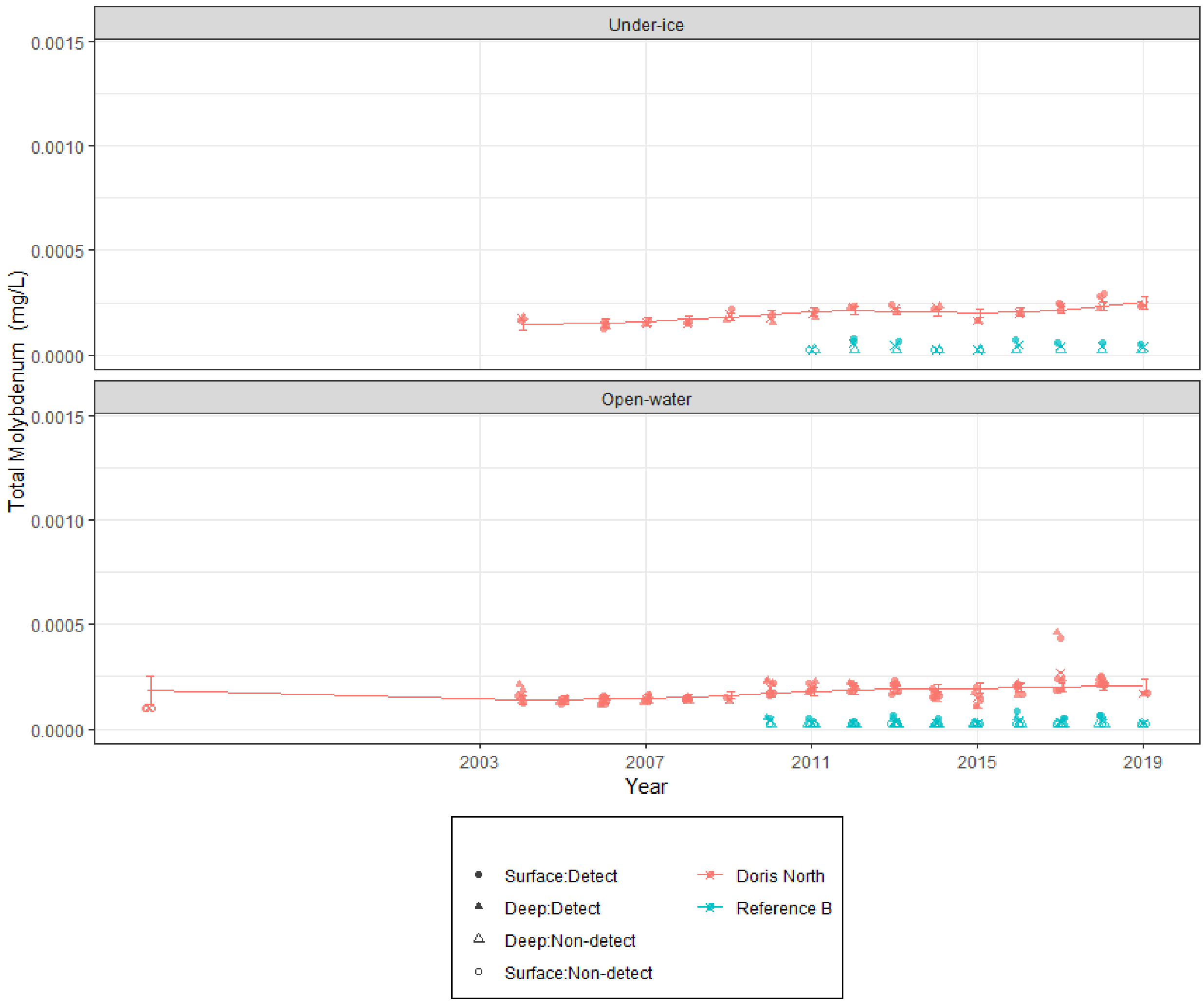
Analysis	Chi.sq	DF	P.value
Compare to slope 0	26.79	4	0.0000

Doris Lake appears to show significant deviation from no trend.

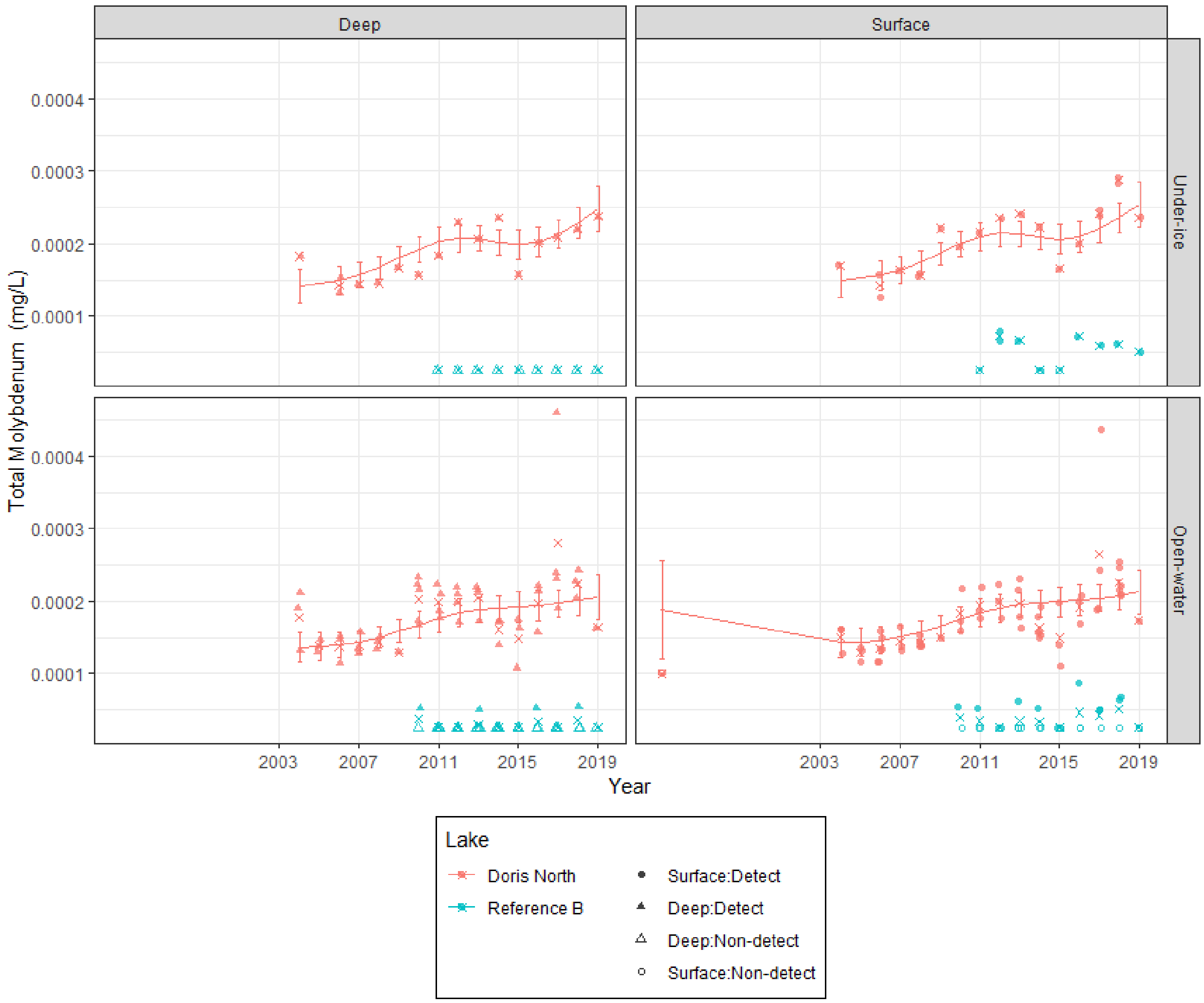
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-1e-04	1e-04	173	-0.7589	0.4489	not sig.

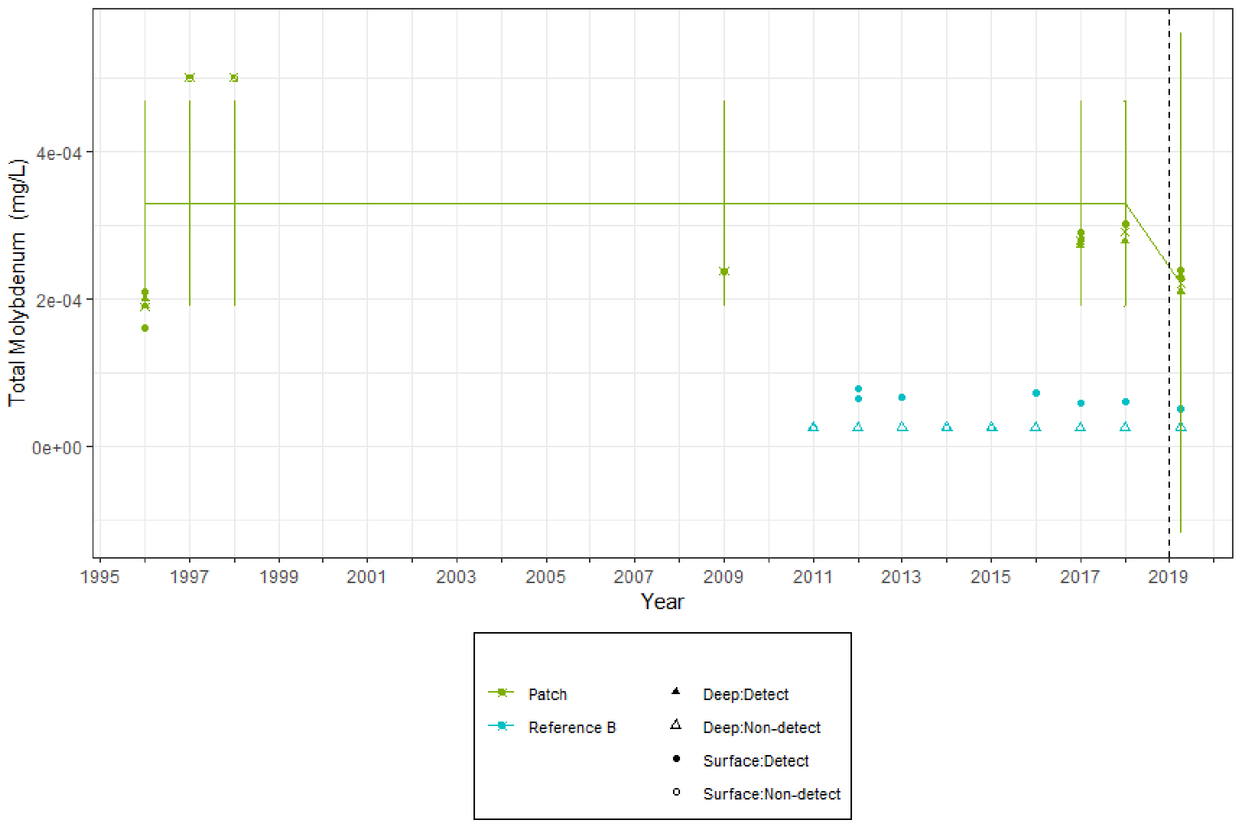
Conclusion:

The change in total molybdenum concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.4489) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-1e-04	2e-04	4.875	-0.418	0.6937	not sig.

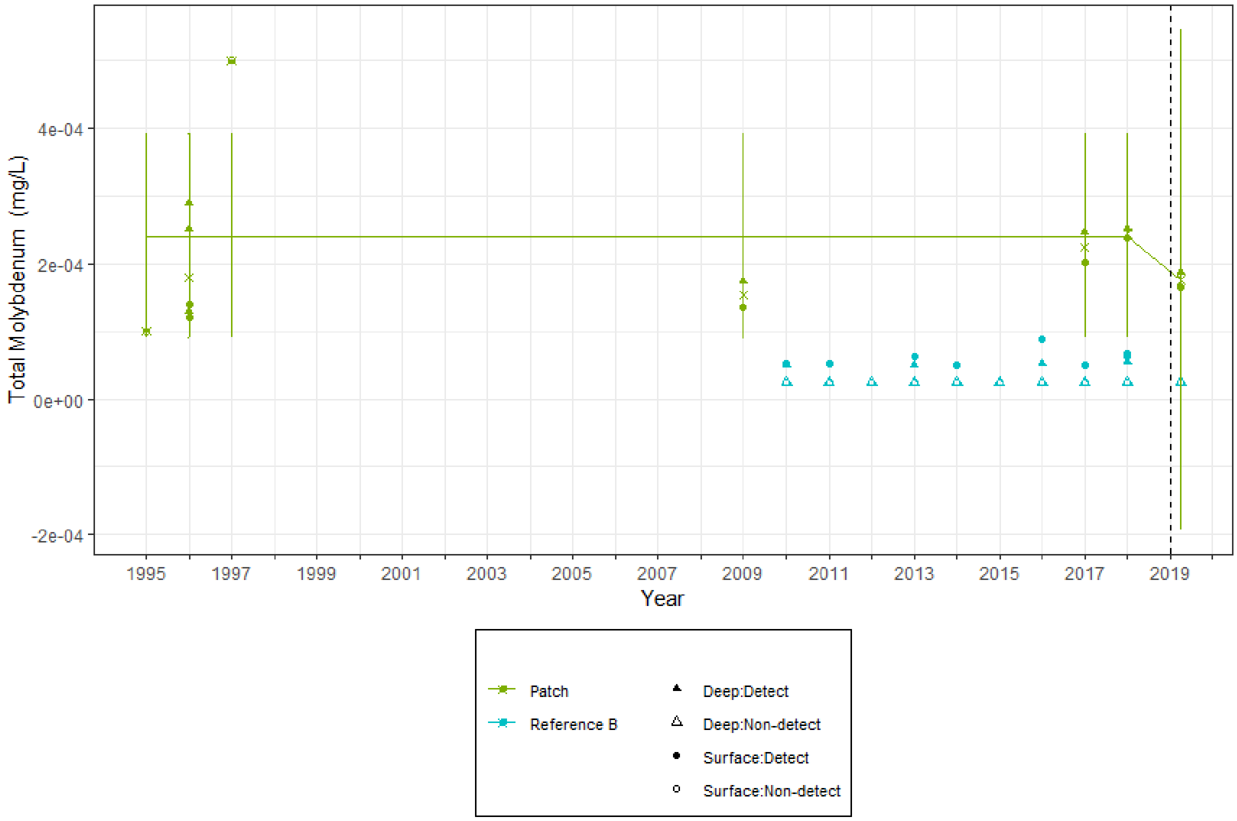
Conclusion:

The change in total molybdenum concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.6937) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0	1e-04	6.823	0.0533	0.959	not sig.

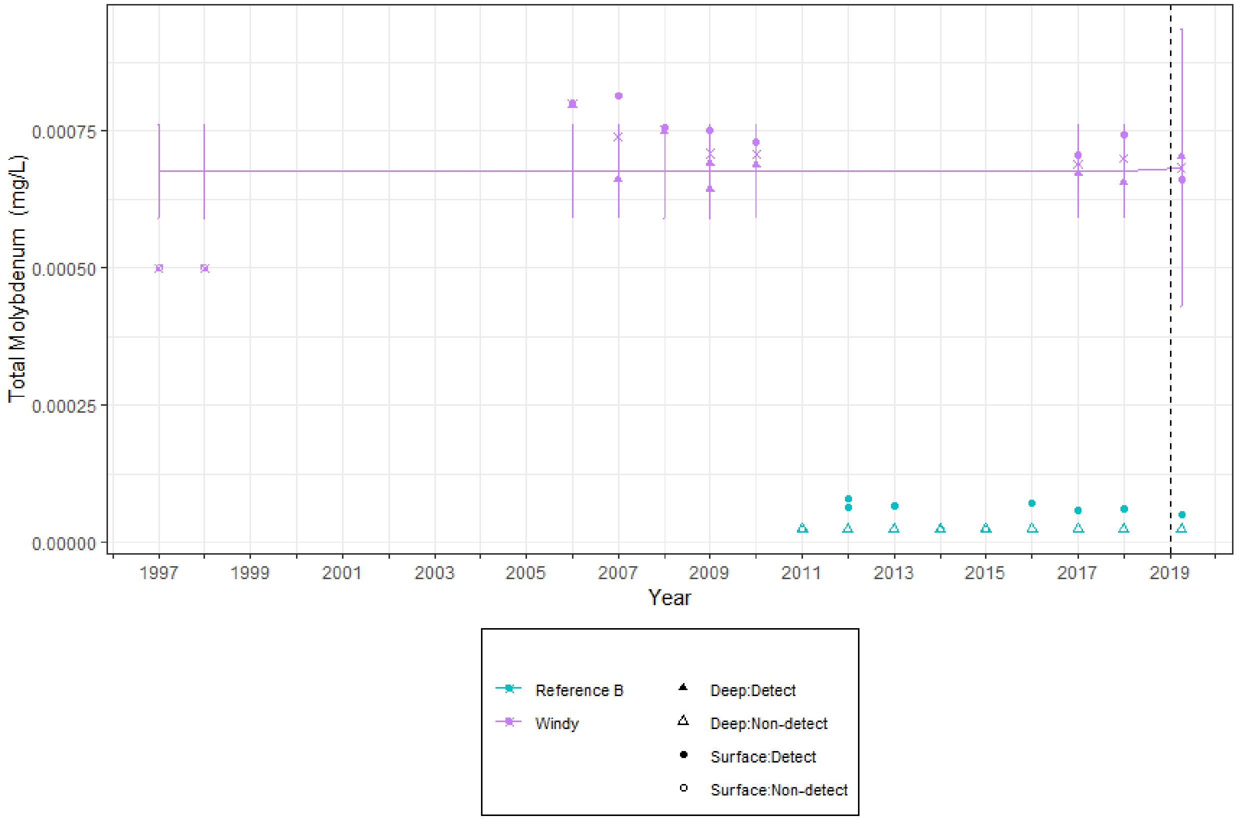
Conclusion:

The change in total molybdenum concentrations in Windy Lake from *before* to *after* was not significantly ($p = 0.959$) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0	1e-04	8.96	-0.0539	0.9582	not sig.

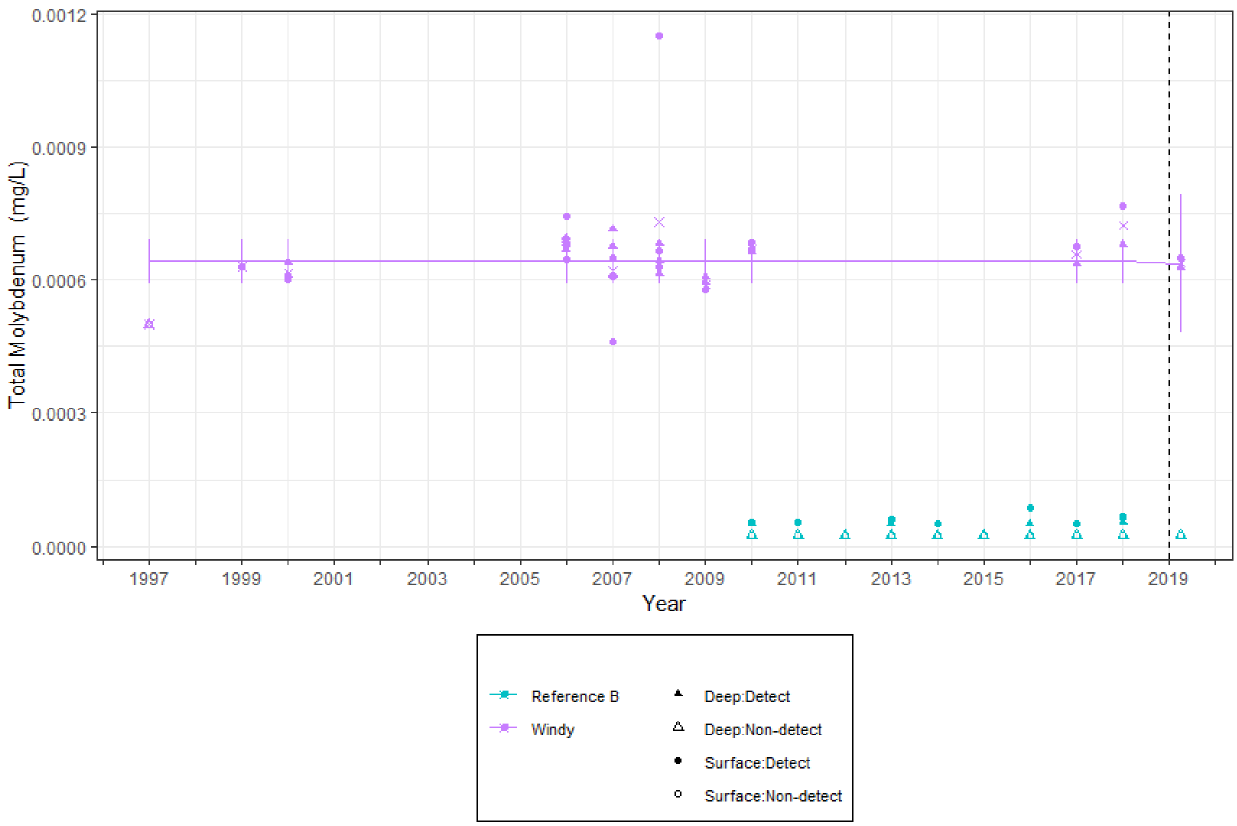
Conclusion:

The change in total molybdenum concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.9582) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

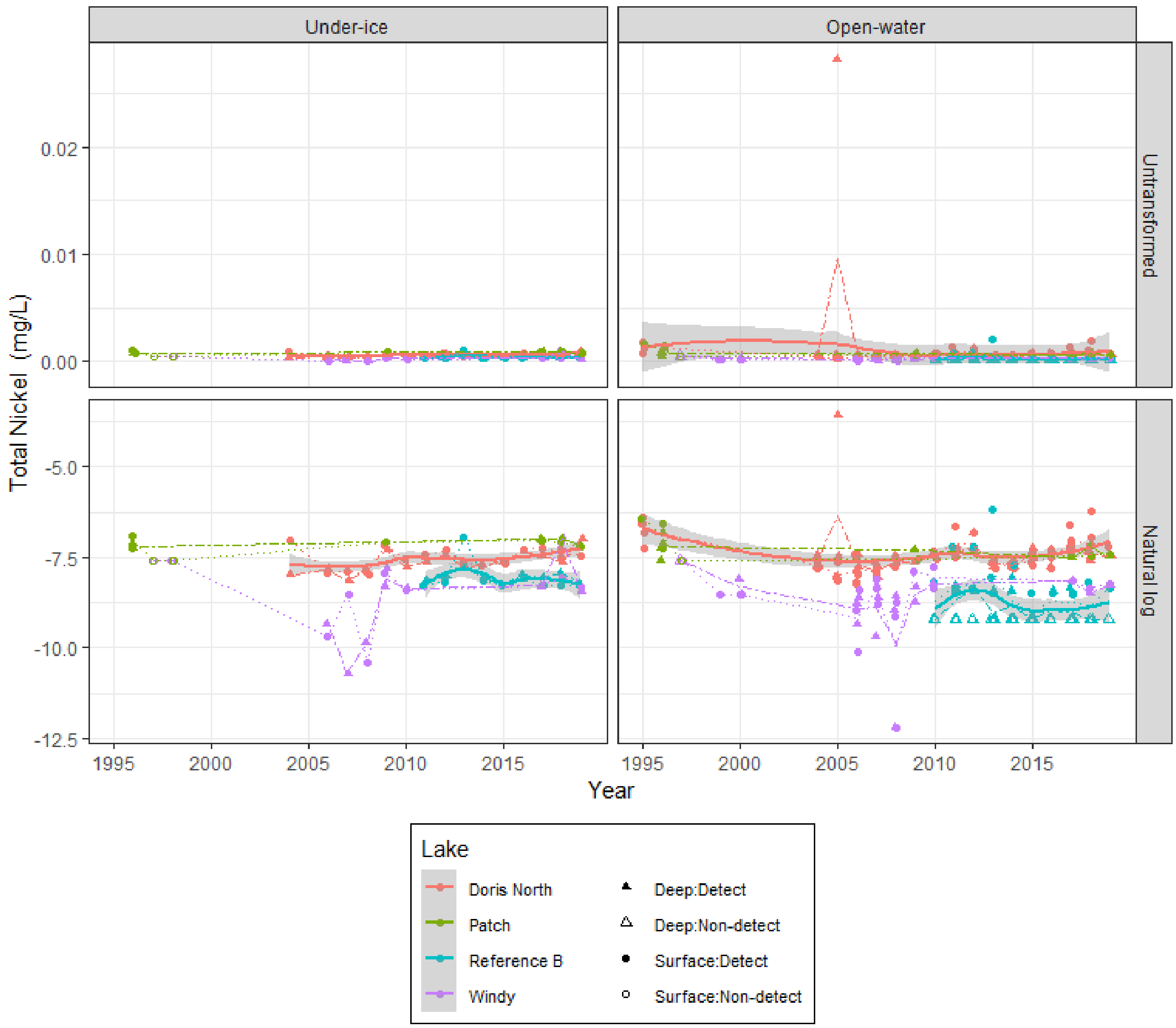
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.20 Total Nickel

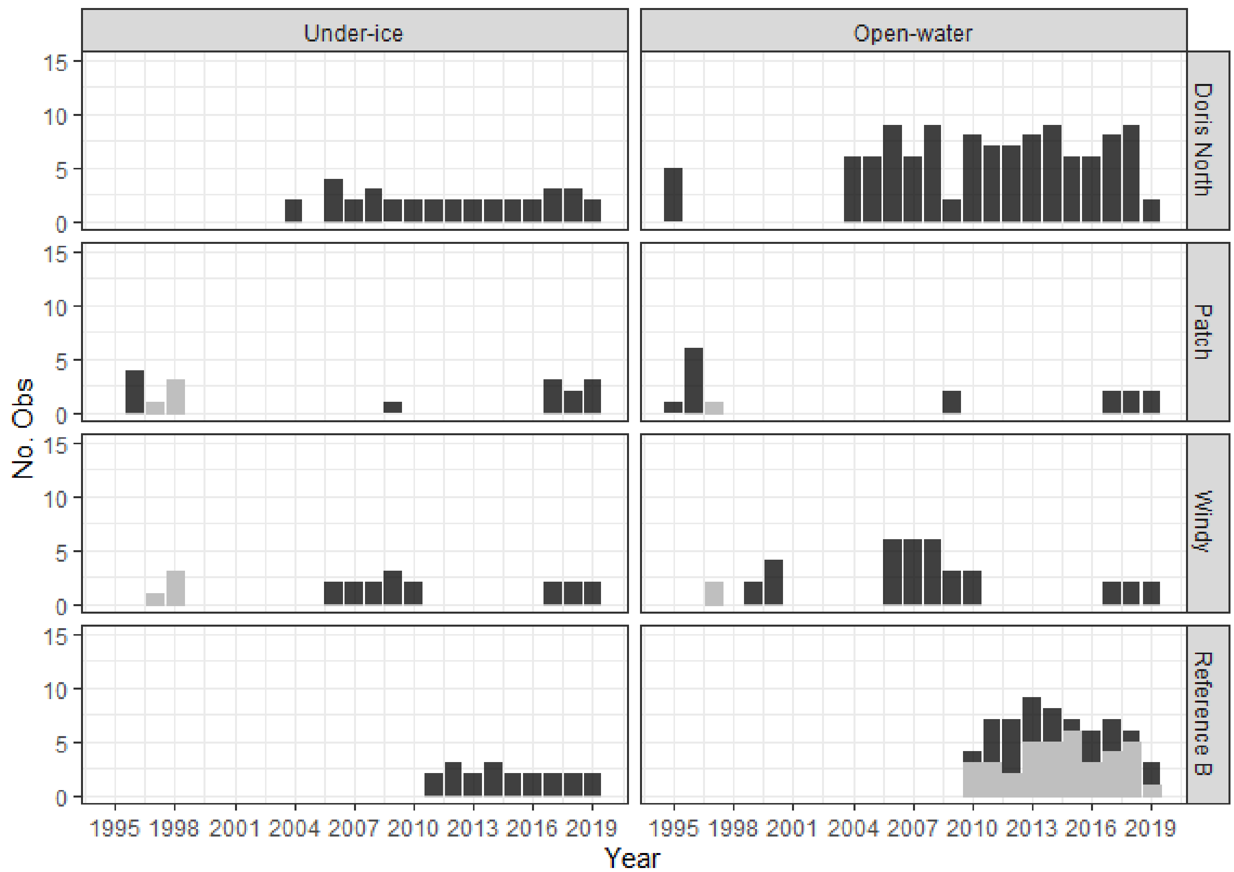
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

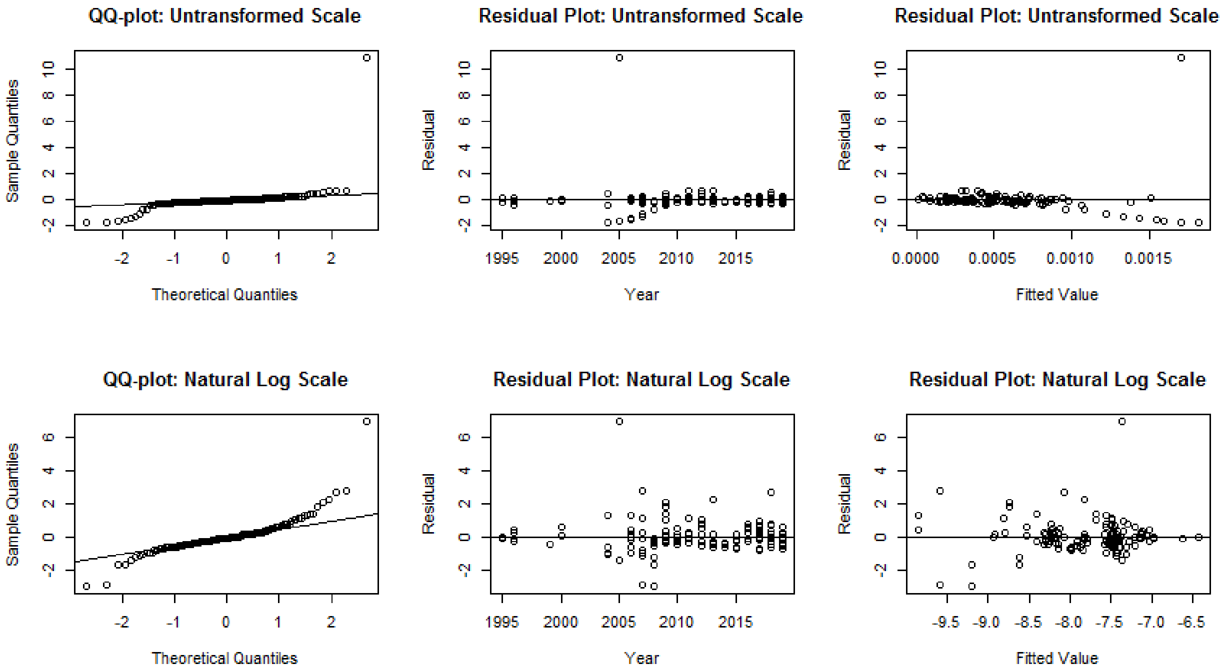
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	0	0.00	0.00	0.0005
Doris	Open-water	113	0	0.00	0.00	0.0006
Patch	Under-ice	17	4	0.24	0.00	0.0009
Patch	Open-water	16	1	0.06	0.00	0.0007
Reference B	Under-ice	20	0	0.00	0.00	0.0003
Reference B	Open-water	64	37	0.58	0.33	0.0002
Windy	Under-ice	21	4	0.19	0.00	0.0002
Windy	Open-water	38	2	0.05	0.00	0.0002

More than 50% of data under detection limit in Reference B open-water. Data from those site-season groupings will be removed from the analysis. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2005	Open-water	Deep	0.0097	0.002	10.92

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Doris	2005	Open-water	Deep	0.0097	-7.368	6.915
Windy	2008	Under-ice	Surface	0.0000	-9.201	-3.024

There was an outlier retained in the analysis. Results should be interpreted with caution and along with graphical results. The natural log data better meets the residual assumptions. Analysis proceeds with natural log data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	3.604	4	0.4622

Doris Lake does not exhibit significant deviation from no trend.

Open-water

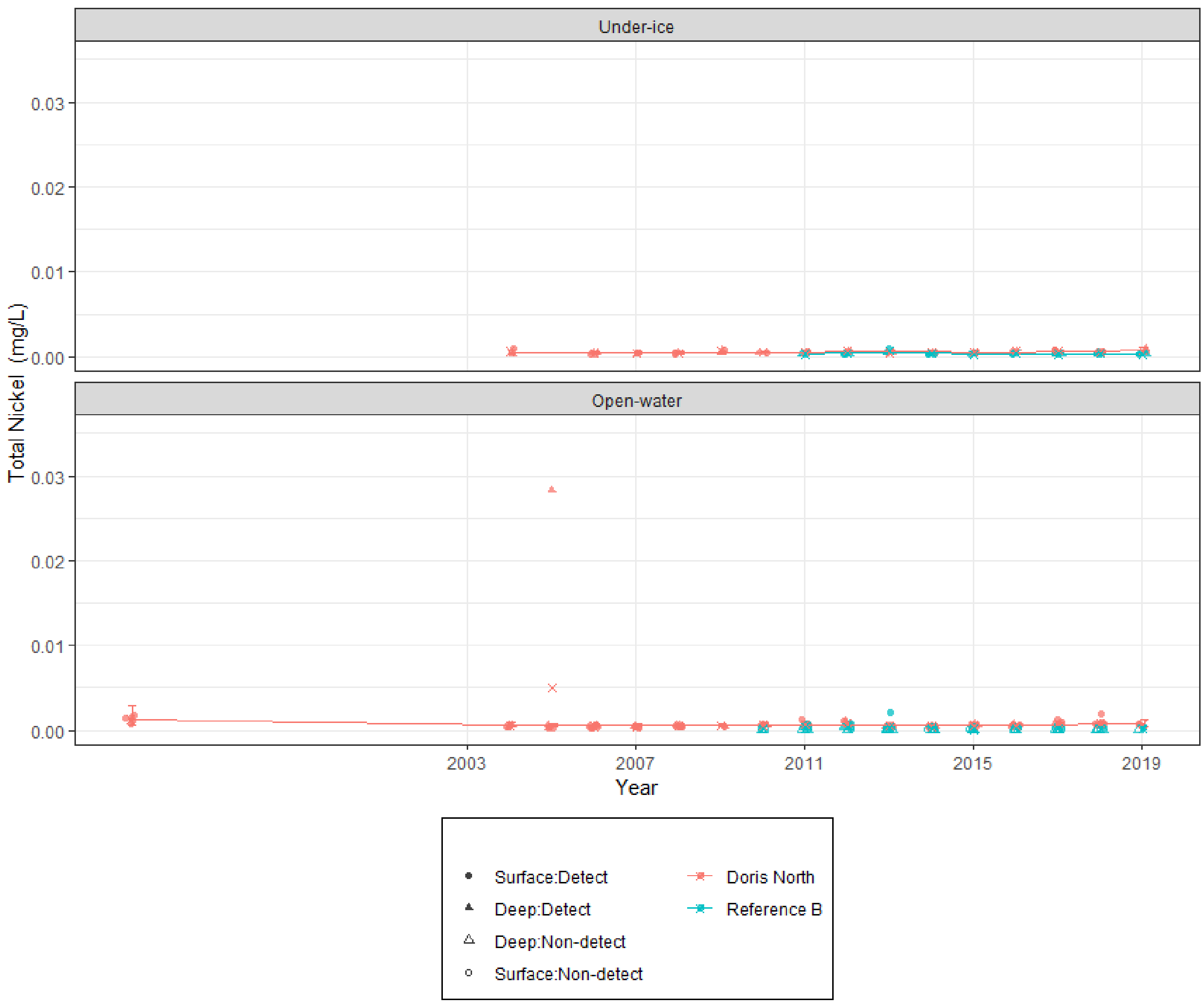
Analysis	Chi.sq	DF	P.value
Compare to slope 0	5.274	4	0.2603

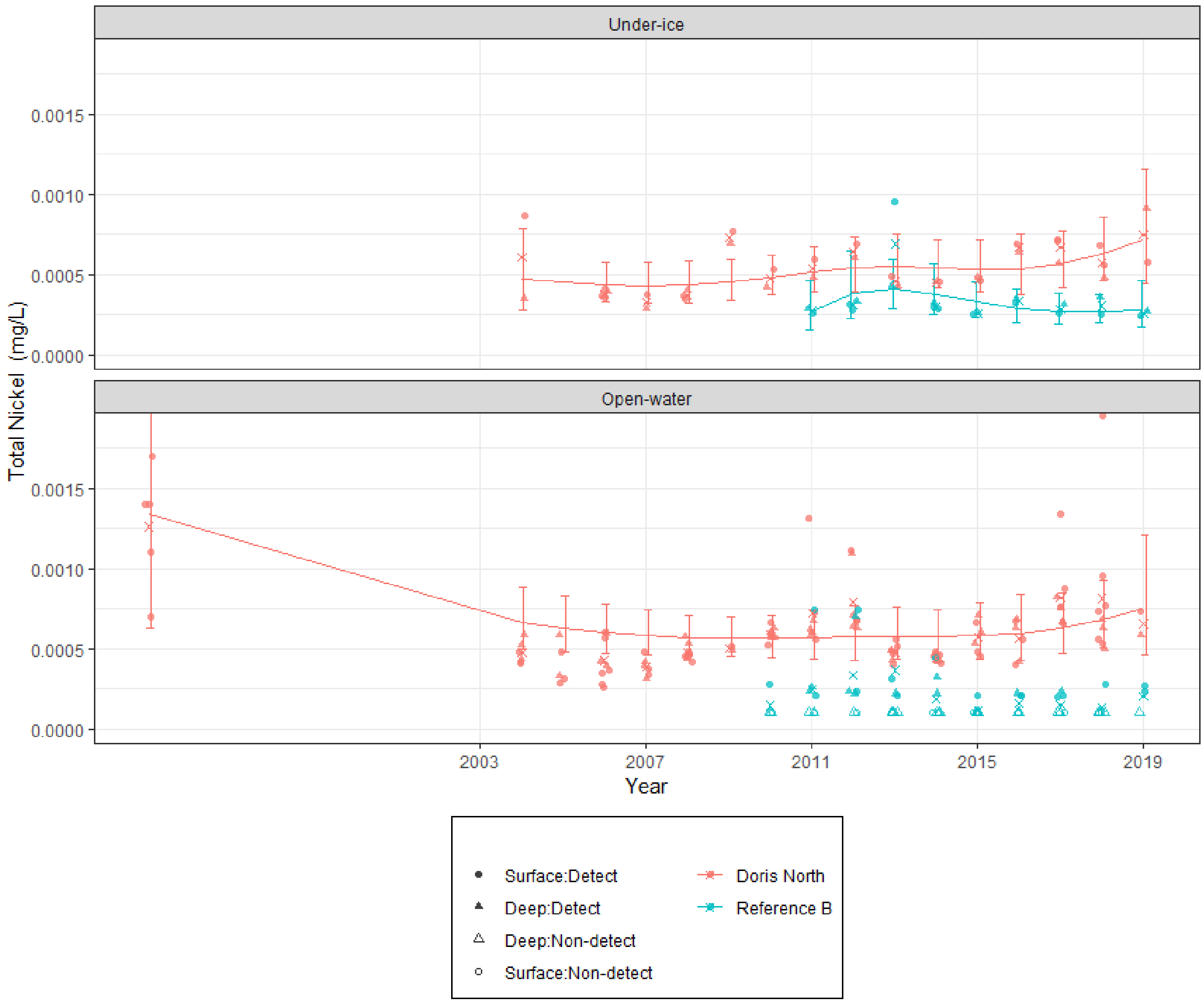
Doris Lake does not exhibit significant deviation from no trend.

Observed data and Fitted Values

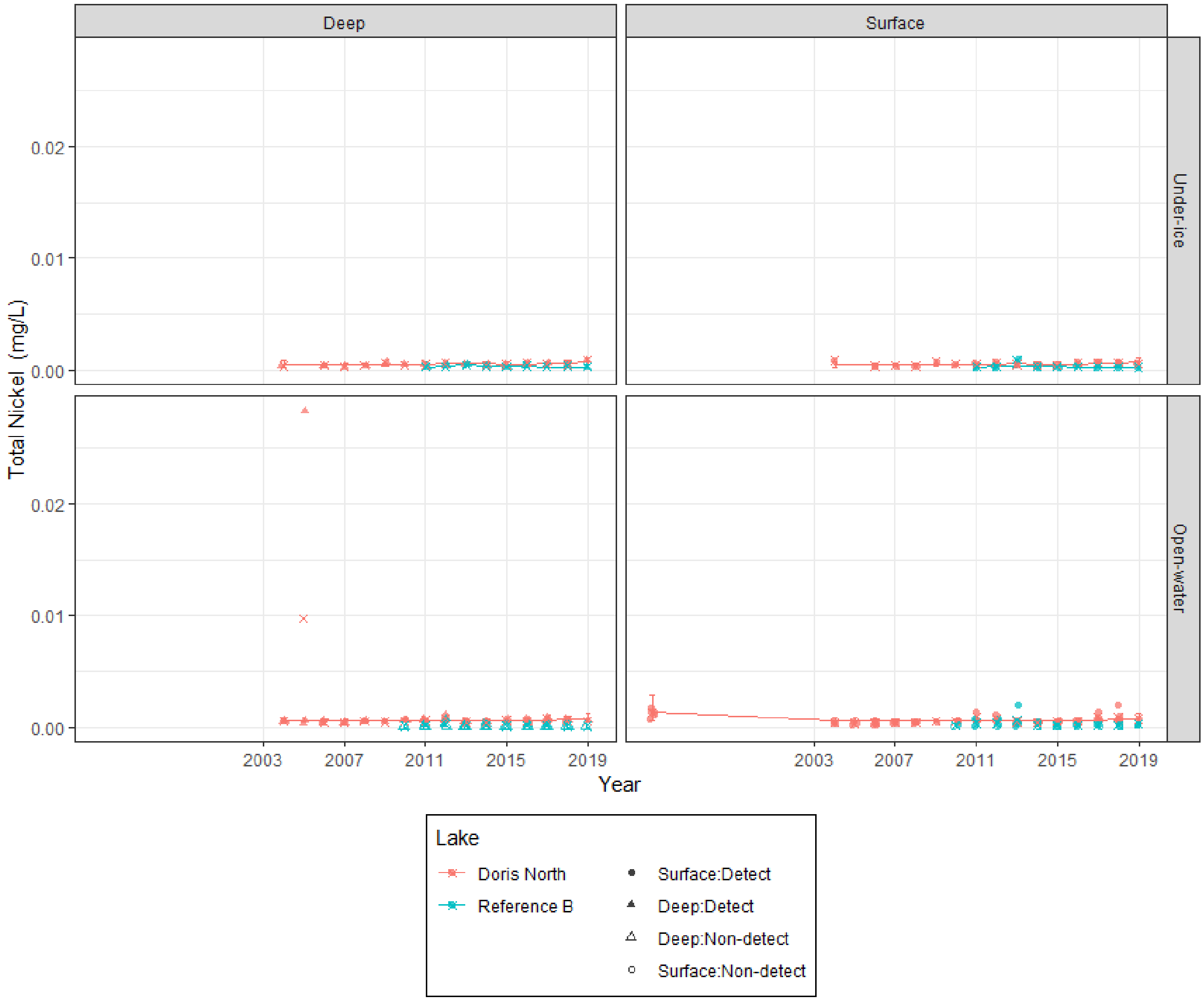
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.




Under-ice
Open-water
Total Nickel (mg/L)
0.0015
0.0010
0.0005
0.0000
2003
2007
2011
2015
2019
Year
Surface:Detect
Deep:Detect
Deep:Non-detect
Surface:Non-detect
Doris North
Reference B

Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.0495	0.3011	4.814	0.1644	0.8761	not sig.

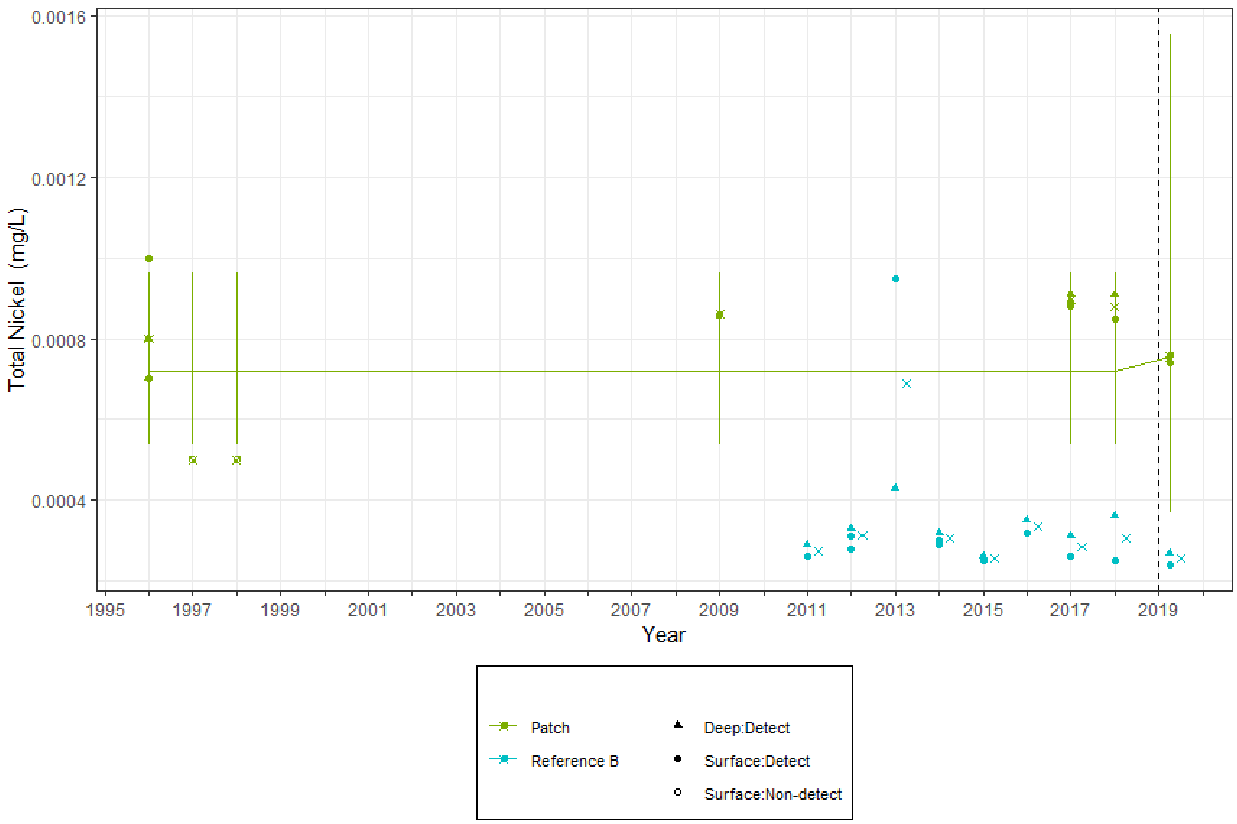
Conclusion:

The change in total nickel concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.8761) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.2399	0.4412	4.308	-0.5438	0.6135	not sig.

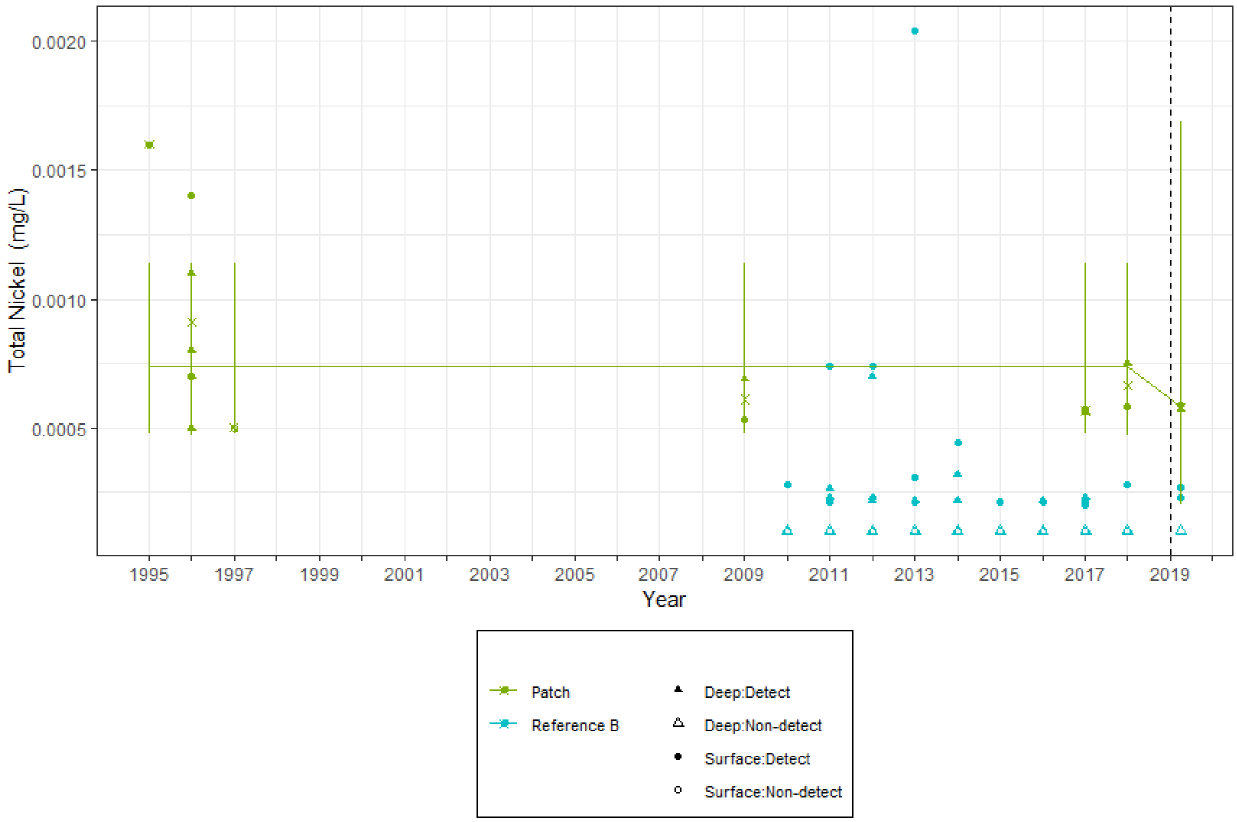
Conclusion:

The change in total nickel concentrations at the Patch site from *before* to *after* was not significantly ($p = 0.6135$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.1982	1.012	7.407	0.1959	0.85	not sig.

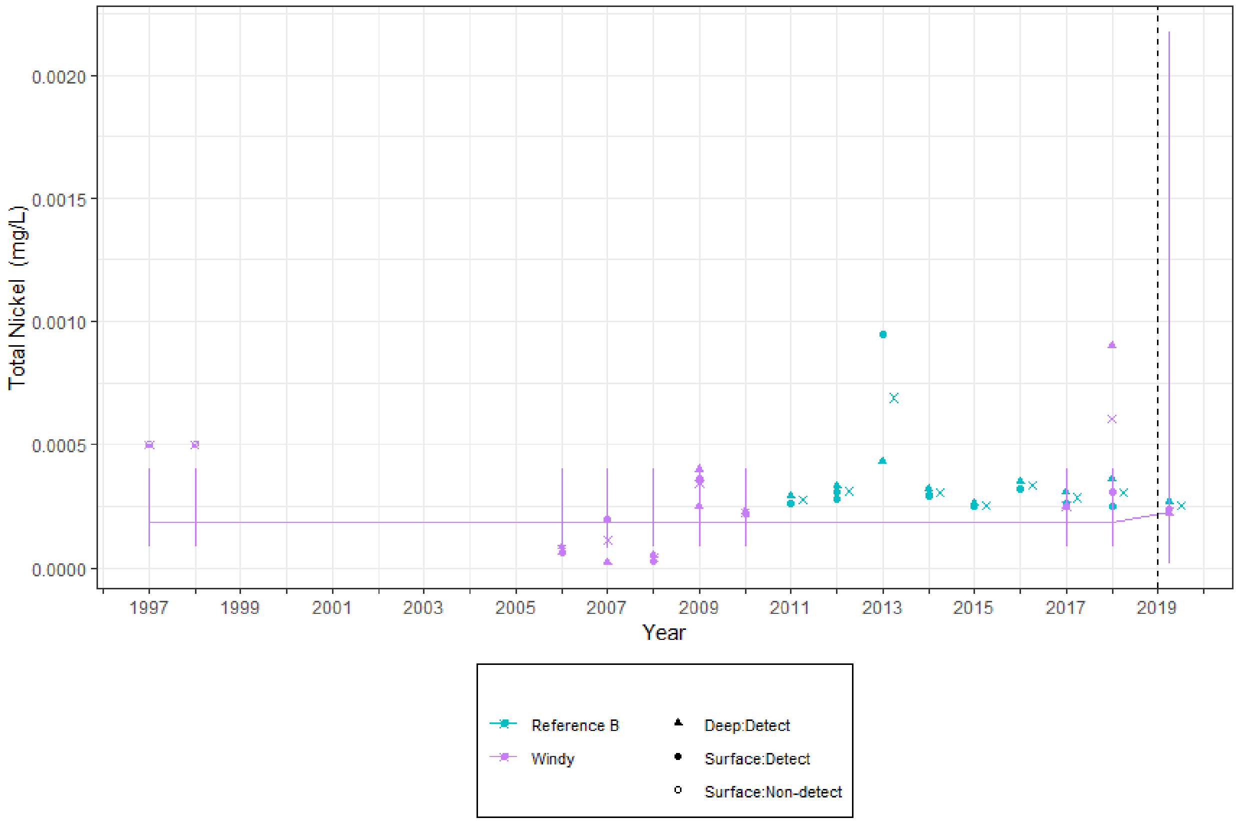
Conclusion:

The change in total nickel concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.85) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.1744	0.4685	8.991	0.3722	0.7184	not sig.

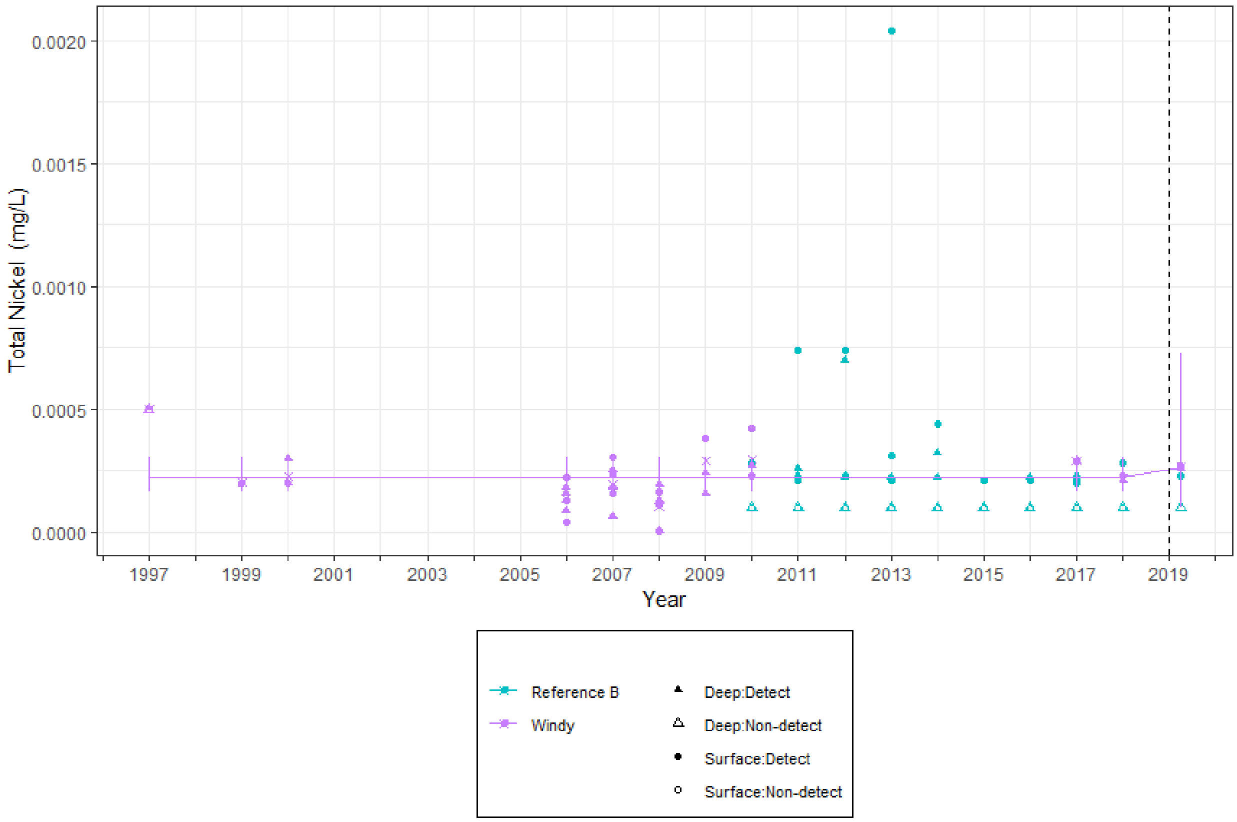
Conclusion:

The change in total nickel concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.7184) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

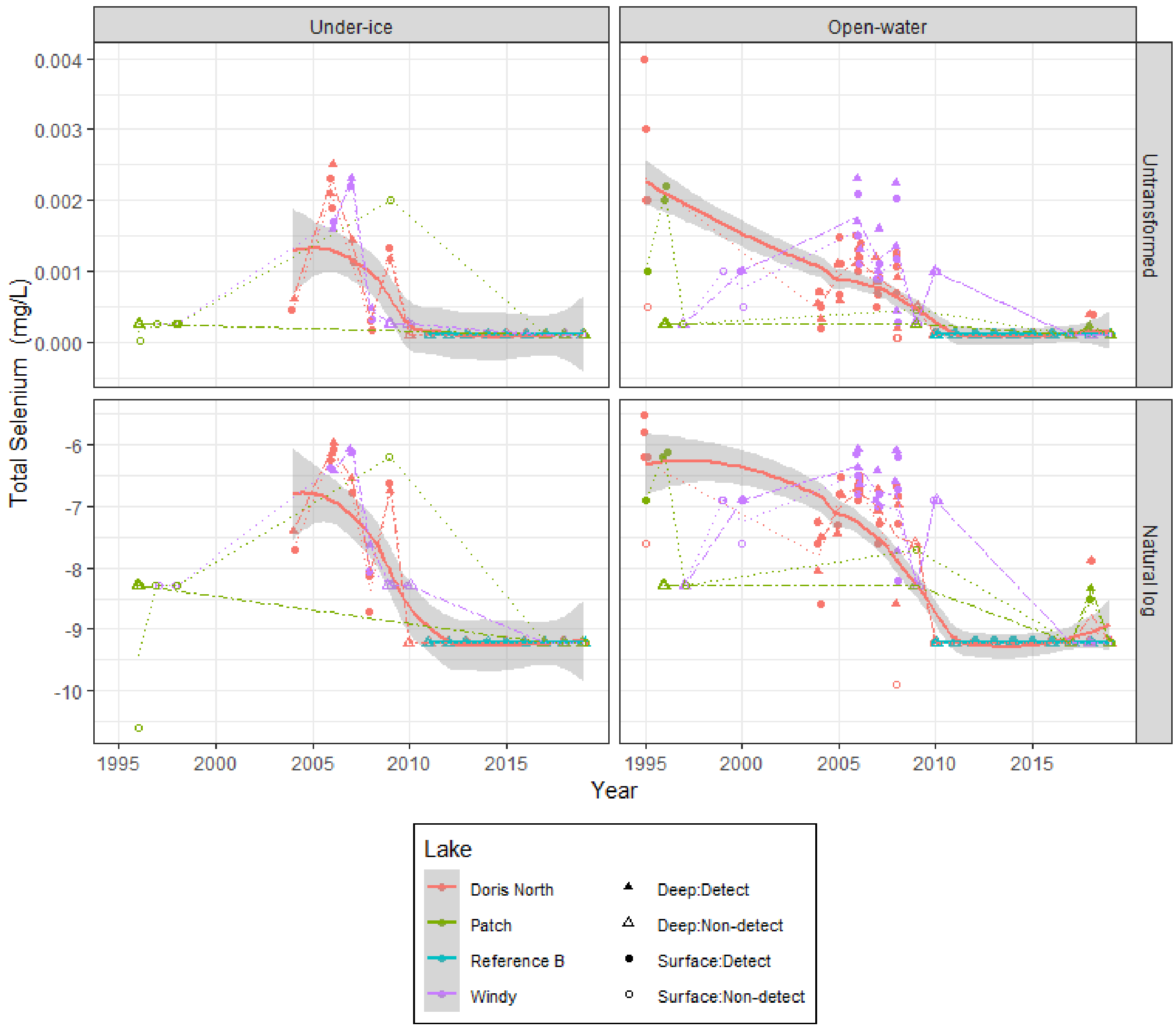
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.21 Total Selenium

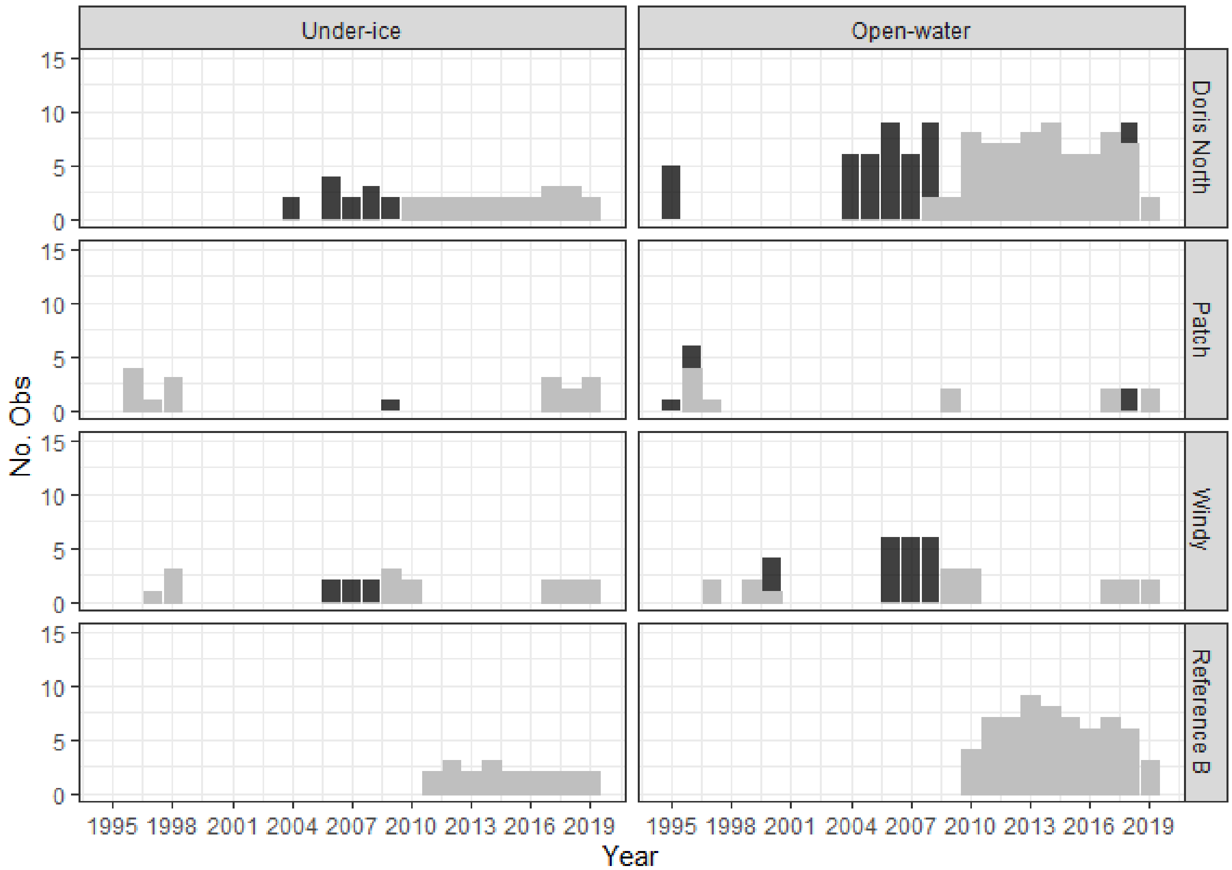
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

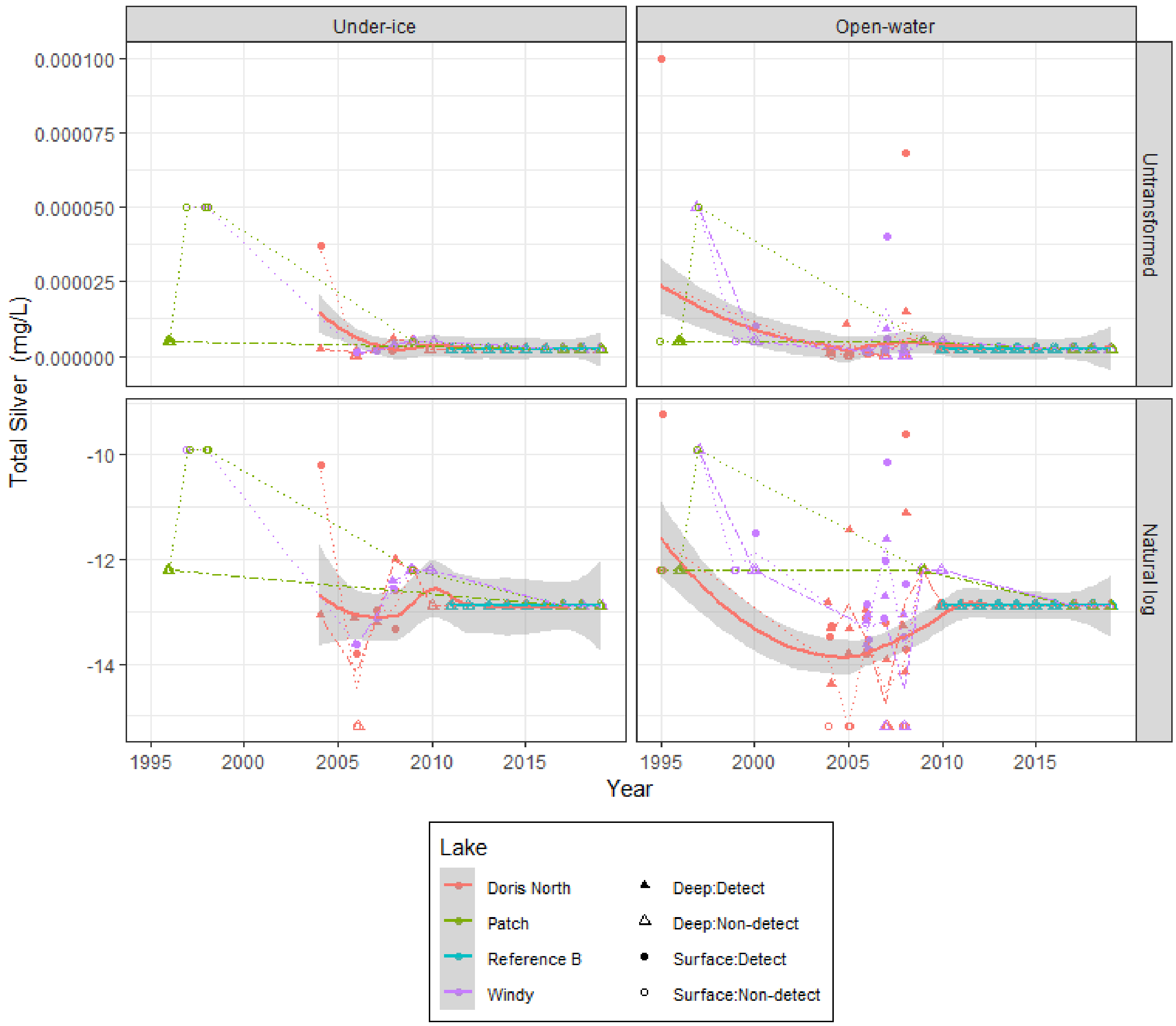
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	22	0.63	1	0.0002
Doris	Open-water	113	73	0.65	1	0.0002
Patch	Under-ice	17	17	1.00	1	0.0002
Patch	Open-water	16	11	0.69	1	0.0005
Reference B	Under-ice	20	20	1.00	1	0.0002
Reference B	Open-water	64	64	1.00	1	0.0002
Windy	Under-ice	21	15	0.71	1	0.0005
Windy	Open-water	38	17	0.45	1	0.0010

All data from 2019 were censored. All data removed from the analysis and no statistical analyses were performed.

C.3.2.22 Total Silver

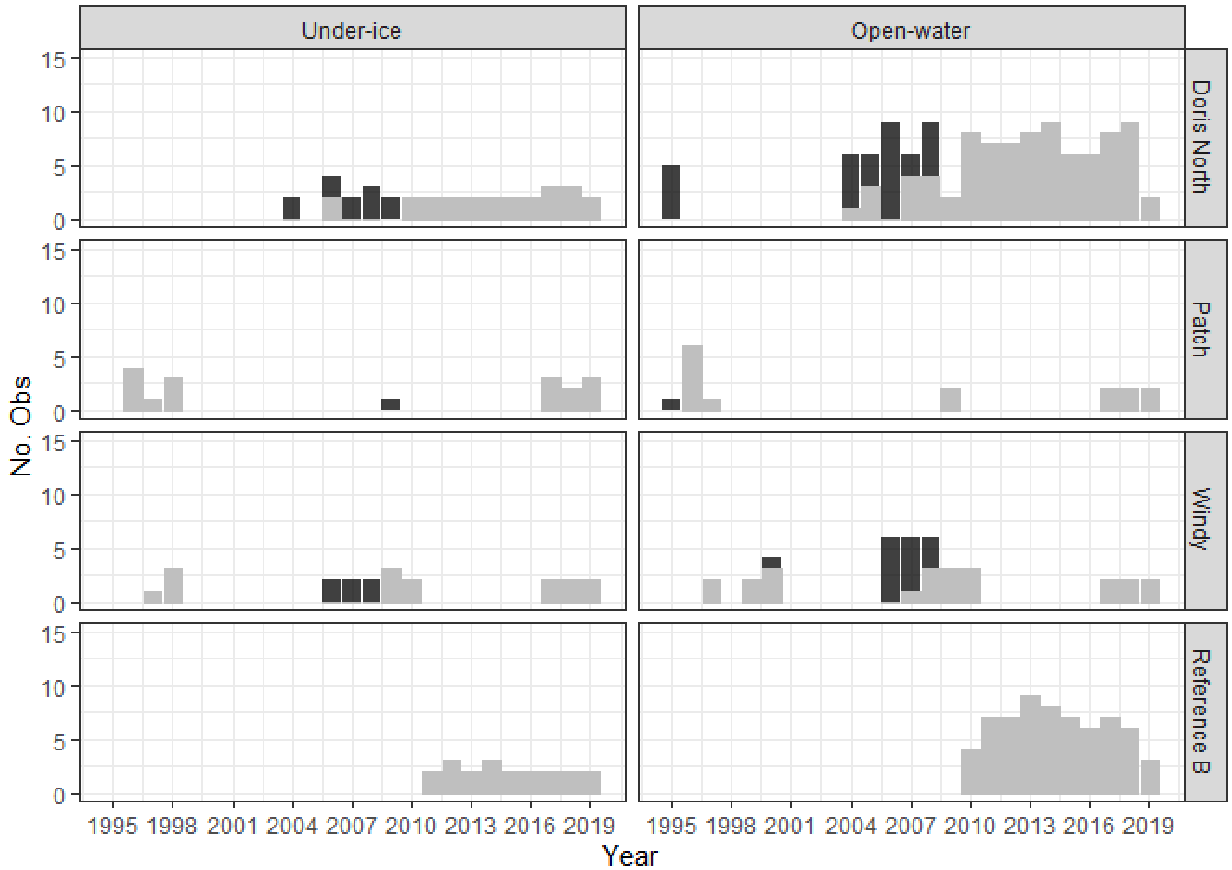
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

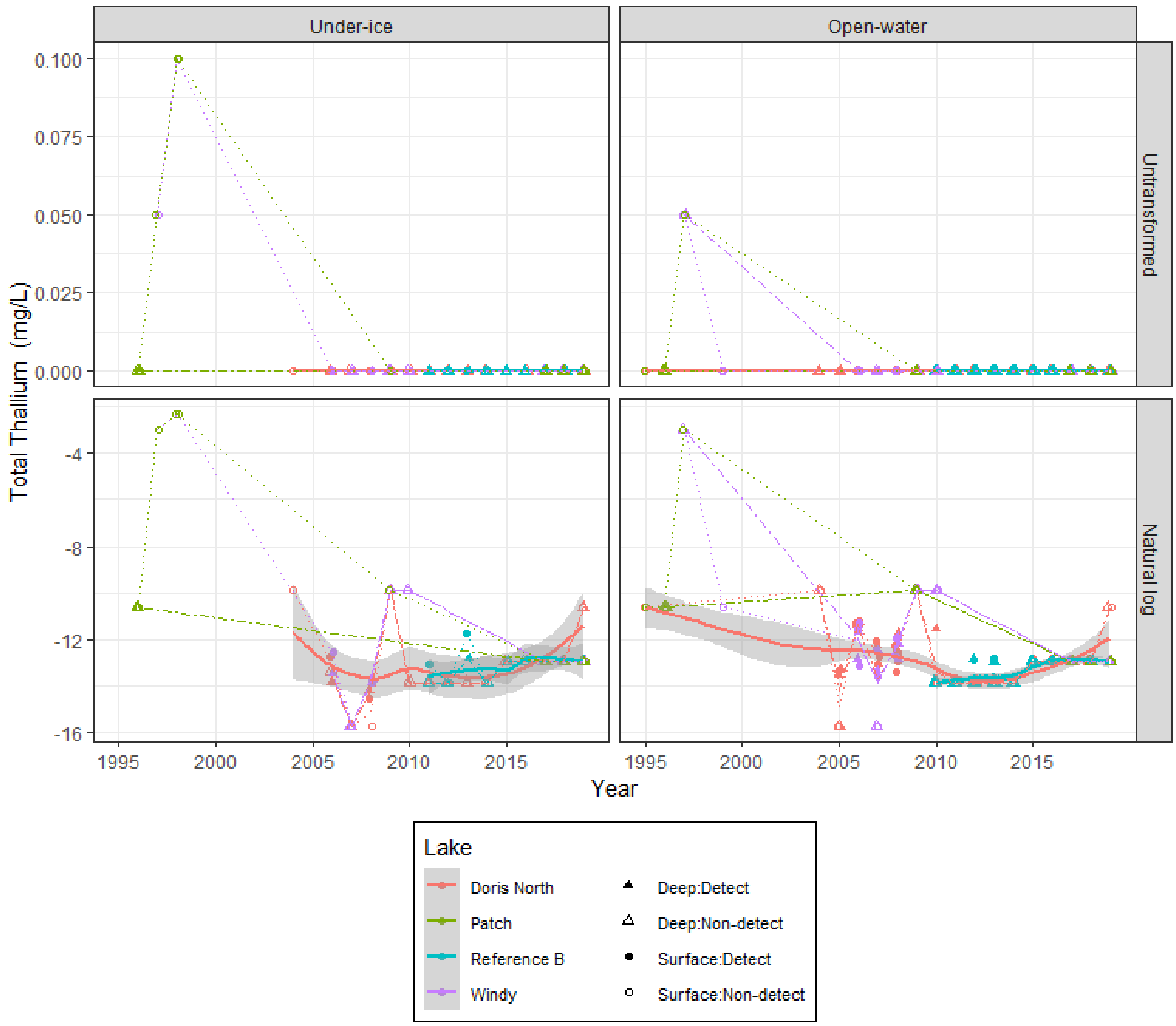
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	26	0.74	1	0
Doris	Open-water	113	88	0.78	1	0
Patch	Under-ice	17	17	1.00	1	0
Patch	Open-water	16	16	1.00	1	0
Reference B	Under-ice	20	20	1.00	1	0
Reference B	Open-water	64	64	1.00	1	0
Windy	Under-ice	21	15	0.71	1	0
Windy	Open-water	38	23	0.61	1	0

All data from 2019 were censored. All data removed from the analysis and no statistical analyses were performed.

C.3.2.23 Total Thallium

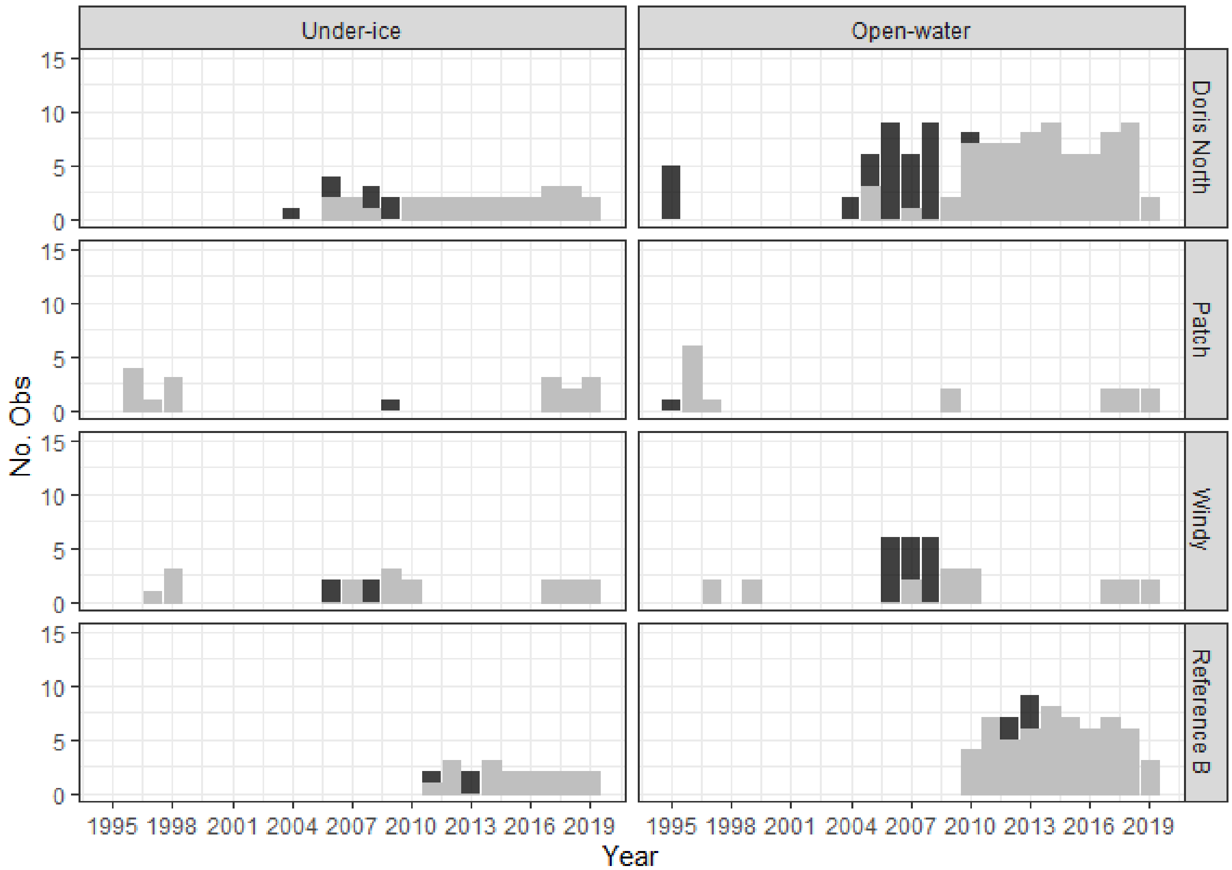
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

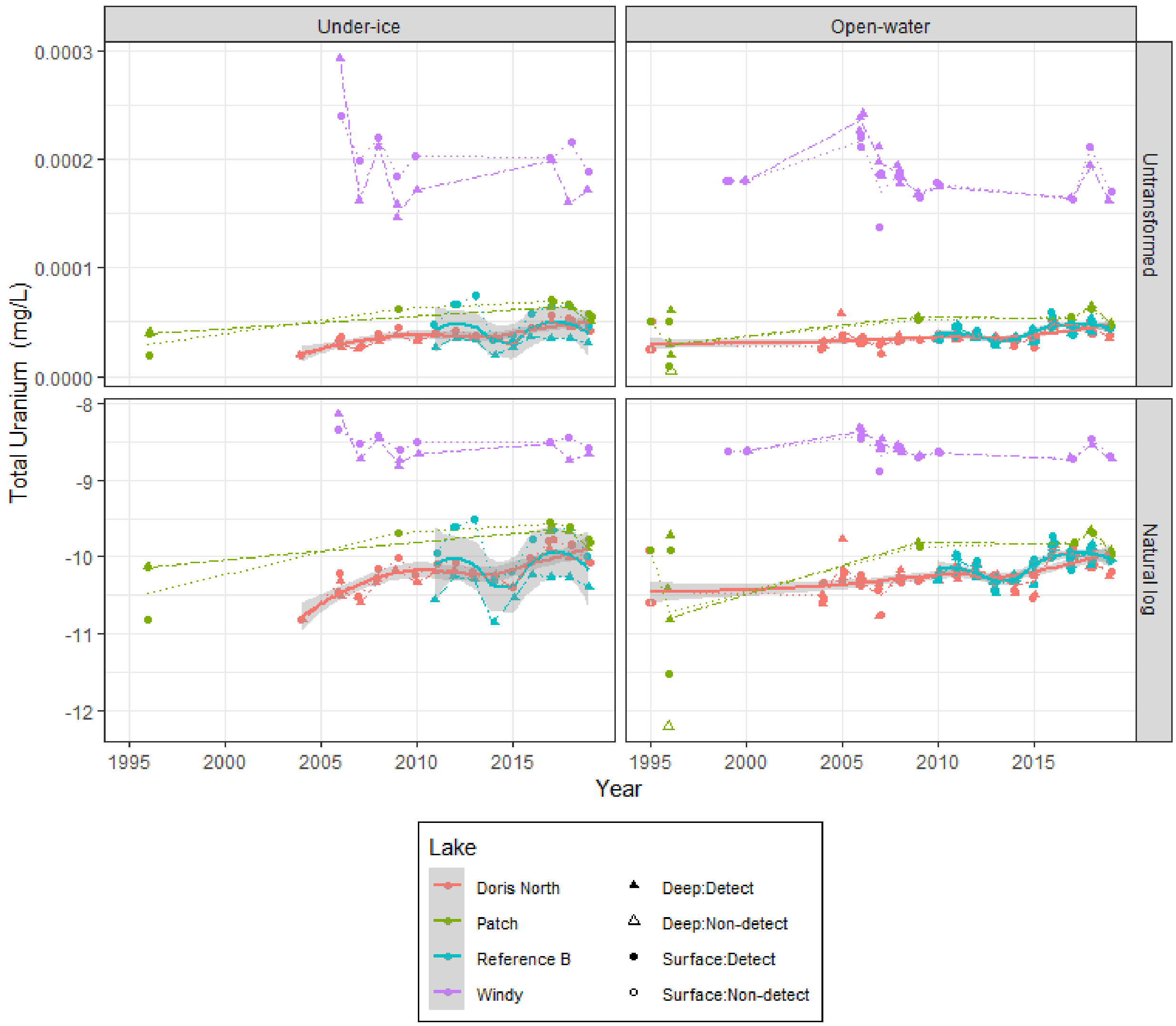
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	34	30	0.88	1	0
Doris	Open-water	109	82	0.75	1	0
Patch	Under-ice	17	17	1.00	1	0
Patch	Open-water	16	16	1.00	1	0
Reference B	Under-ice	20	17	0.85	1	0
Reference B	Open-water	64	59	0.92	1	0
Windy	Under-ice	21	17	0.81	1	0
Windy	Open-water	34	18	0.53	1	0

All data from 2019 were censored. All data removed from the analysis and no statistical analyses were performed.

C.3.2.24 Total Uranium

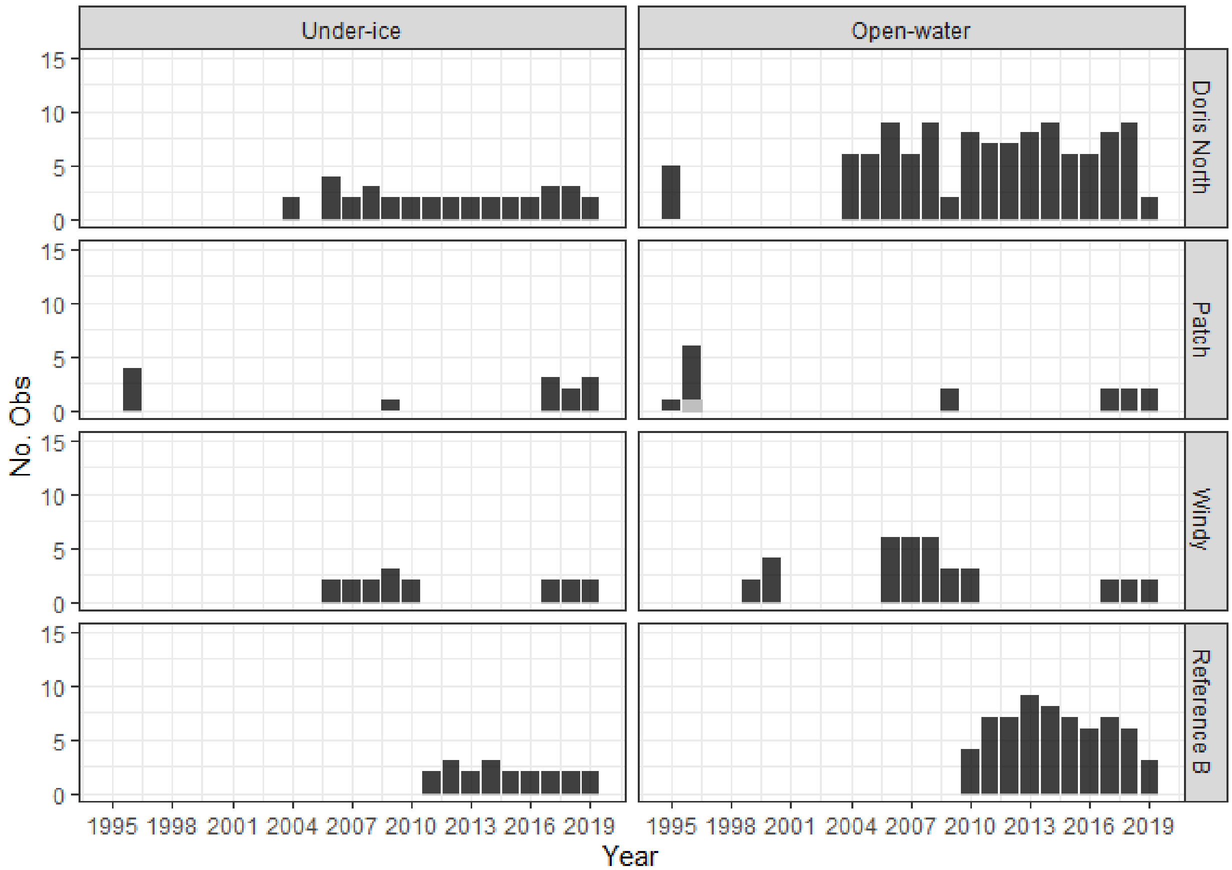
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

The sample sizes and median values per lake and season are summarized in the table below.

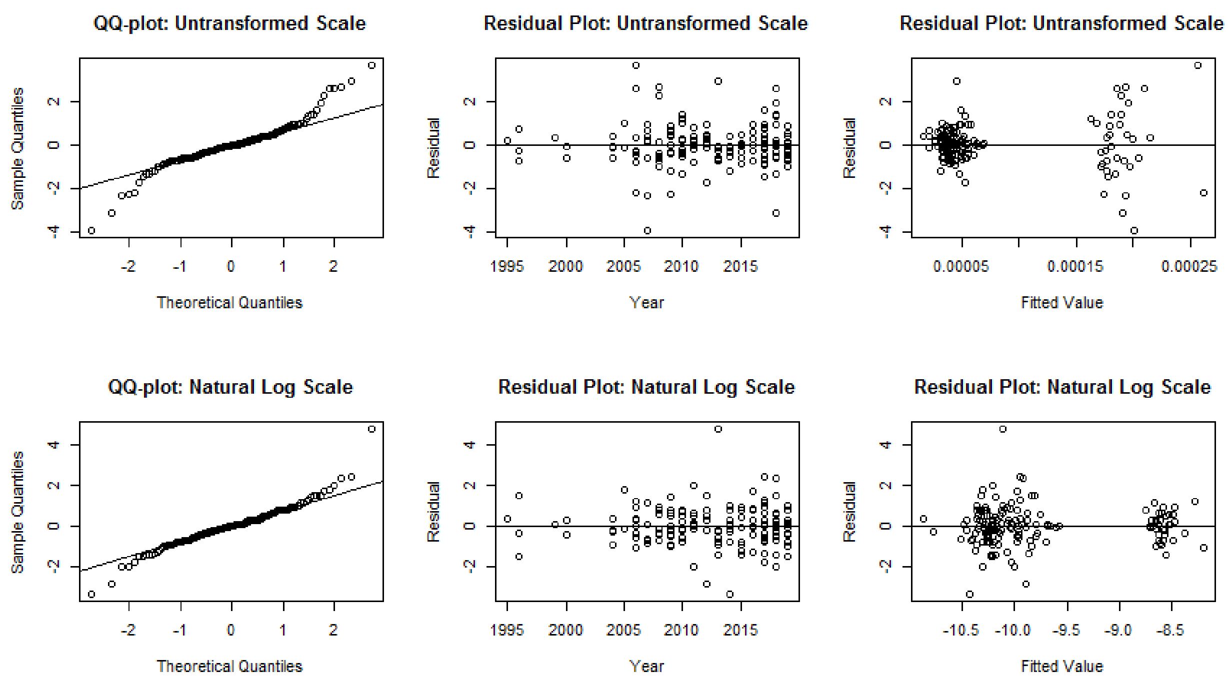
Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	35	0	0.00	0	0.0000
Doris	Open-water	113	4	0.04	0	0.0000
Patch	Under-ice	13	0	0.00	0	0.0001
Patch	Open-water	15	1	0.07	0	0.0000
Reference B	Under-ice	20	0	0.00	0	0.0000
Reference B	Open-water	64	0	0.00	0	0.0000
Windy	Under-ice	17	0	0.00	0	0.0002
Windy	Open-water	36	0	0.00	0	0.0002

None of the sites exhibited greater than 50% of data less than the detection limit. The analysis proceeds with linear mixed model regression. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.

L



Outliers on untransformed scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Windy	2006	Under-ice	Deep	0.0003	0	3.642
Windy	2007	Under-ice	Deep	0.0002	0	-3.938
Windy	2018	Under-ice	Deep	0.0002	0	-3.135

Outliers on natural log scale:

Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
Reference B	2013	Under-ice	Surface	0.0001	-10.11	4.785
Reference B	2014	Under-ice	Deep	0.0000	-10.42	-3.392

However, there was an outlier retained in the analysis. Results should be interpreted with caution and along with graphical results.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	38.00	4	0.0000
Compare to Reference B	14.67	4	0.0054

Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B lake.

Open-water

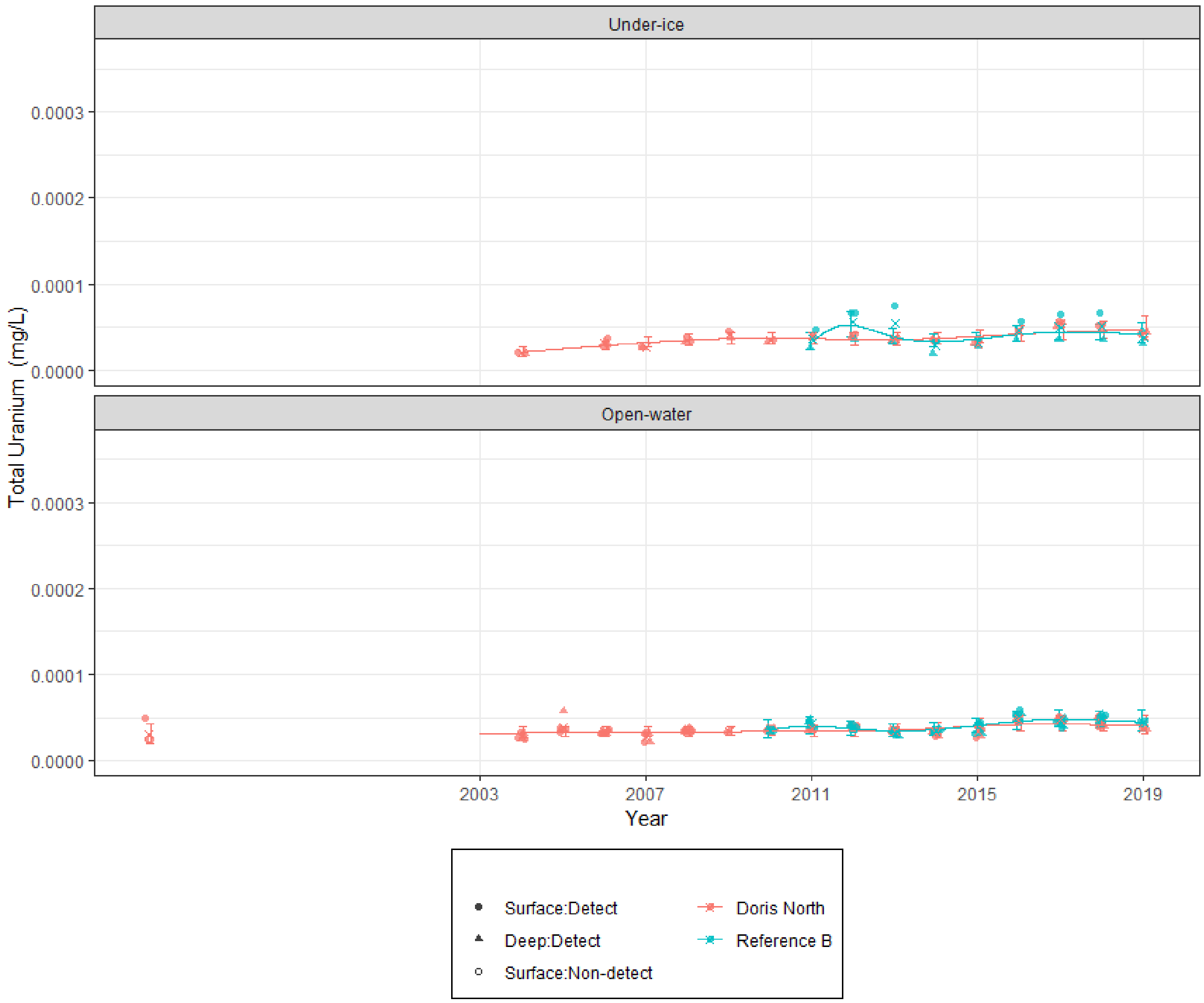
Analysis	Chi.sq	DF	P.value
Compare to slope 0	12.603	4	0.0134
Compare to Reference B	2.727	4	0.6045

Doris Lake appears to show significant deviation from no trend. Doris Lake does not exhibit significant deviation from the trend of Reference B lake.

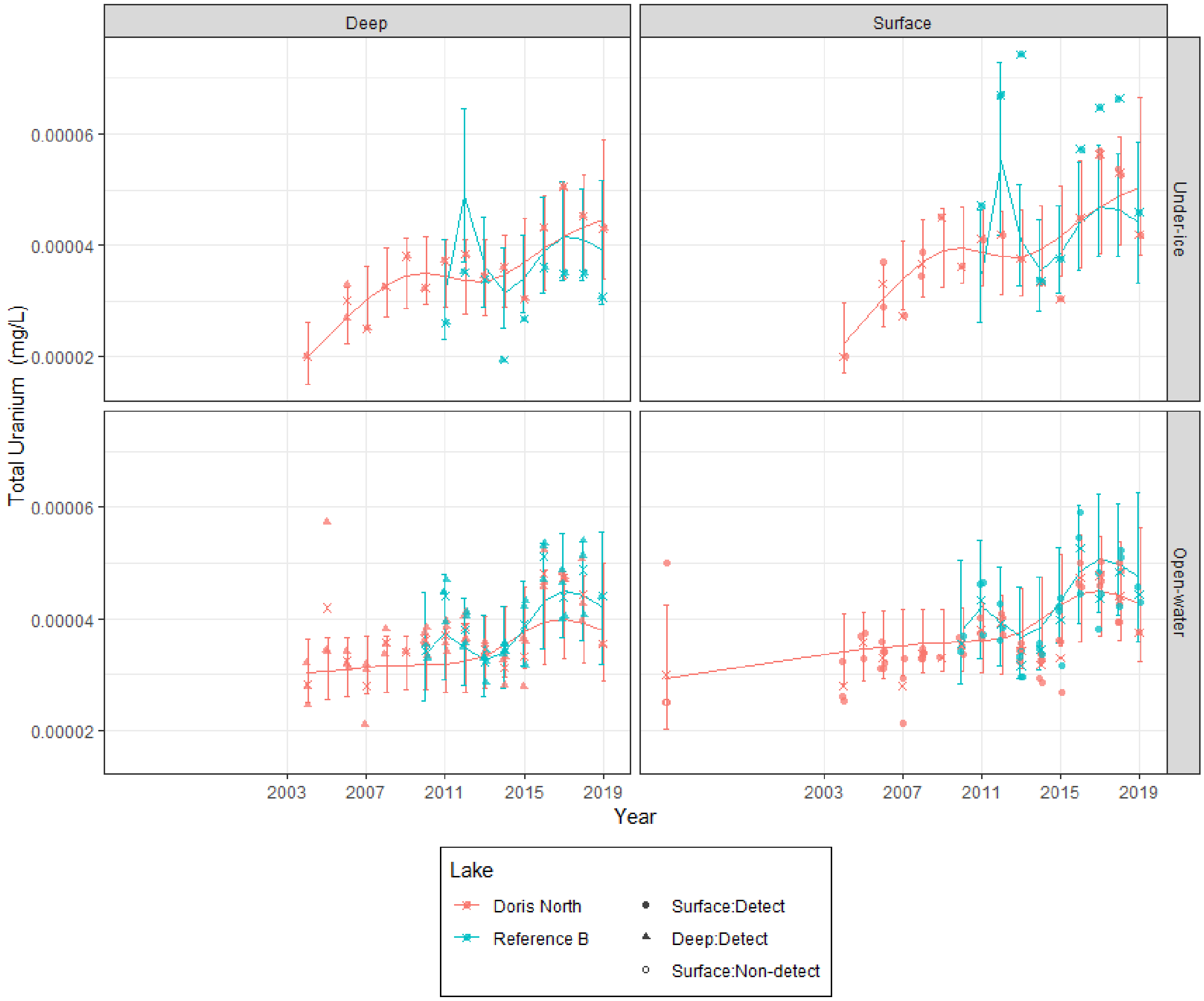
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.


Under-ice
Open-water
Total Uranium (mg/L)
0.0003
0.0002
0.0001
0.0000
2003
2007
2011
2015
2019
Year
Surface:Detect
Deep:Detect
Surface:Non-detect
Doris North
Reference B

Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0369	0.3532	2.998	-0.1044	0.9235	not sig.

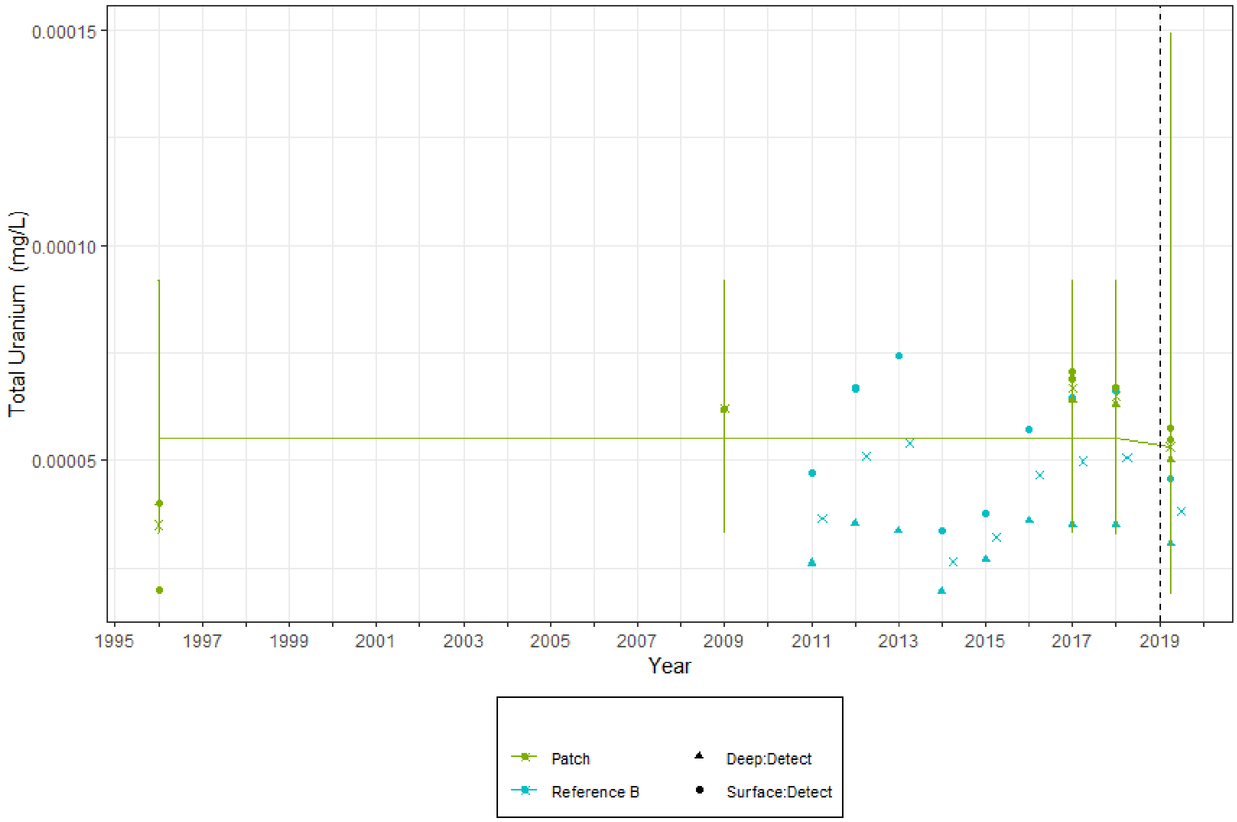
Conclusion:

The change in total uranium concentrations in Patch Lake from *before* to *after* was not significantly ($p = 0.9235$) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0104	0.3232	4.002	-0.0321	0.9759	not sig.

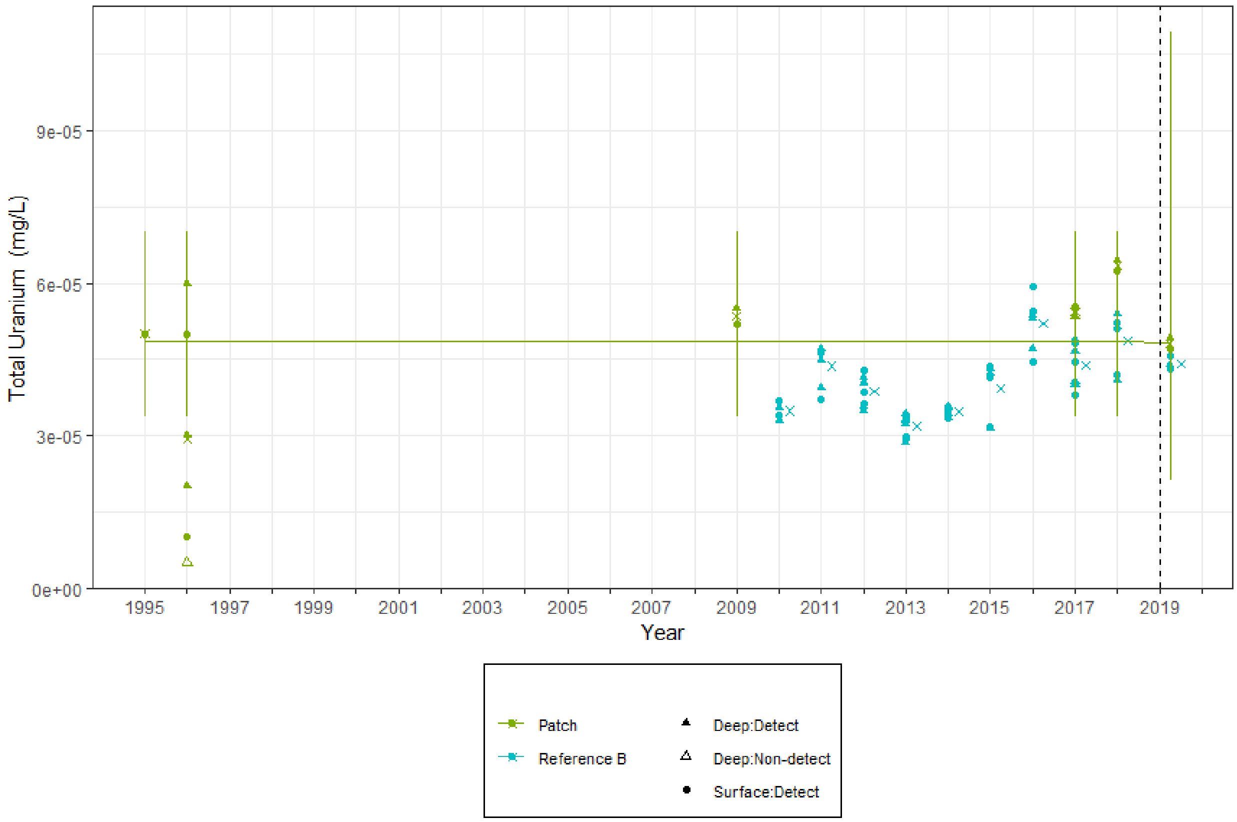
Conclusion:

The change in total uranium concentrations in Patch Lake from *before* to *after* was not significantly ($p = 0.9759$) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.0953	0.1629	6.002	-0.5853	0.5797	not sig.

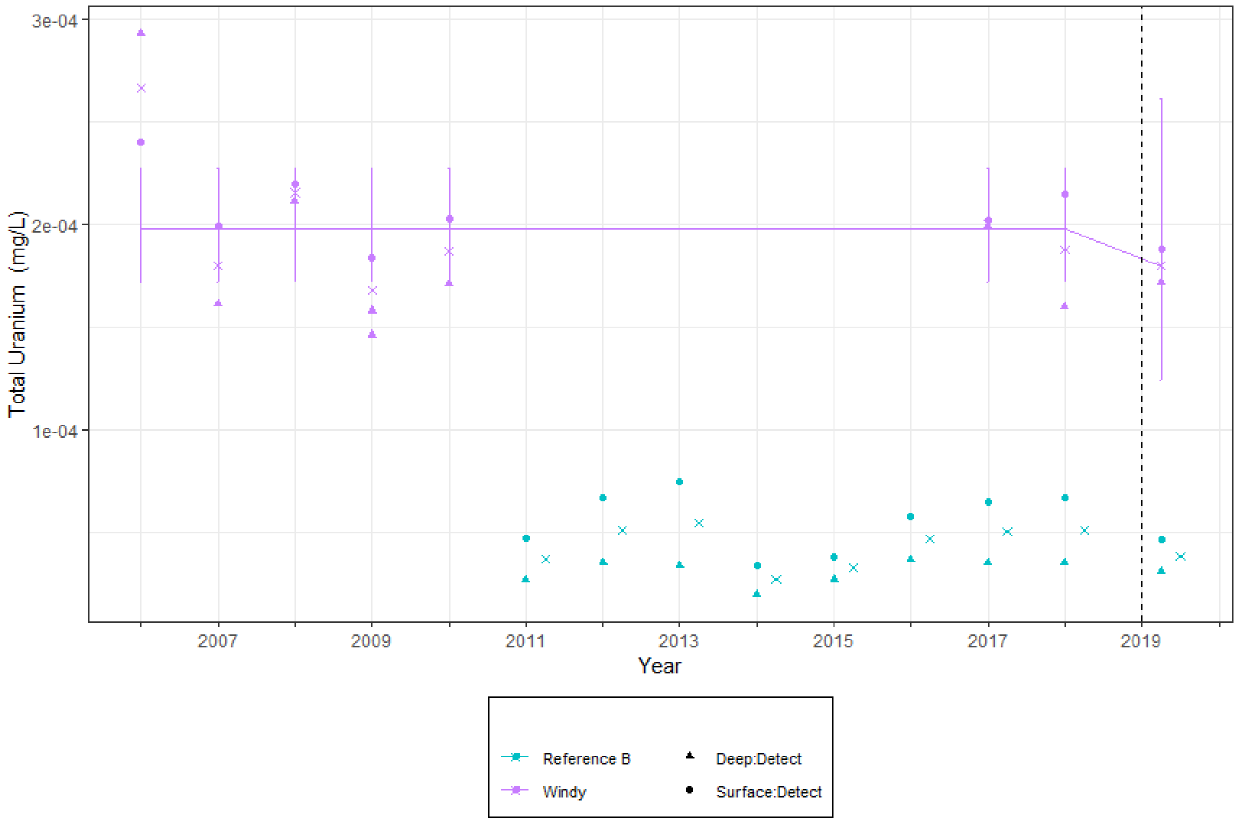
Conclusion:

The change in total uranium concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.5797) different.

BACI analysis not performed.

Under-ice Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



Open-water Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-0.1045	0.1049	8.001	-0.9955	0.3486	not sig.

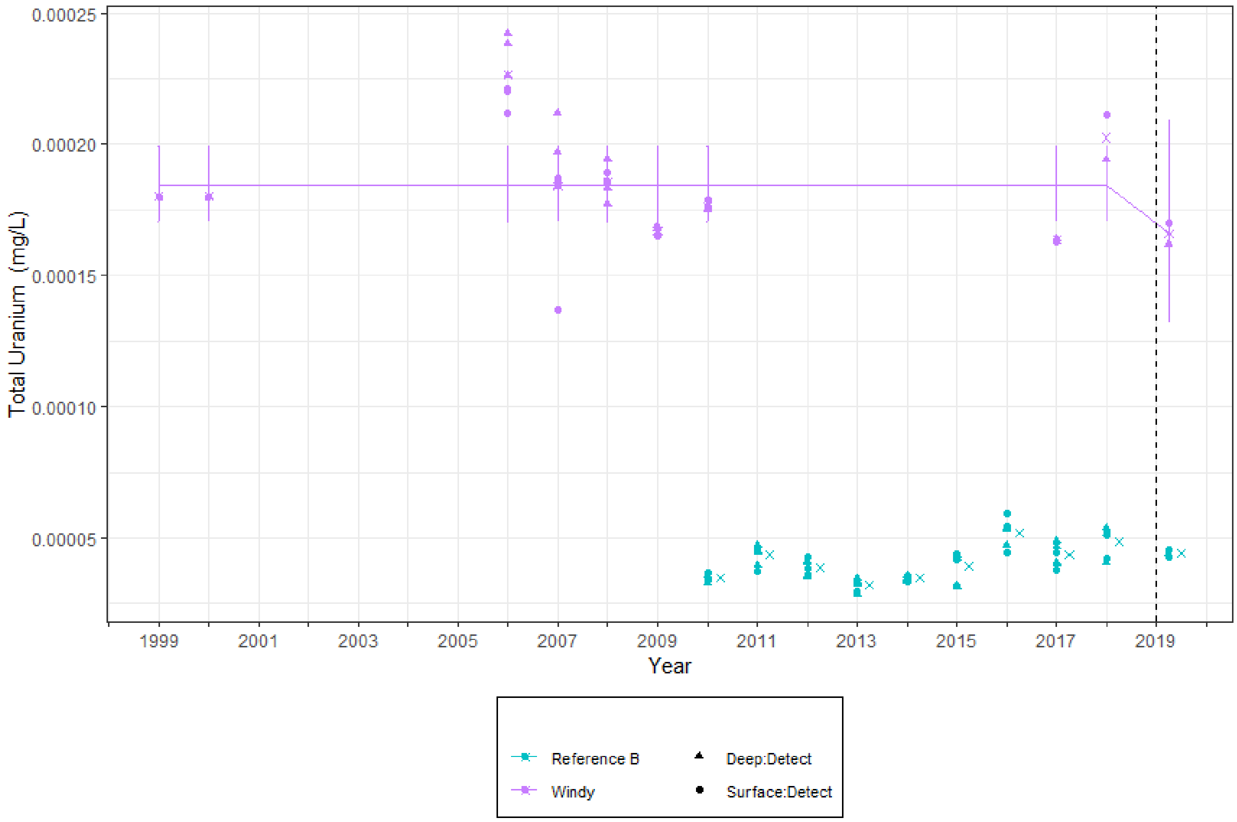
Conclusion:

The change in total uranium concentrations in Windy Lake from *before* to *after* was not significantly (p = 0.3486) different.

BACI analysis not performed.

Open-water Observed Data and Fitted Values

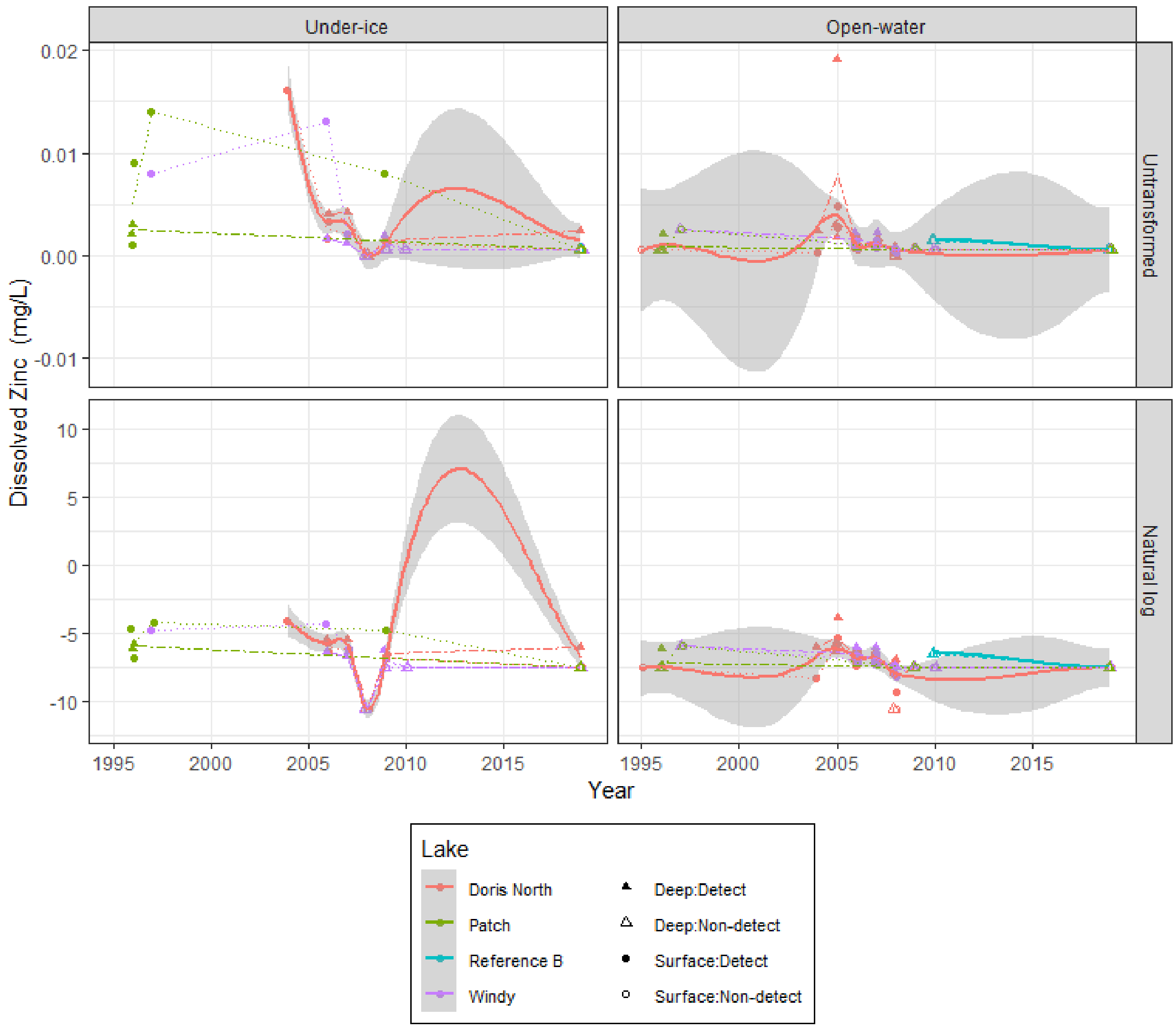
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.2.25 Dissolved Zinc

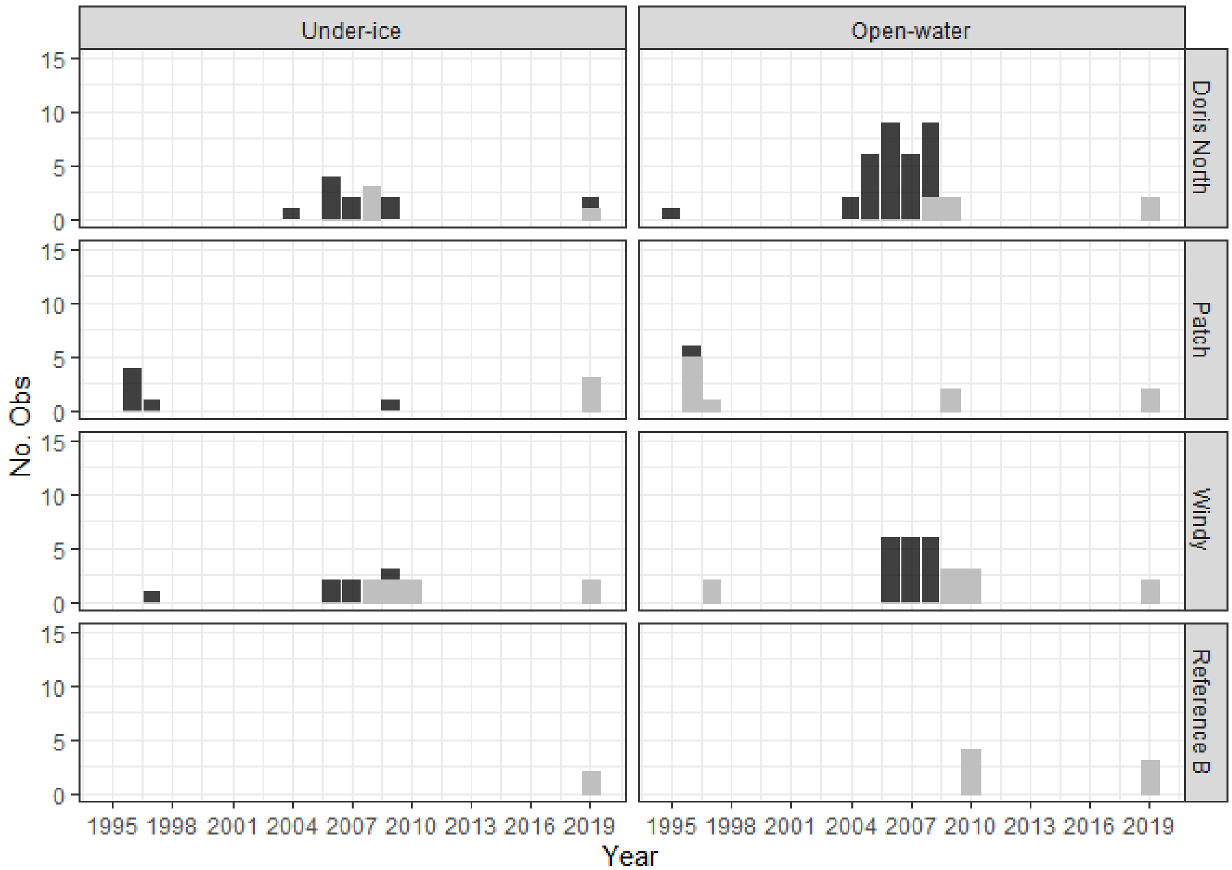
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Under-ice samples were collected in April, May, or June, and open-water samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. Samples collected at different depths are shown by symbols and lines. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals are represented by solid lines and grey shading, respectively, to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

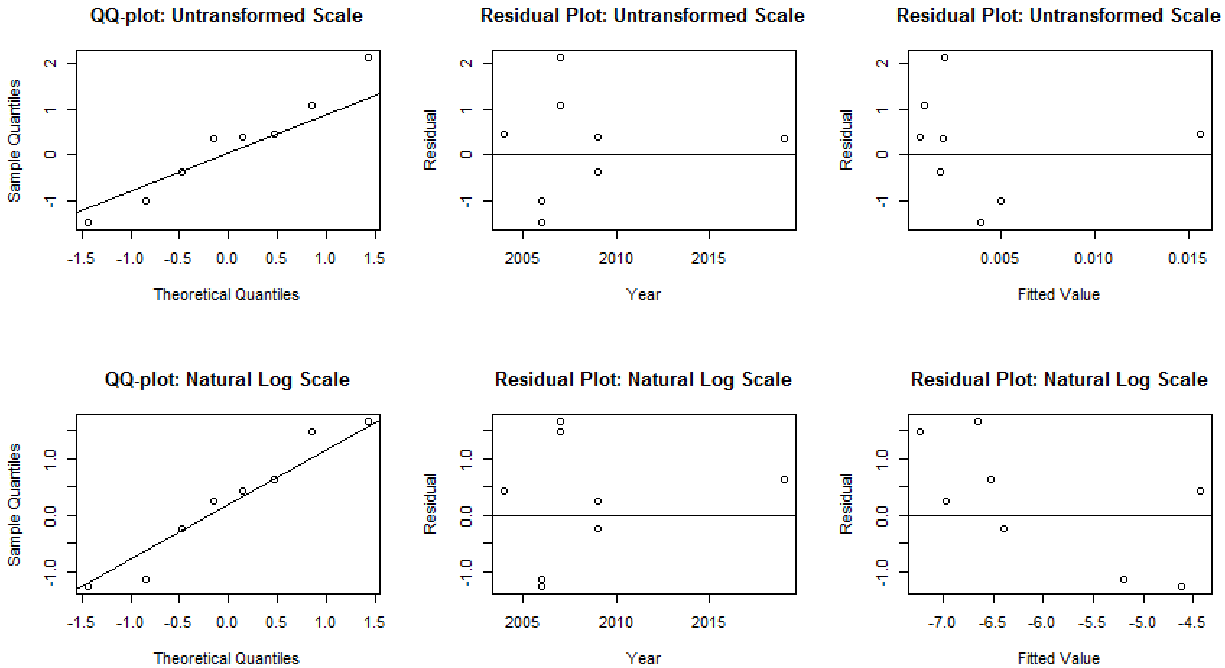
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Under-ice	14	4	0.29	0.5	0.0018
Doris	Open-water	37	7	0.19	1.0	0.0010
Patch	Under-ice	9	3	0.33	1.0	0.0020
Patch	Open-water	11	10	0.91	1.0	0.0010
Reference B	Under-ice	2	2	1.00	1.0	0.0010
Reference B	Open-water	7	7	1.00	1.0	0.0030
Windy	Under-ice	14	8	0.57	1.0	0.0010
Windy	Open-water	28	10	0.36	1.0	0.0010

More than 50% of data under detection limit in Doris open-water, Patch under-ice, Patch open-water, Reference B under-ice, Reference B open-water, Windy under-ice, and Windy open-water. Data from those site-season groupings will be removed from the analysis. Doris under-ice, Doris open-water, Patch under-ice, and Windy open-water exhibited more than 10% of data under detection limit. The analysis proceeds with tobit regression for Doris. The analysis proceeds with linear mixed effects regression for Patch. The analysis proceeds with linear mixed effects regression for Windy.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Under-ice

Analysis	Chi.sq	DF	P.value
Compare to slope 0	189.8	4	0.0000

Doris Lake appears to show significant deviation from no trend.

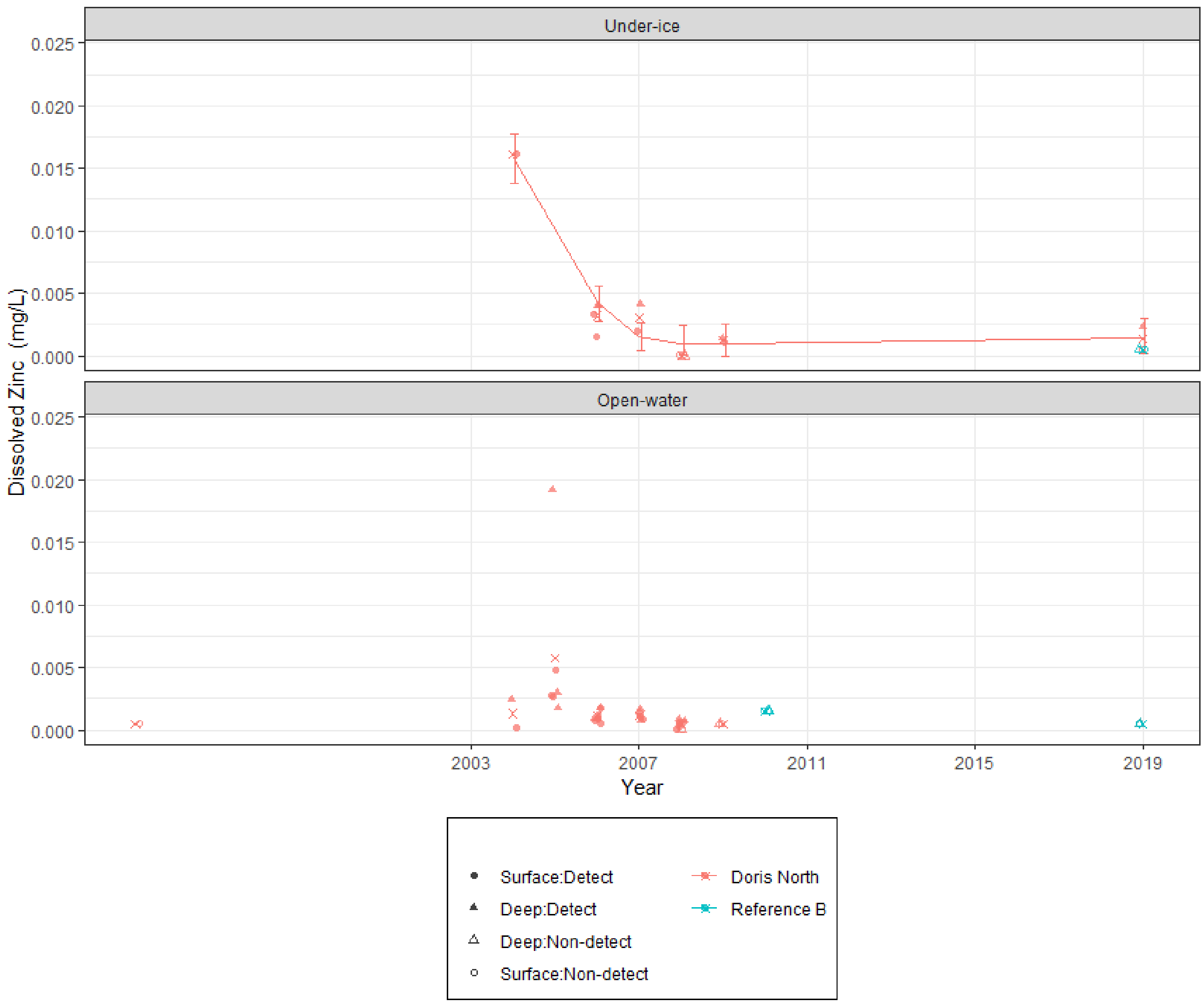
Open-water

All data from Doris open-water removed from the analysis. No analysis performed.

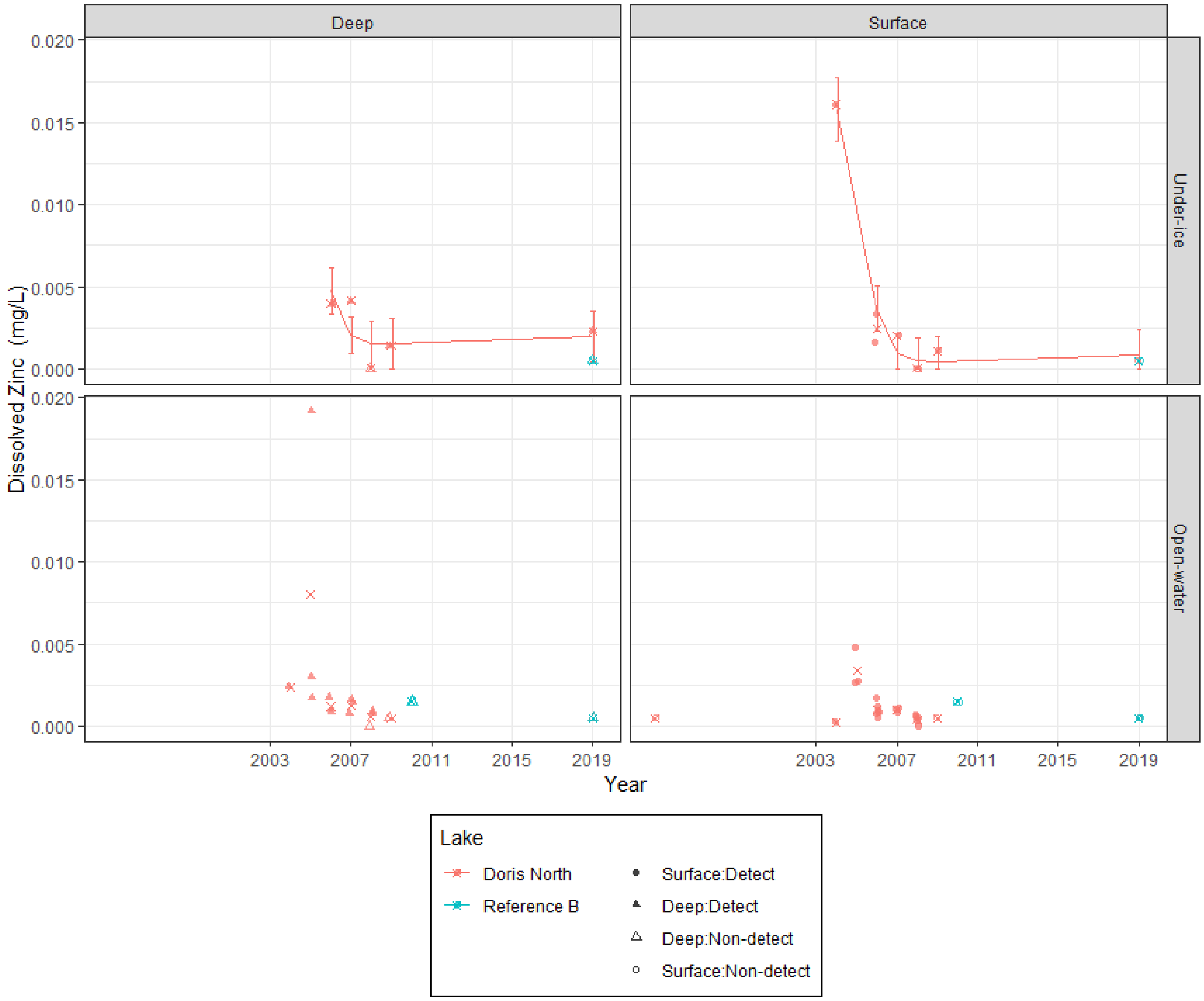
Observed Data and Fitted Values

Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over depth and separated by depth to visually assess the differences between shallow and deep samples. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.

Plot of observed and fitted data averaged over depth.



Plot of observed and fitted data separated by depth.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

Open-water Before-vs-After Analysis

Analysis not performed.

Windy Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Windy. Models were fit separately for each season.

Under-ice Before-vs-After Analysis

Analysis not performed.

Open-water Before-vs-After Analysis

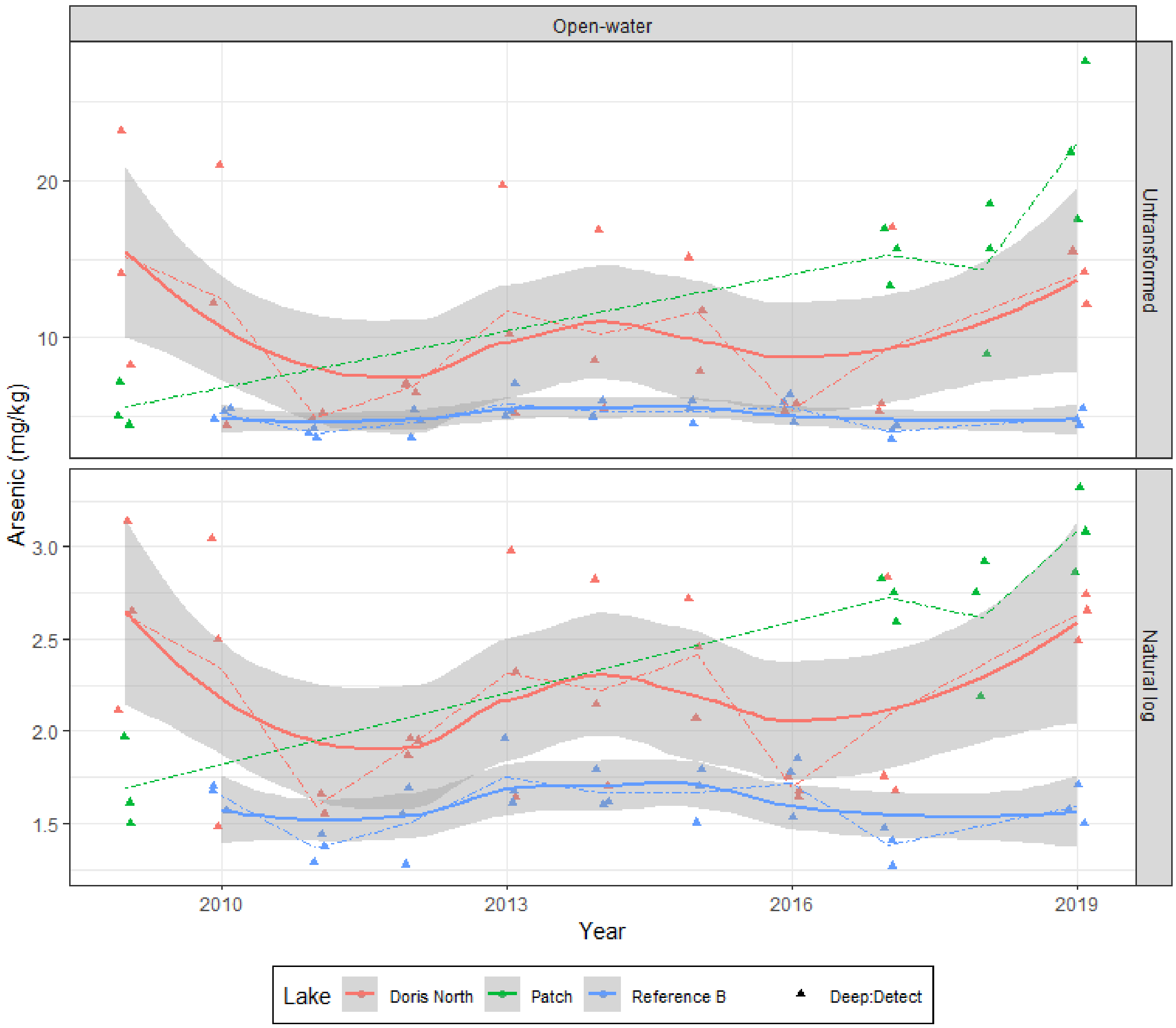
Analysis not performed.

C.3.3 Sediment Quality

C.3.3.1 Arsenic

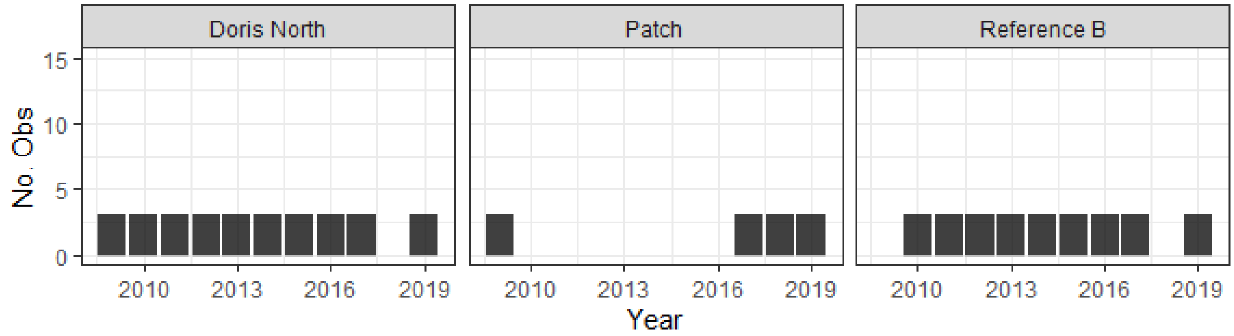
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

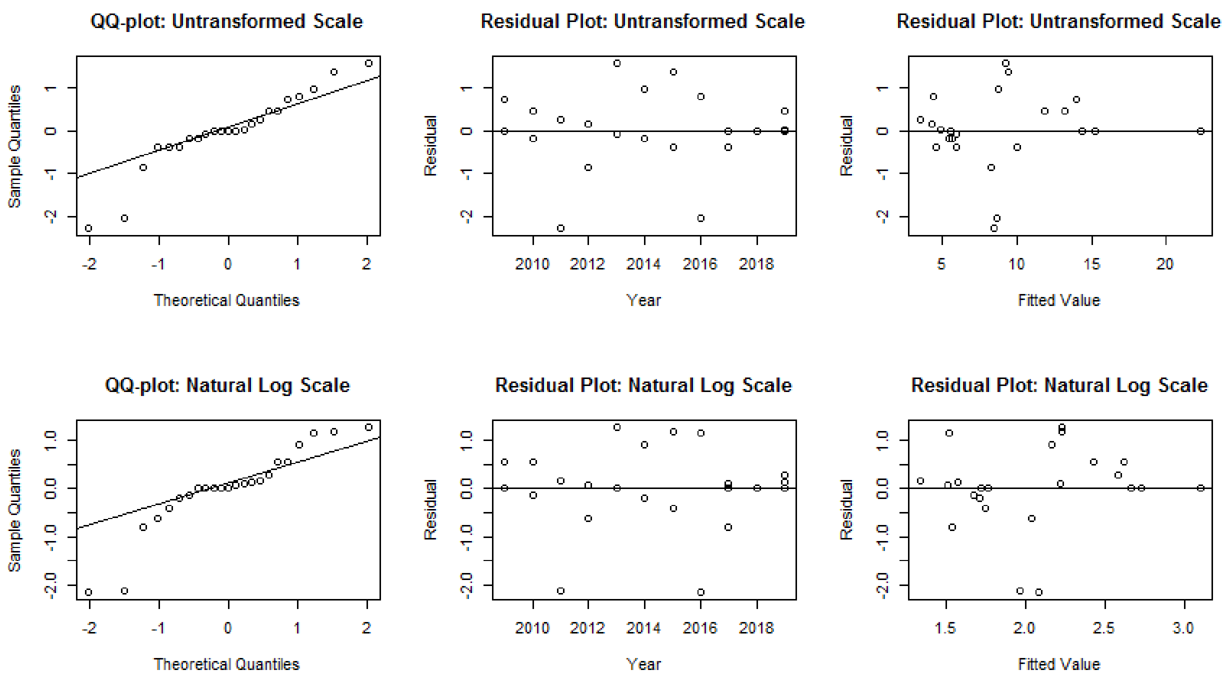
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	30	0	0	0	8.075
Patch	Open-water	12	0	0	0	15.600
Reference B	Open-water	27	0	0	0	4.940

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

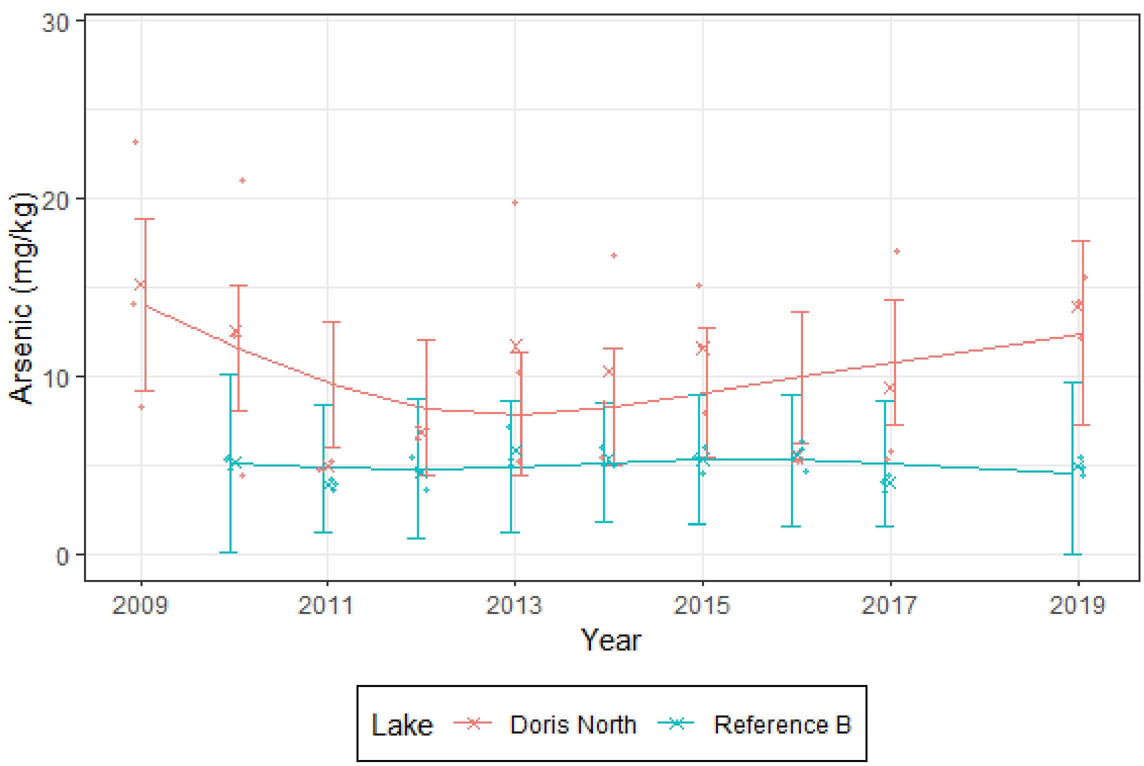
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	8.908	3	0.0305
Compare to Reference B	3.892	3	0.2734

Doris Lake appears to show significant deviation from no trend. Doris Lake does not exhibit significant deviation from the trend of Reference B lake.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was, then detected then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch Lake.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	10.58	6.194	1.708	0.2297	not sig.

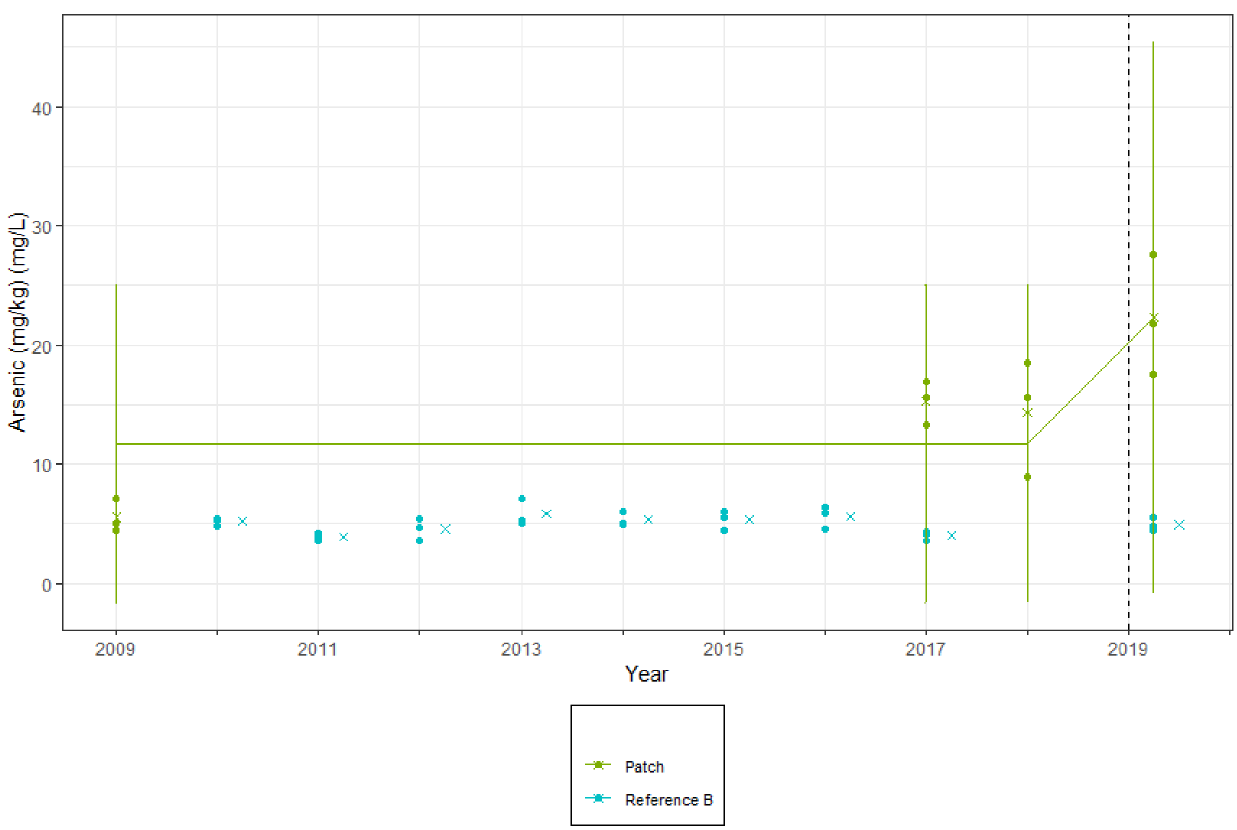
Conclusion:

The change in arsenic concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.2297) different.

BACI analysis not performed.

Observed Data and Fitted Values

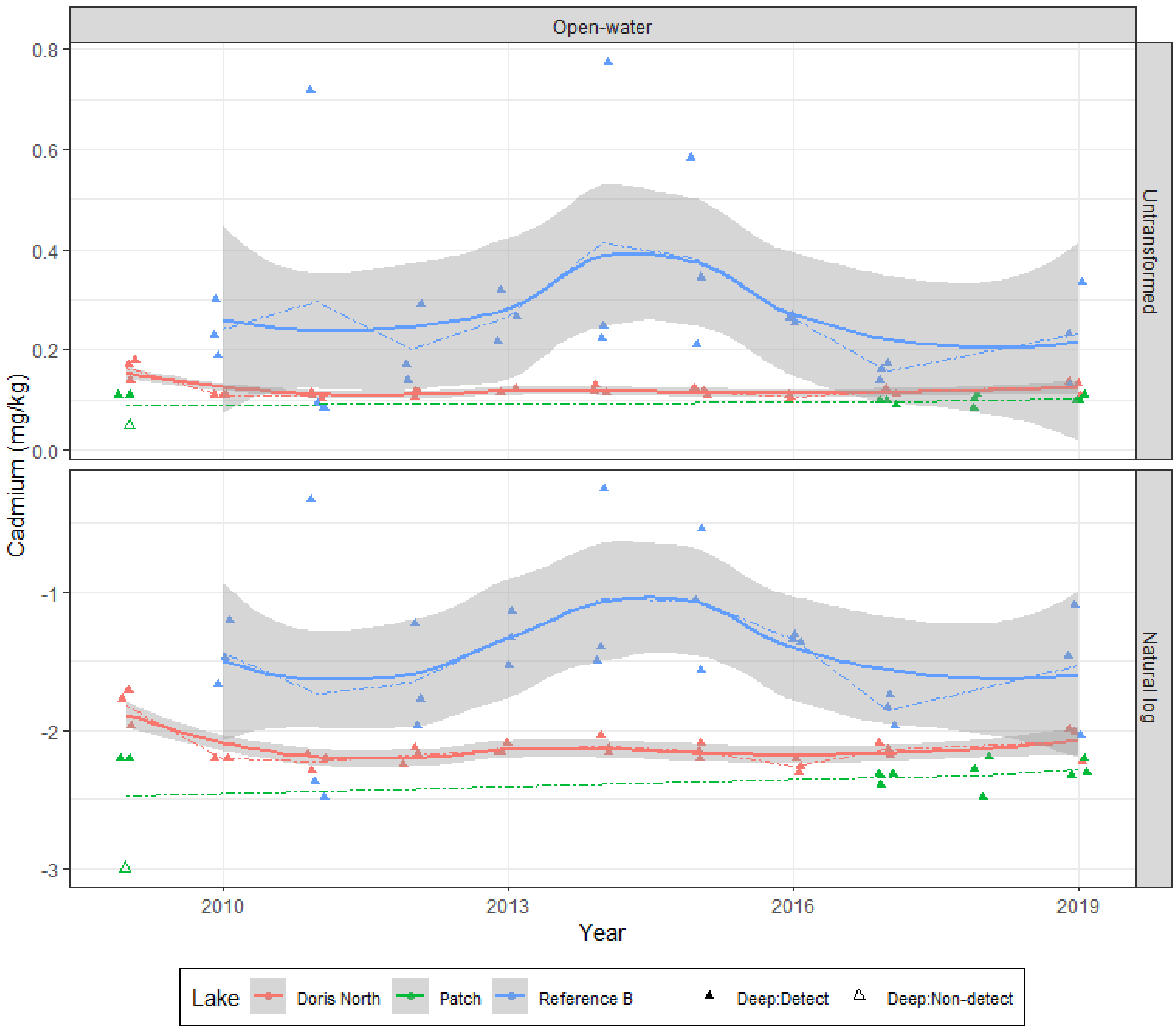
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.3.2 Cadmium

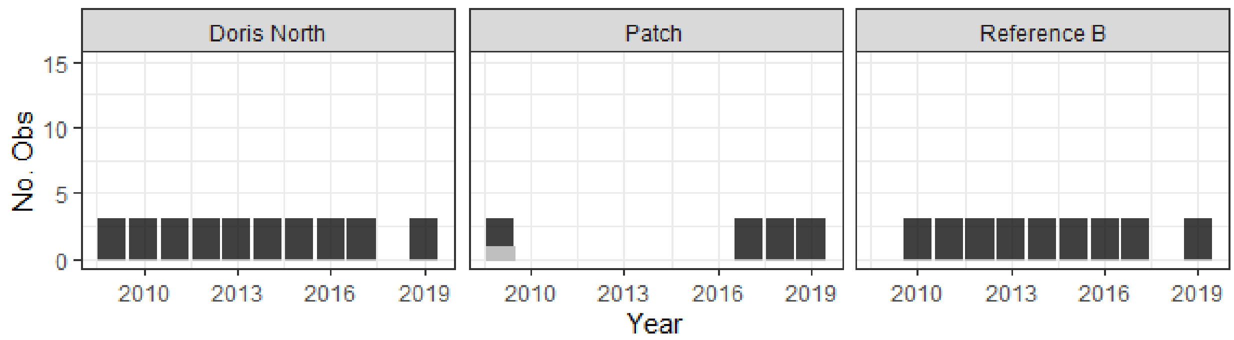
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

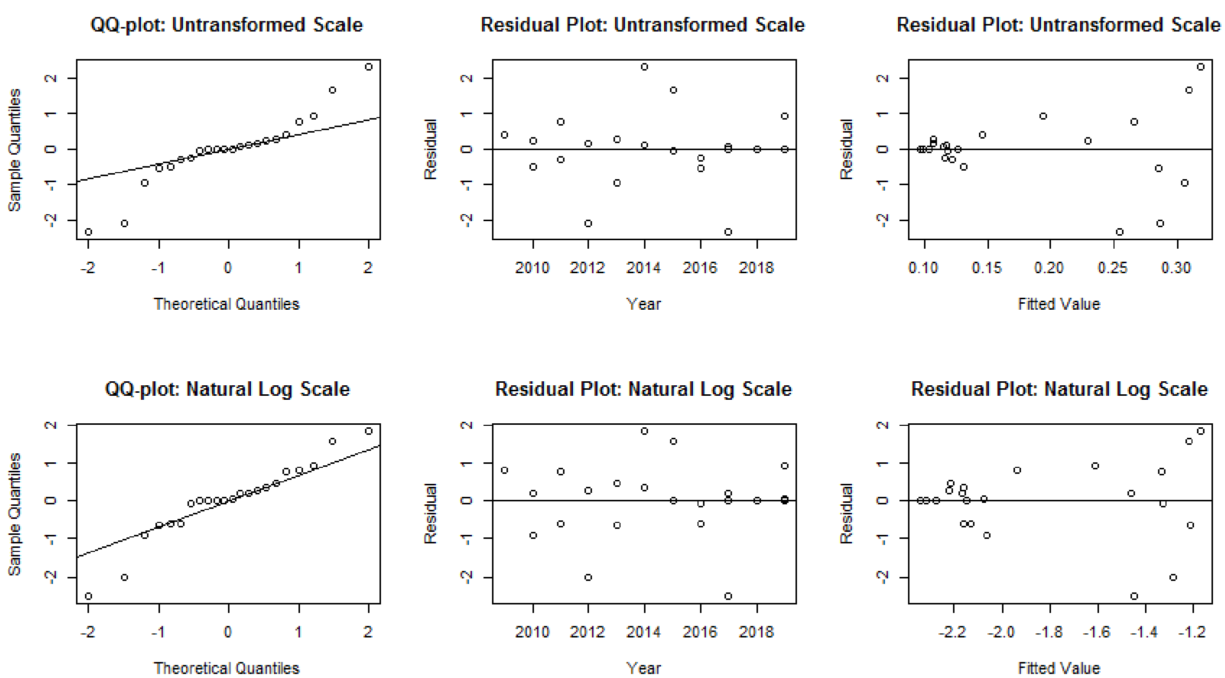
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	30	0	0.00	0	0.115
Patch	Open-water	12	1	0.08	0	0.100
Reference B	Open-water	27	0	0.00	0	0.231

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

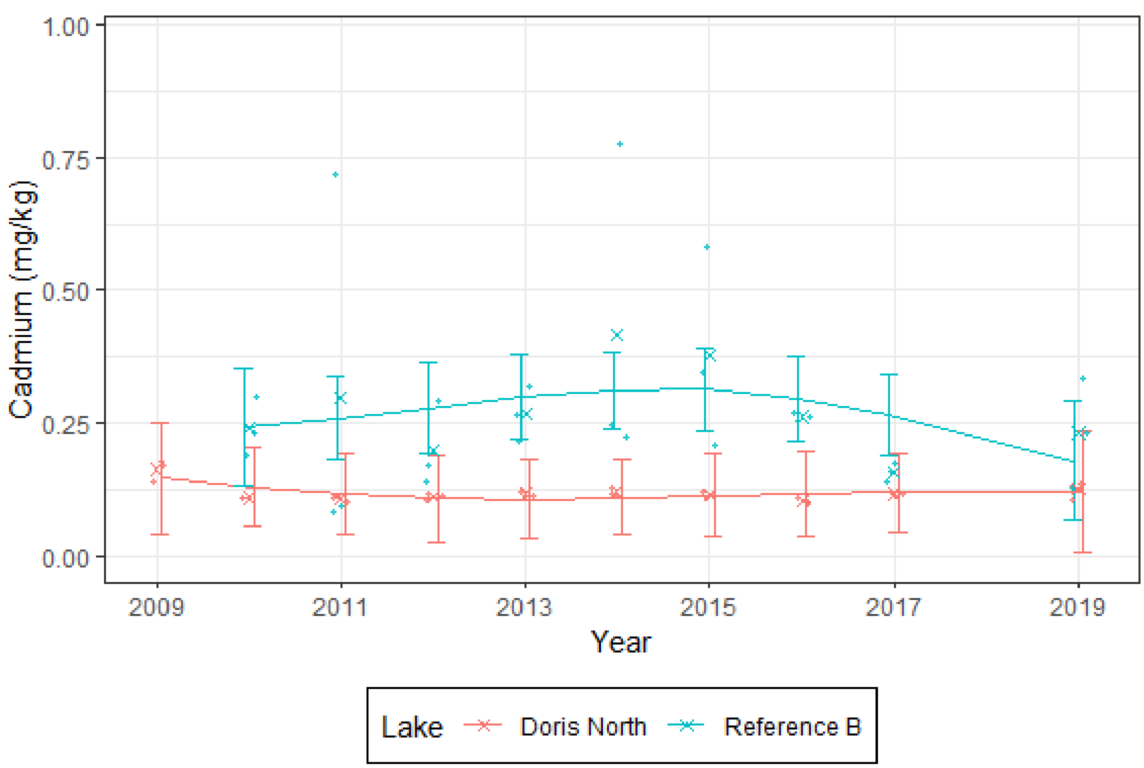
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	0.577	3	0.9017

Doris Lake does not exhibit significant deviation from no trend.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	0.0077	0.0052	1.48	0.2769	not sig.

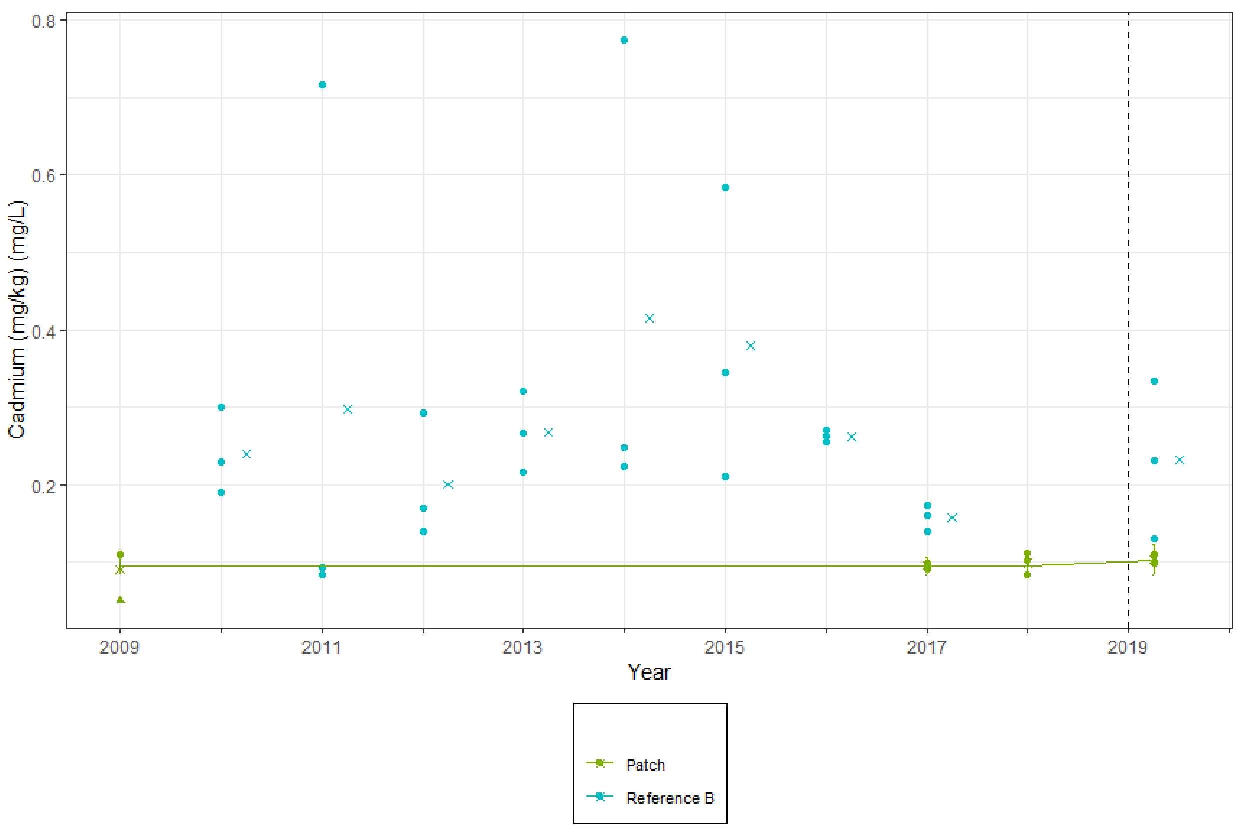
Conclusion:

The change in cadmium concentrations in Patch Lake from *before* to *after* was not significantly ($p = 0.2769$) different.

BACI analysis not performed.

Observed Data and Fitted Values

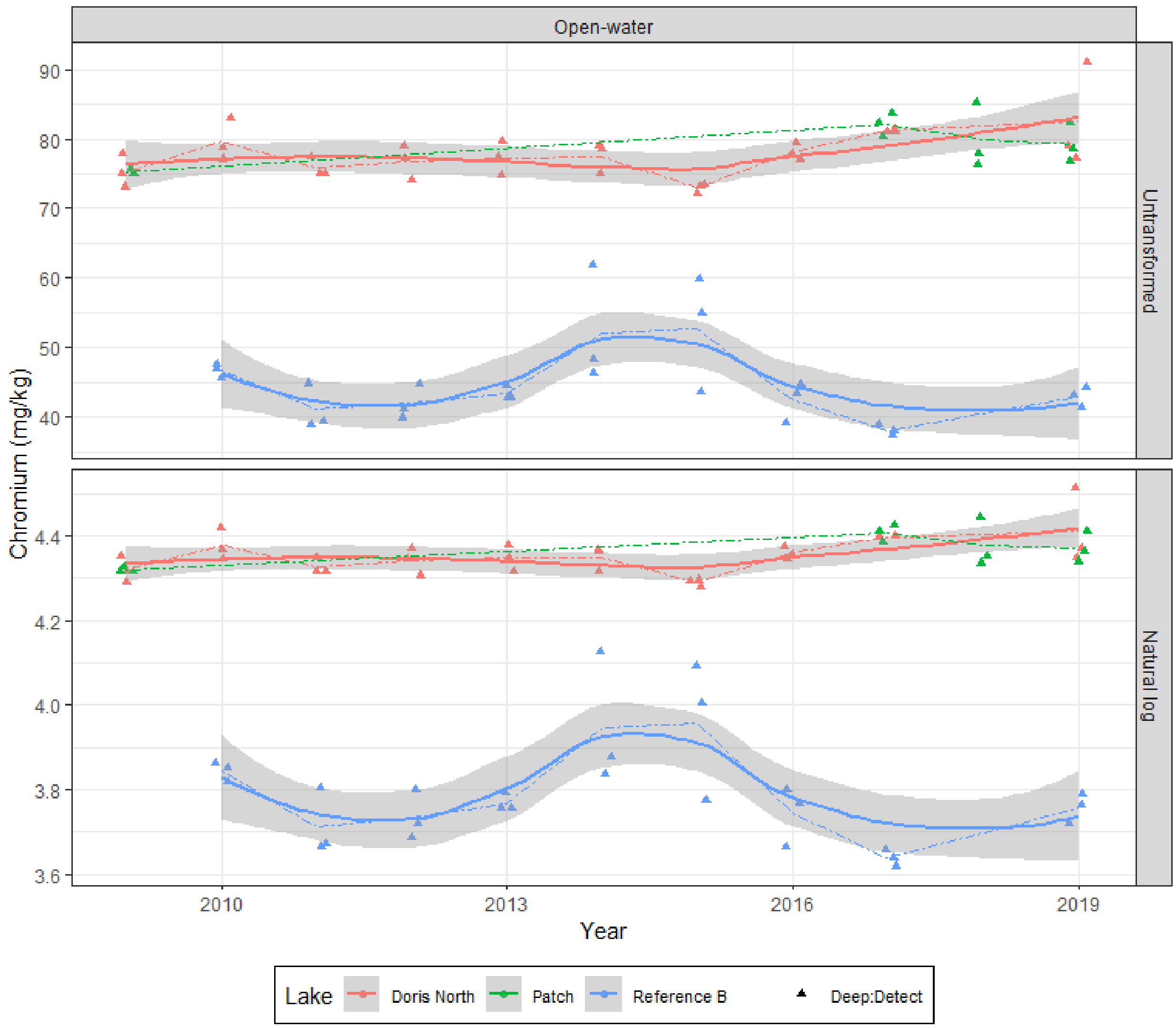
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.3.3 Chromium

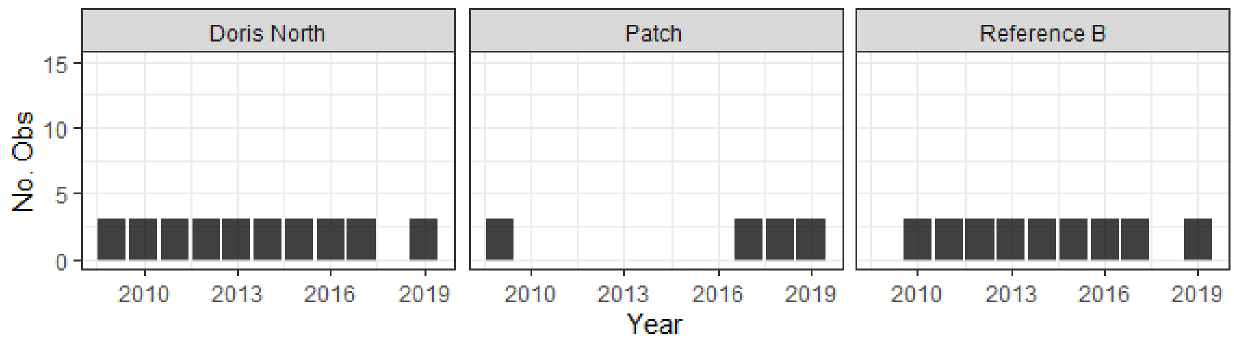
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

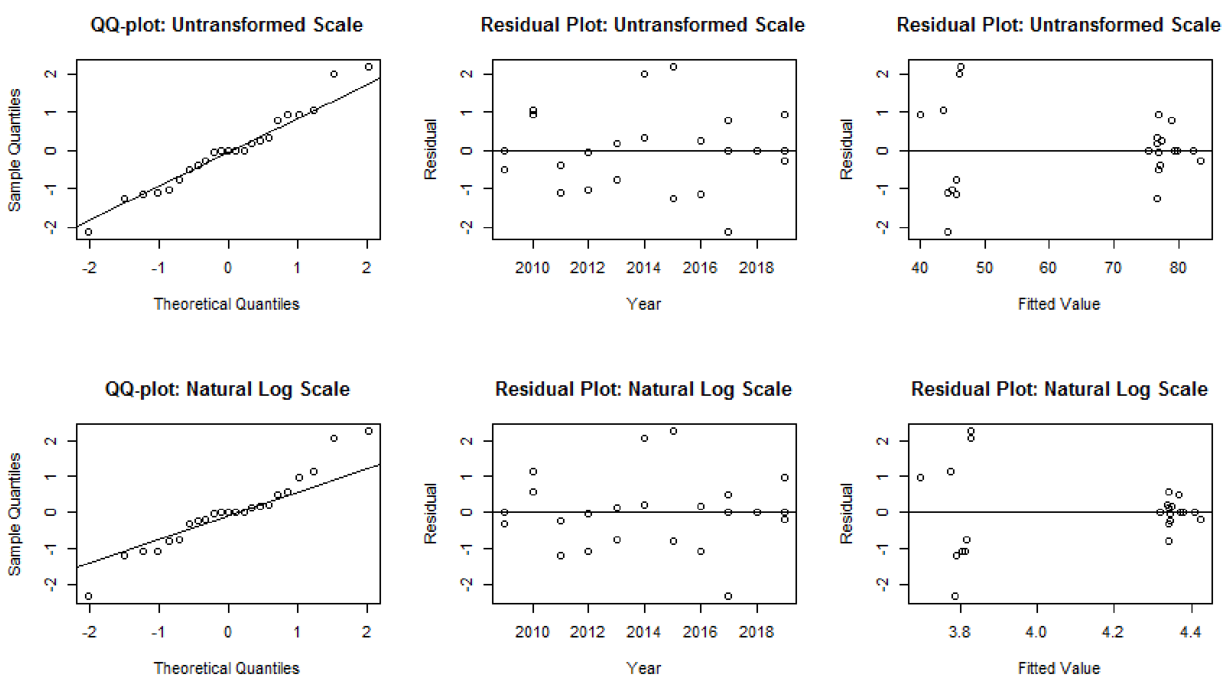
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	30	0	0	0	77.50
Patch	Open-water	12	0	0	0	78.15
Reference B	Open-water	27	0	0	0	43.60

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

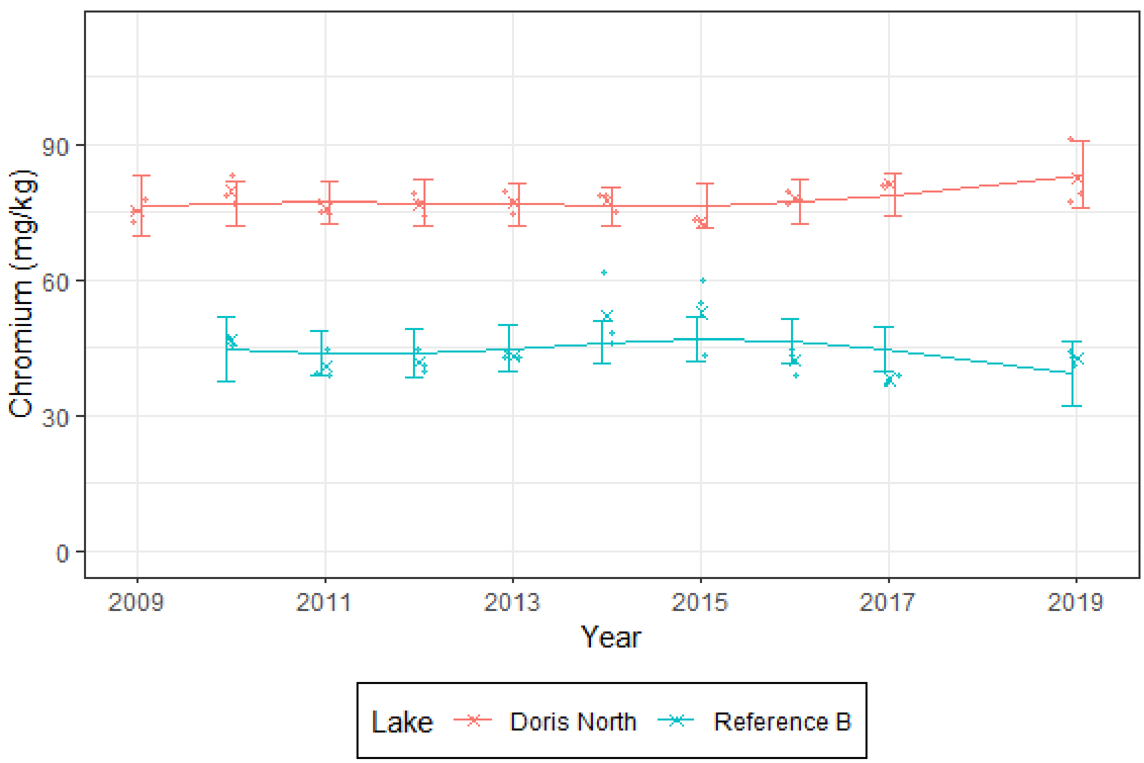
The trend of Doris Lake was compared to a slope of 0. If there is a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	4.08	3	0.2529

Doris Lake does not exhibit significant deviation from no trend.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	0.1667	4.057	0.0411	0.971	not sig.

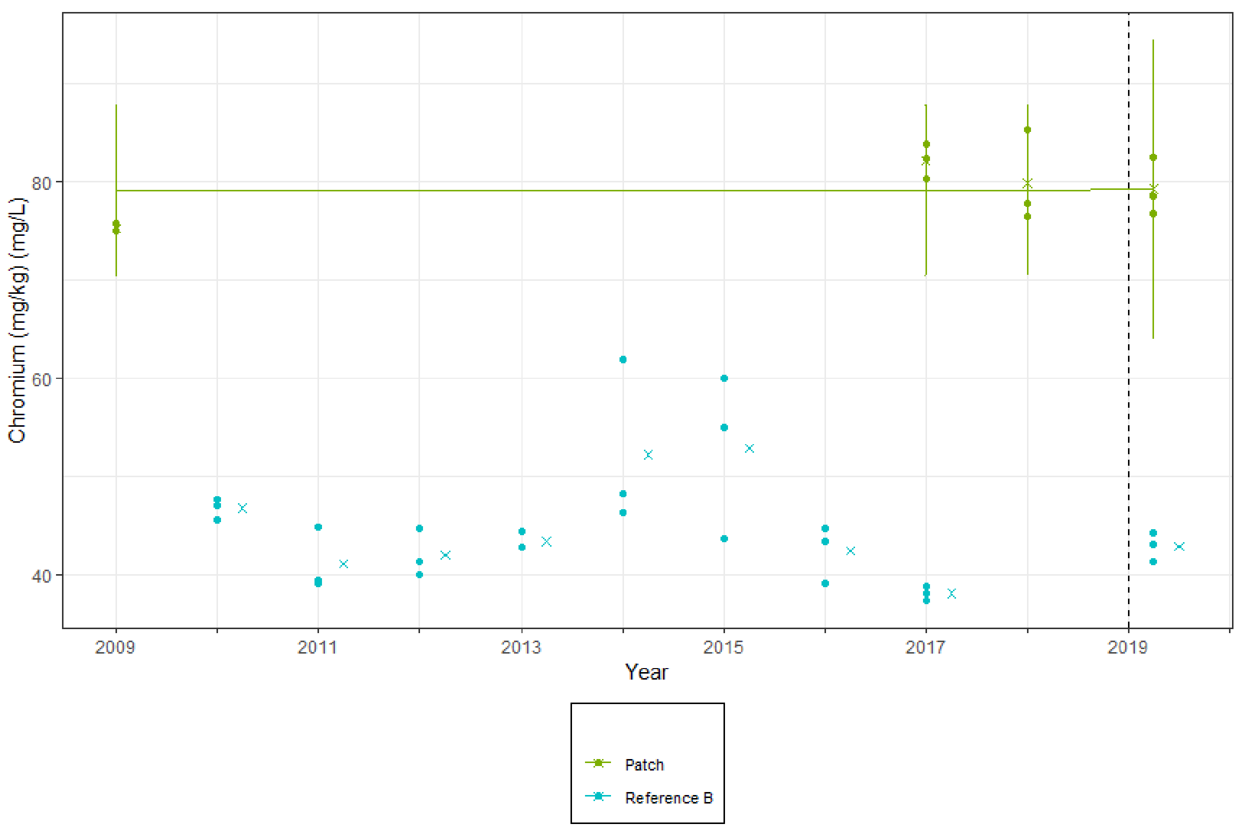
Conclusion:

The change in chromium concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.971) different.

BACI analysis not performed.

Observed Data and Fitted Values

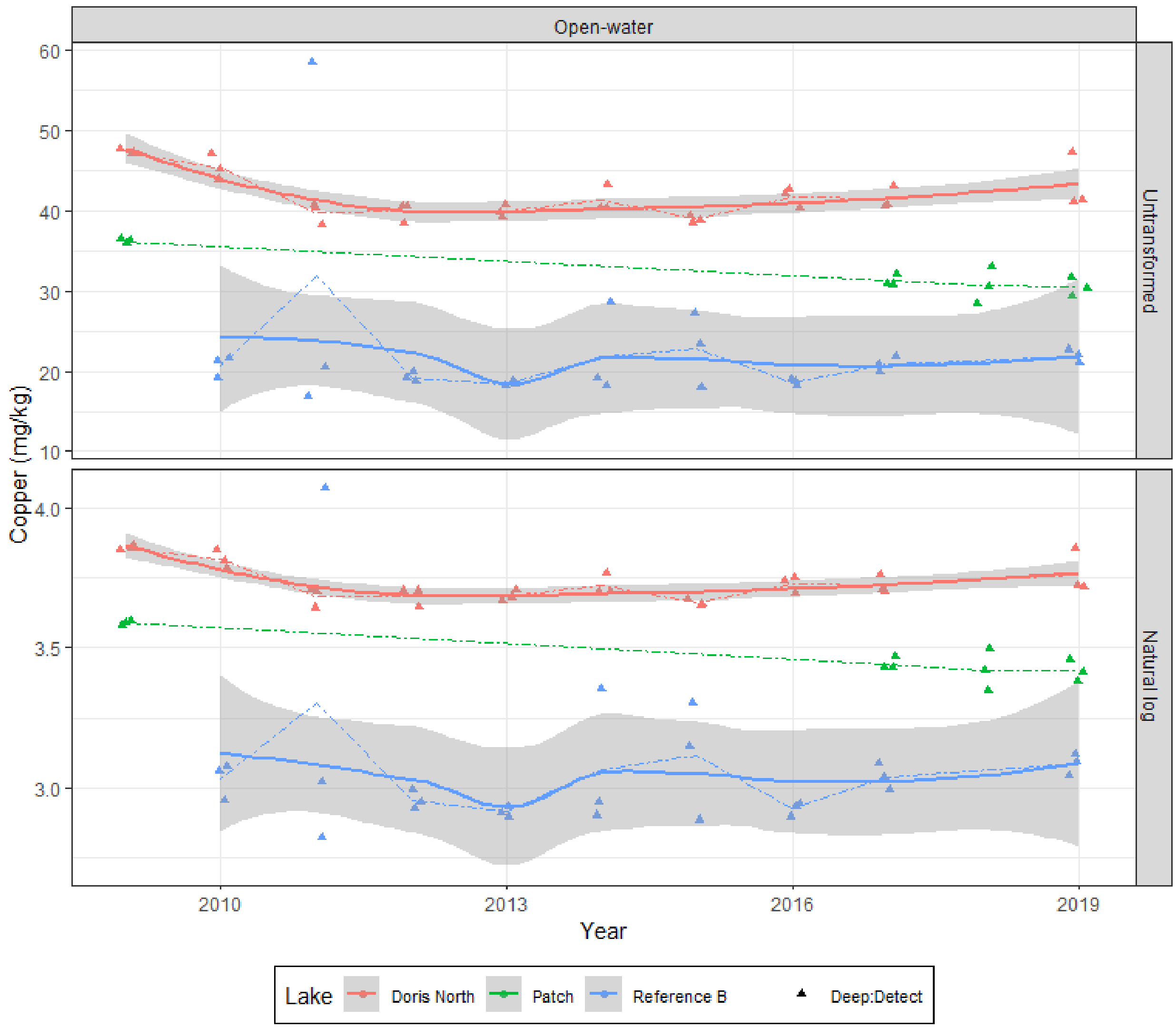
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.3.4 Copper

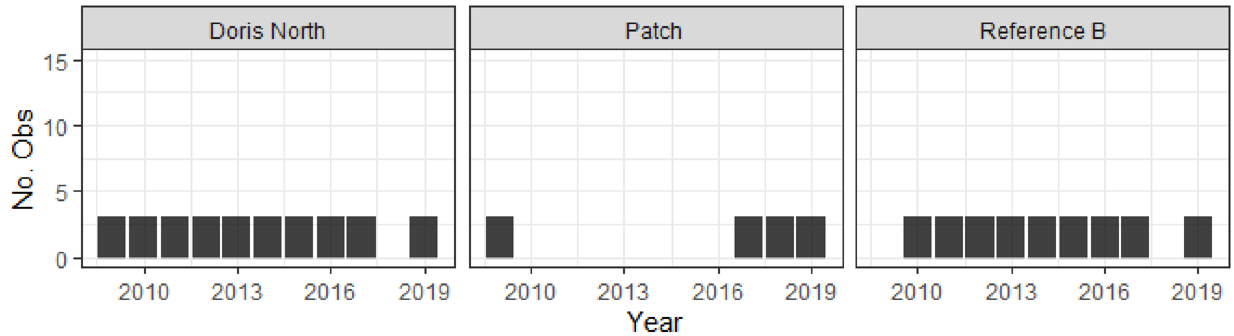
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

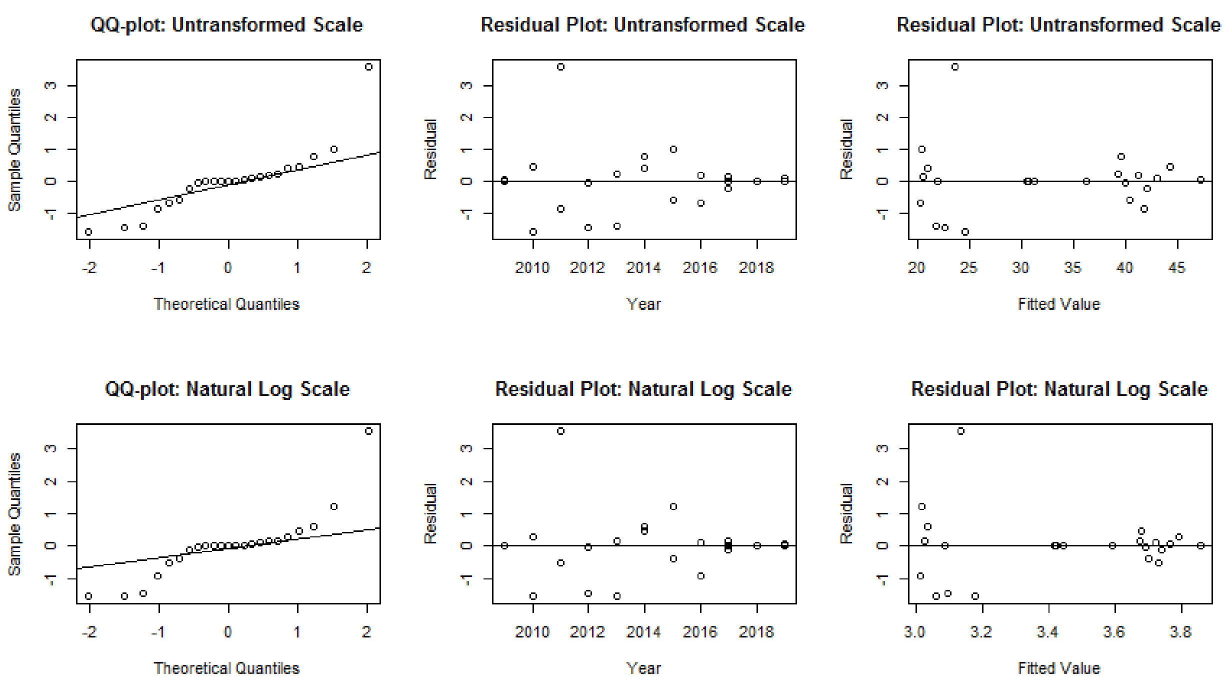
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	30	0	0	0	40.7
Patch	Open-water	12	0	0	0	31.3
Reference B	Open-water	27	0	0	0	19.9

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

	Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
16	Reference B	2011	Open-water	Deep	31.93	23.54	3.564

Outliers on natural log scale:

	Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
16	Reference B	2011	Open-water	Deep	31.93	3.134	3.54

The natural log transformed model better meets the residual assumptions. Analysis proceeds with natural log transformed data.

Doris Lake

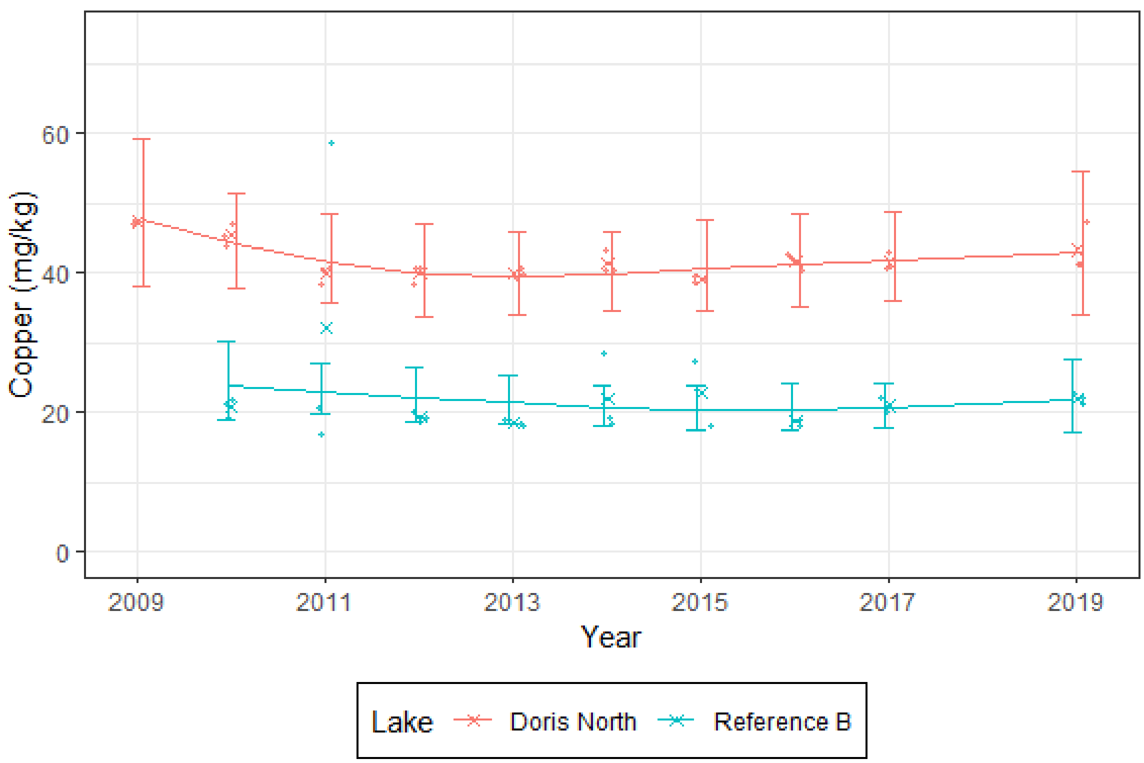
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	2.804	3	0.4228

Doris Lake does not exhibit significant deviation from no trend.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	-0.0665	0.1045	-0.6364	0.5896	not sig.

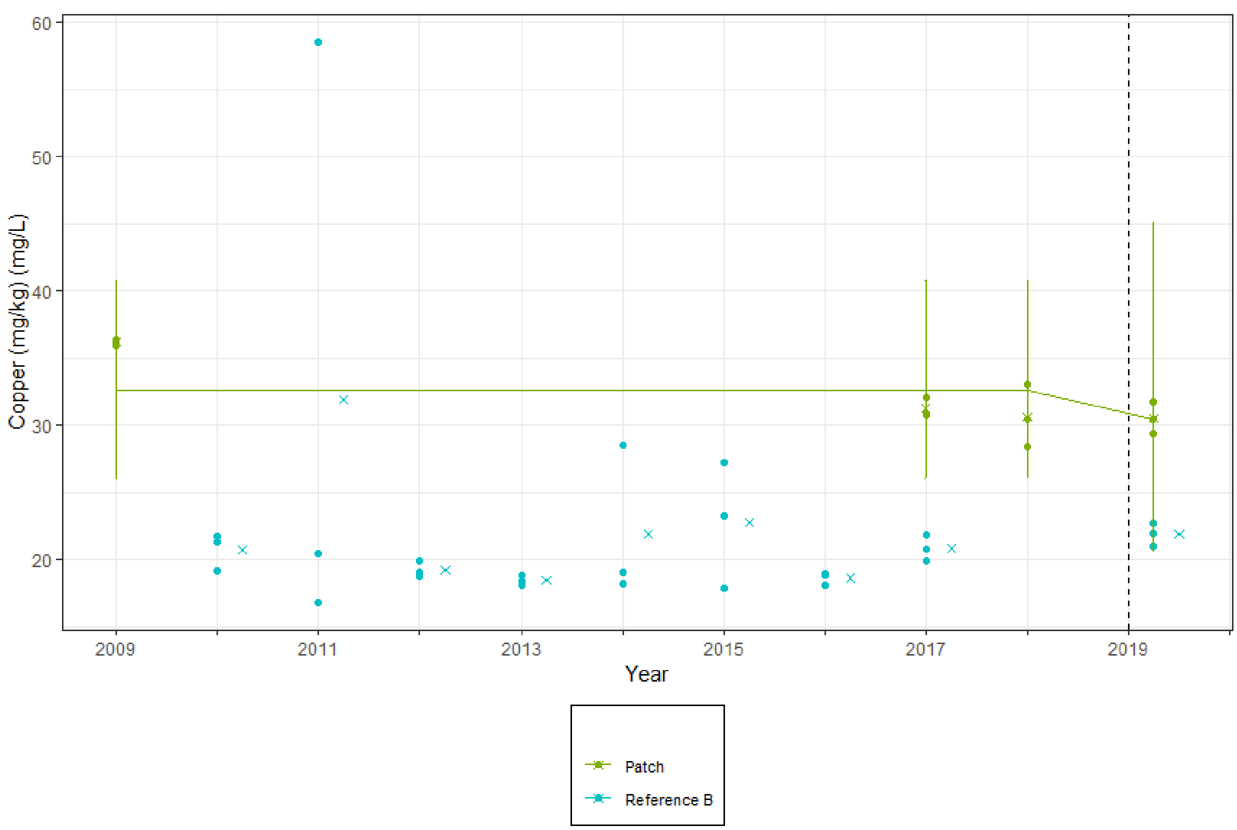
Conclusion:

The change in copper concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.5896) different.

BACI analysis not performed.

Observed Data and Fitted Values

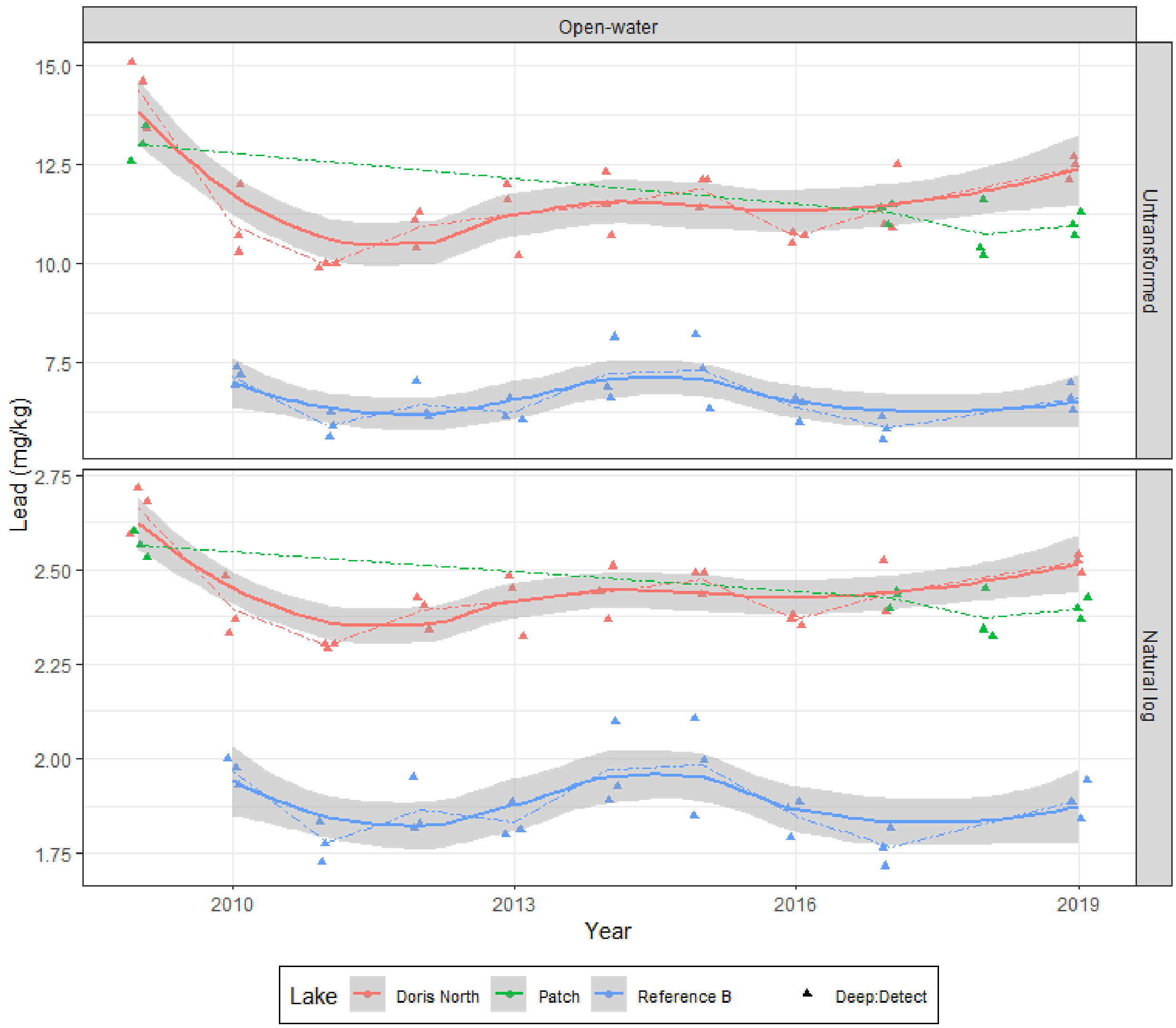
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.3.5 Lead

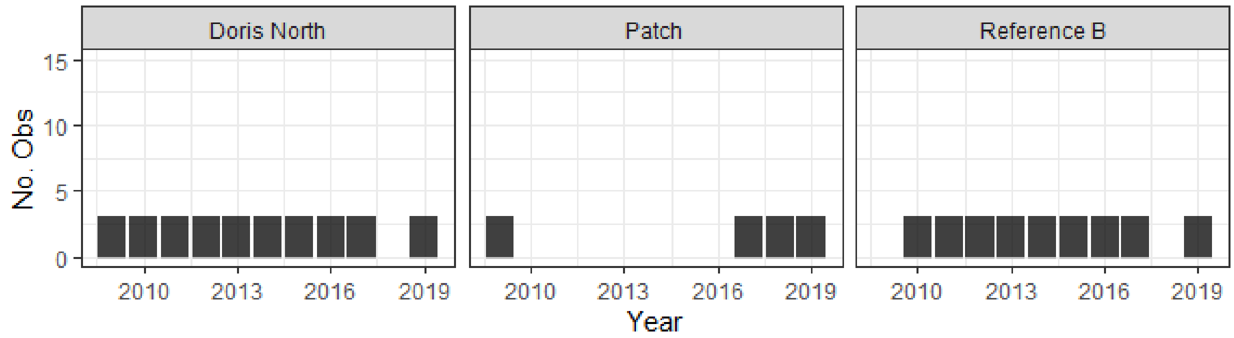
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

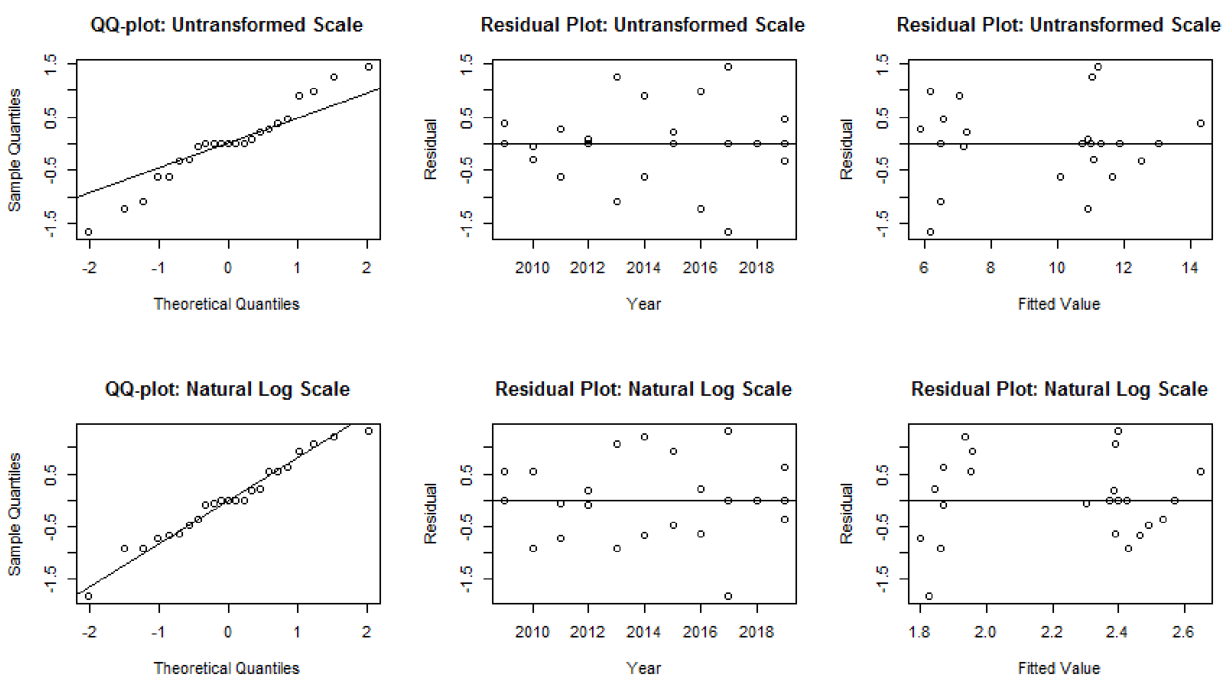
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	30	0	0	0	11.35
Patch	Open-water	12	0	0	0	11.35
Reference B	Open-water	27	0	0	0	6.49

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

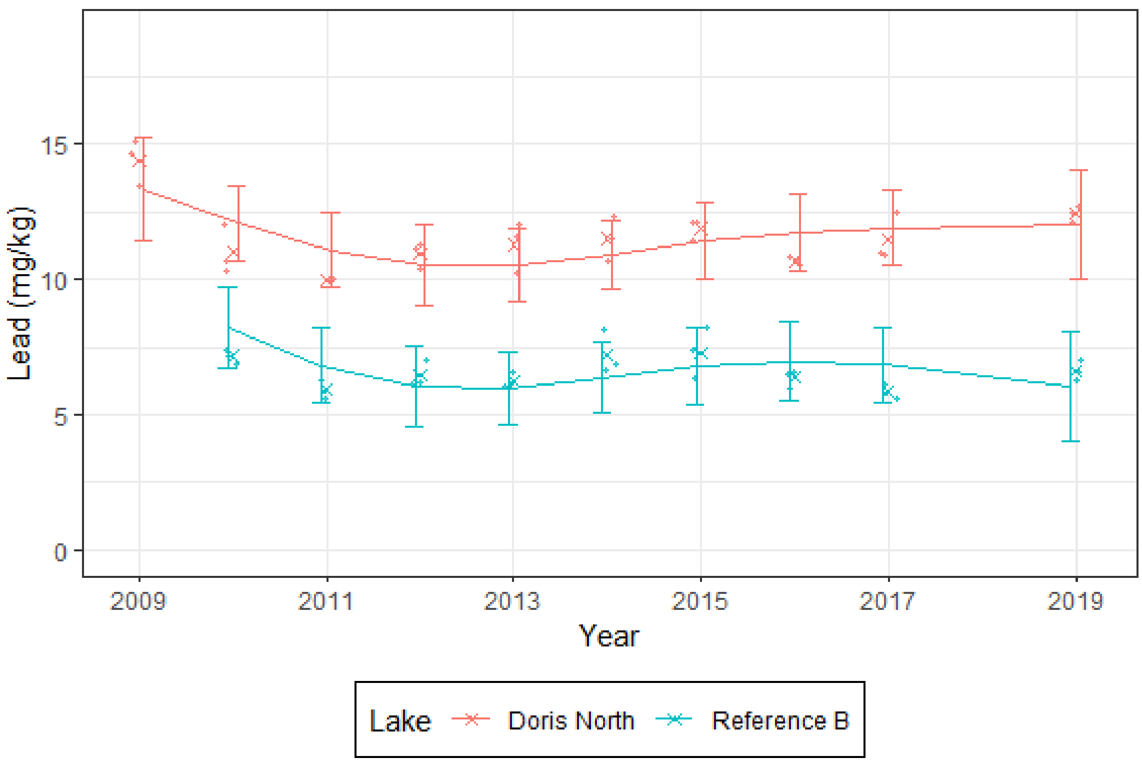
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	10.83	3	0.0127
Compare to Reference B	29.65	3	0.0000

Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B lake.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	-0.6889	1.384	-0.4979	0.6679	not sig.

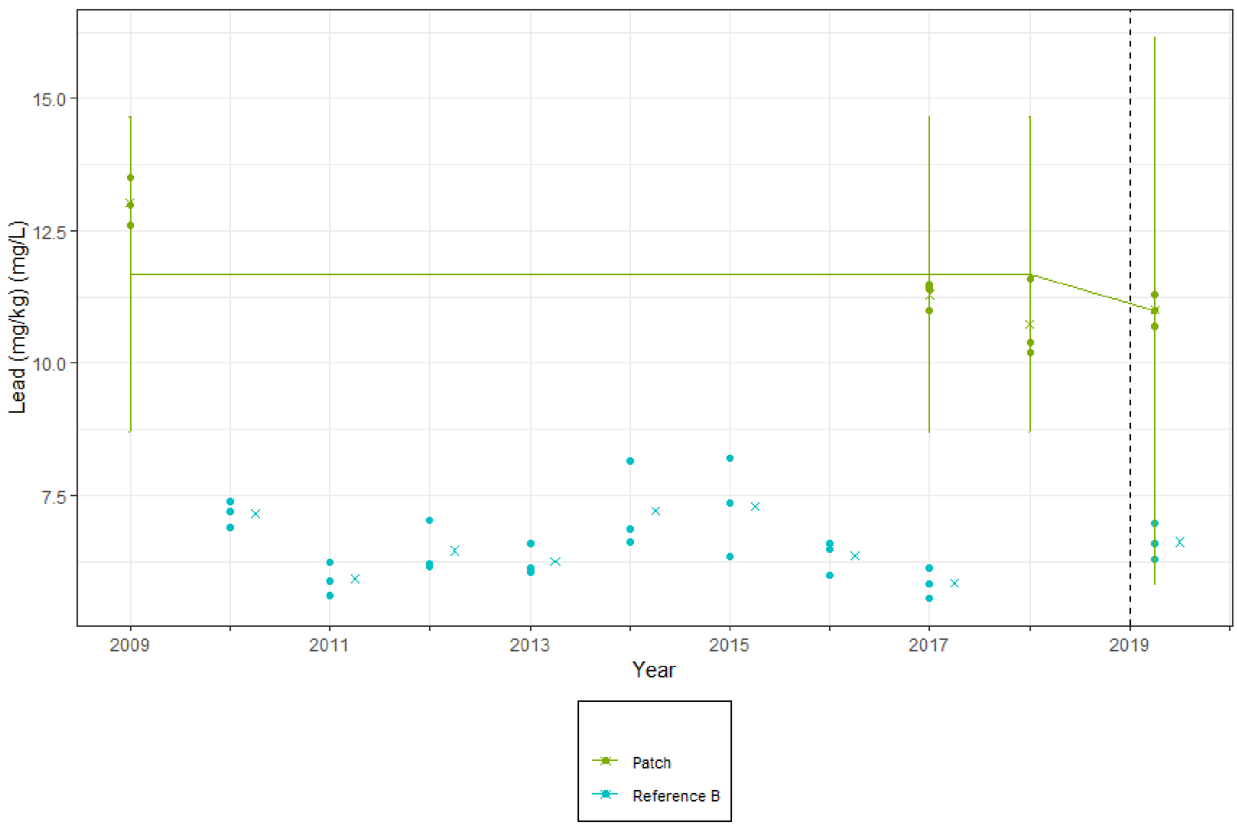
Conclusion:

The change in lead concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.6679) different.

BACI analysis not performed.

Observed Data and Fitted Values

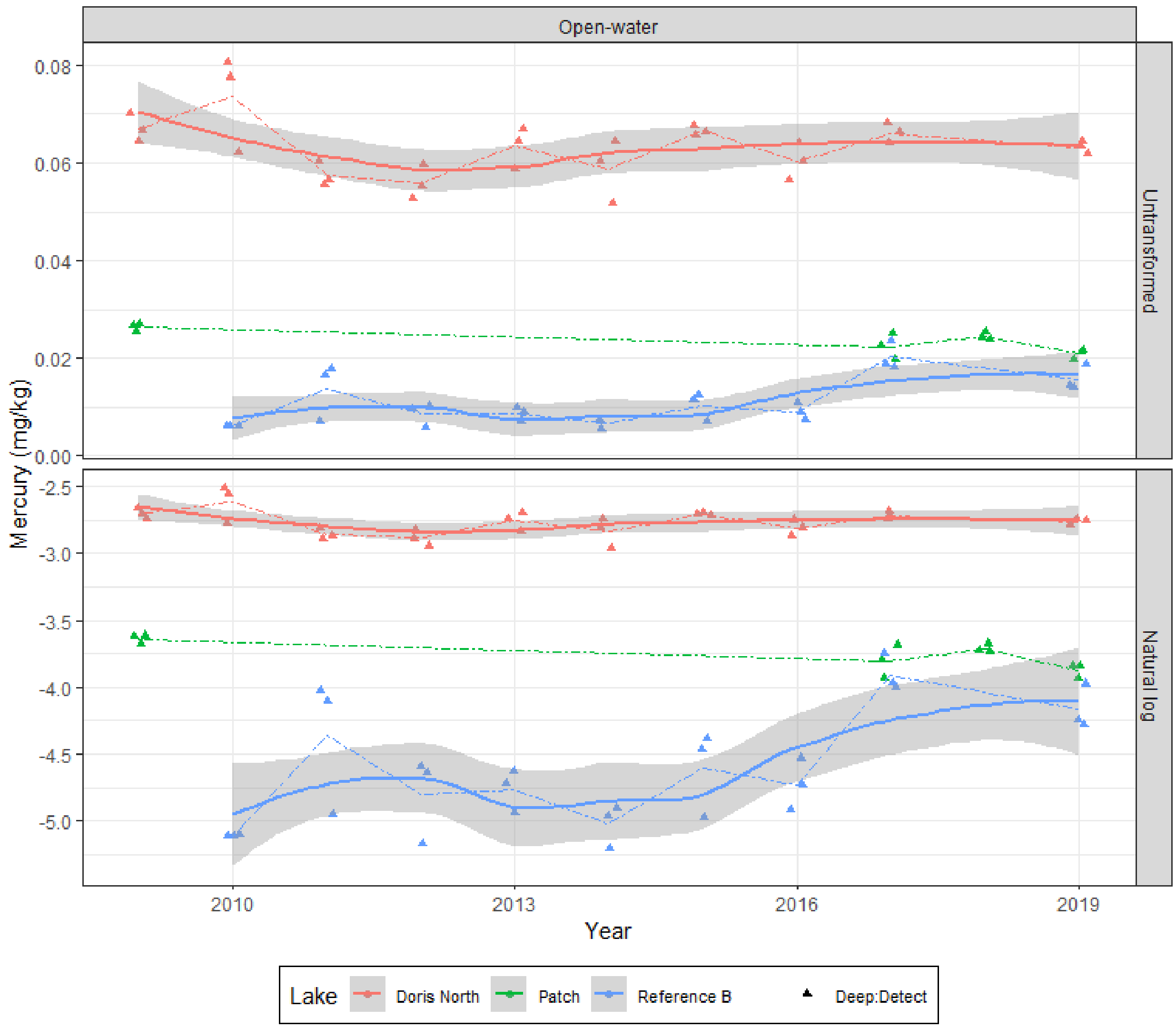
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.3.6 Mercury

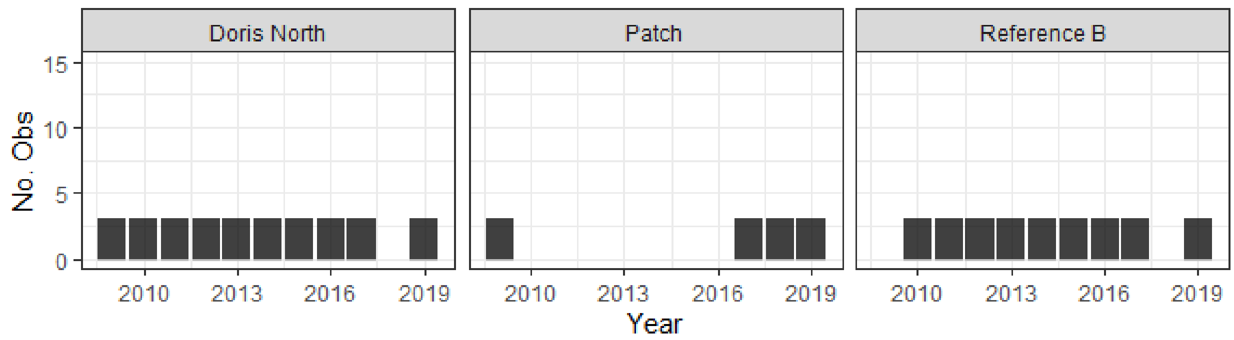
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

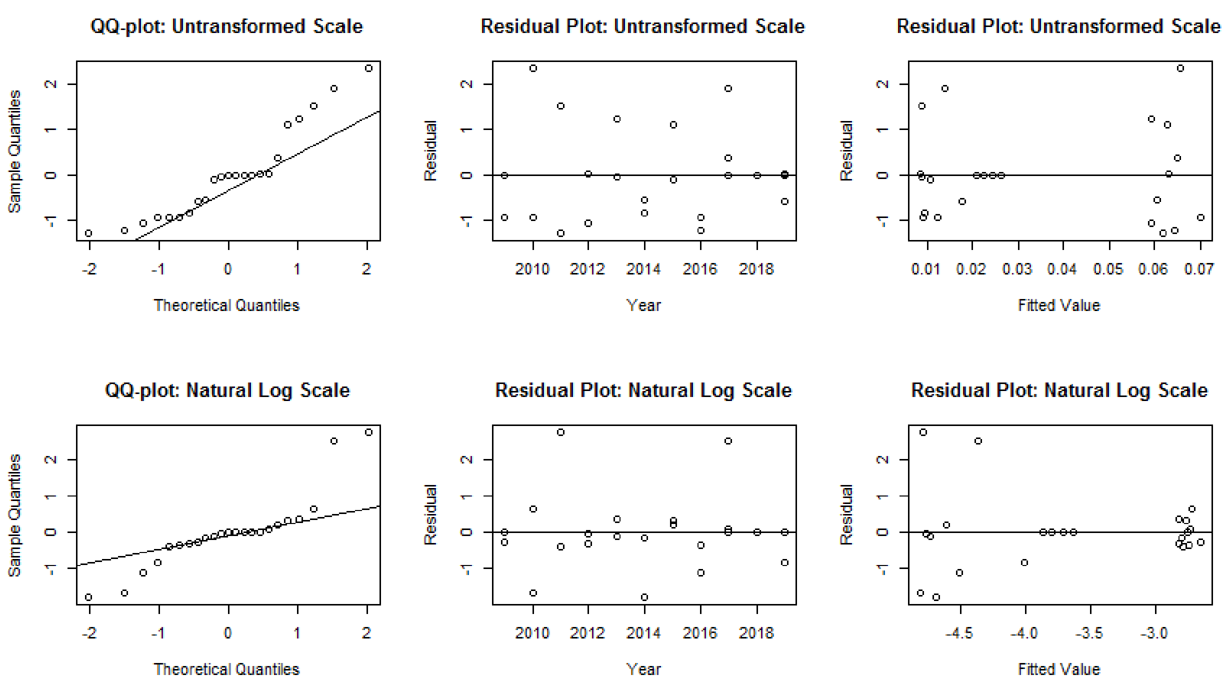
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	30	0	0	0	0.0640
Patch	Open-water	12	0	0	0	0.0240
Reference B	Open-water	27	0	0	0	0.0097

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

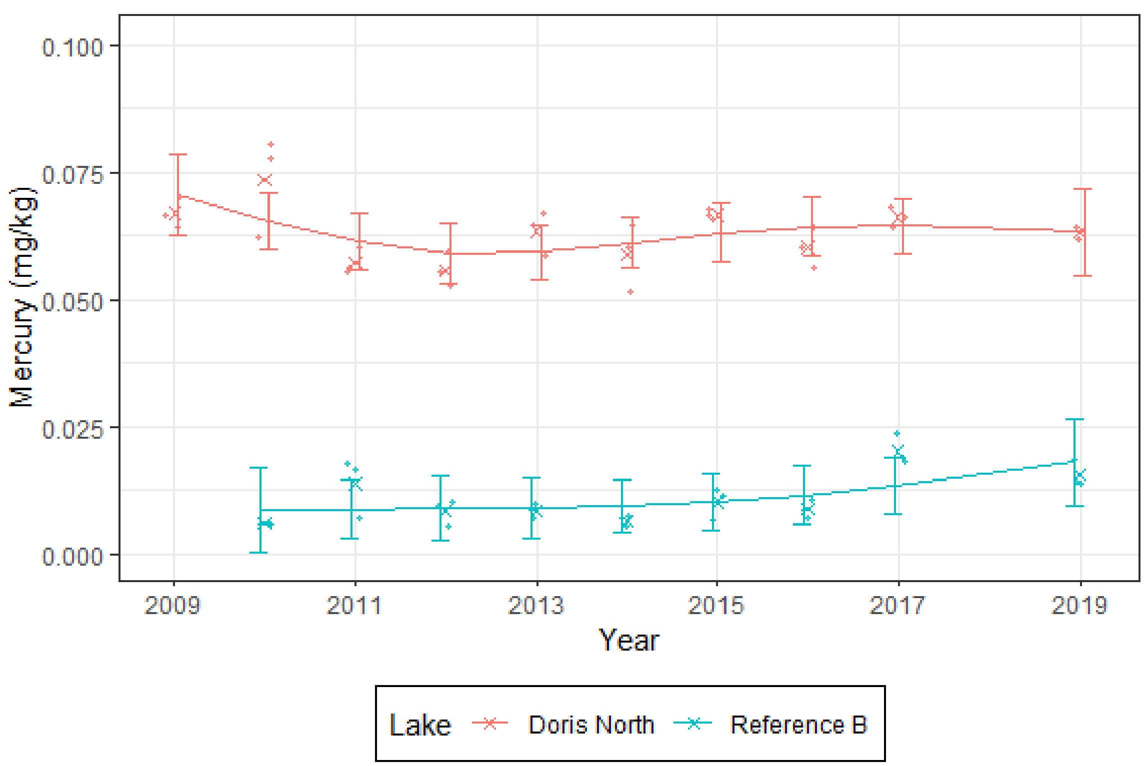
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	7.49	3	0.0578

Doris Lake does not exhibit significant deviation from no trend.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	-0.0036	0.0023	-1.578	0.2553	not sig.

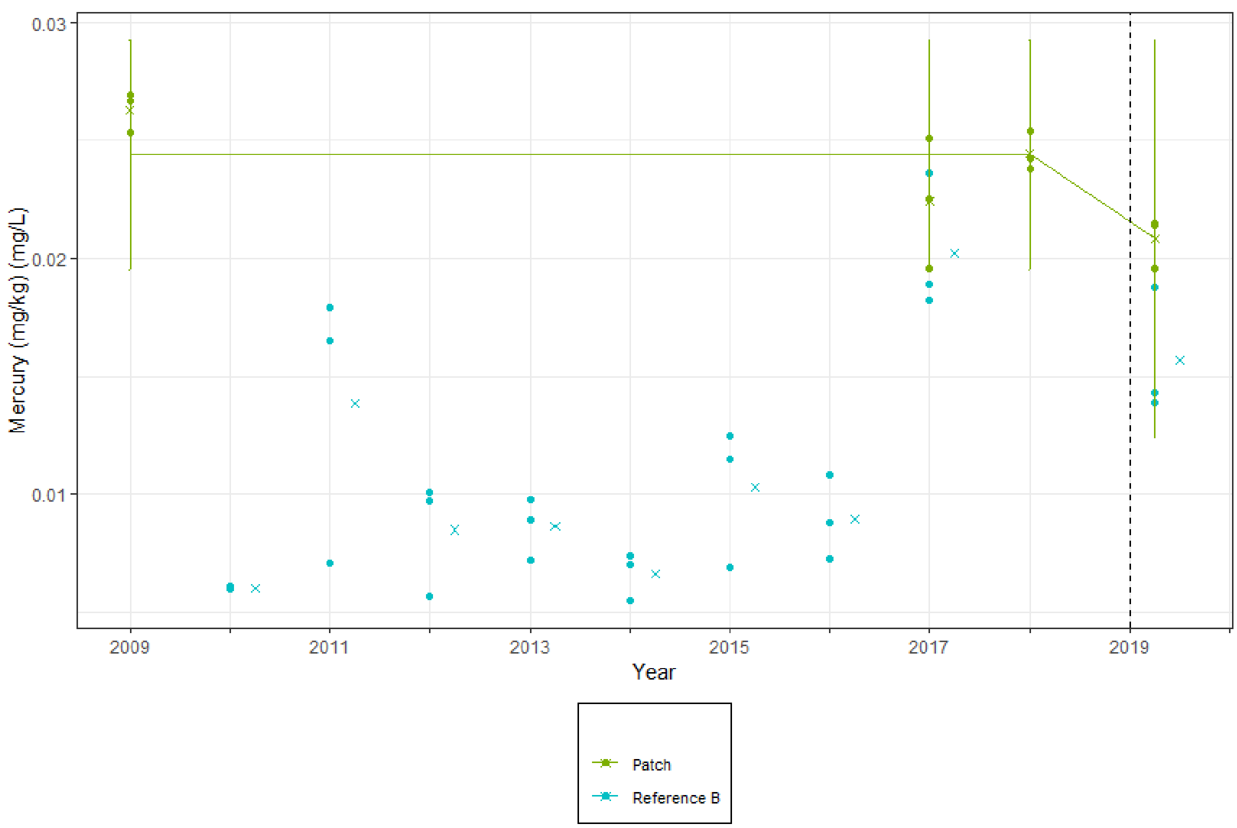
Conclusion:

The change in mercury concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.2553) different.

BACI analysis not performed.

Observed Data and Fitted Values

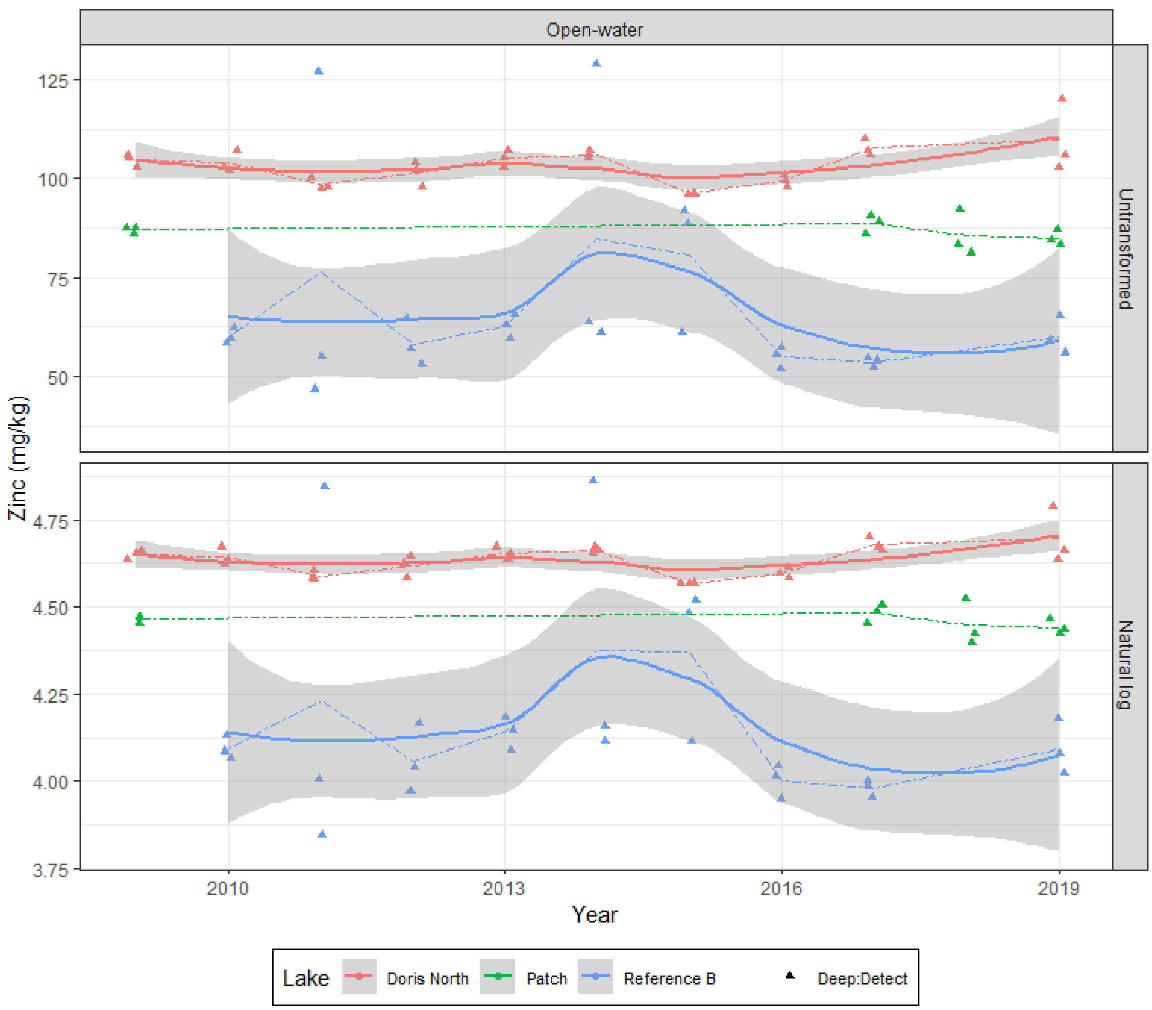
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.3.7 Zinc

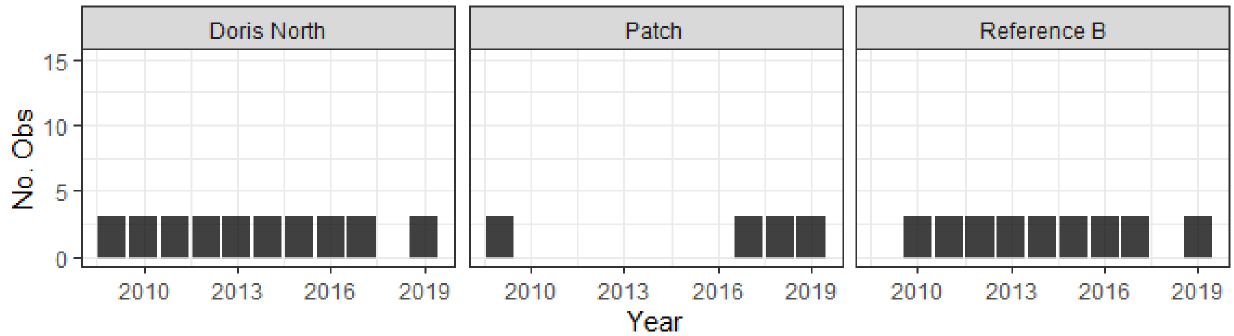
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

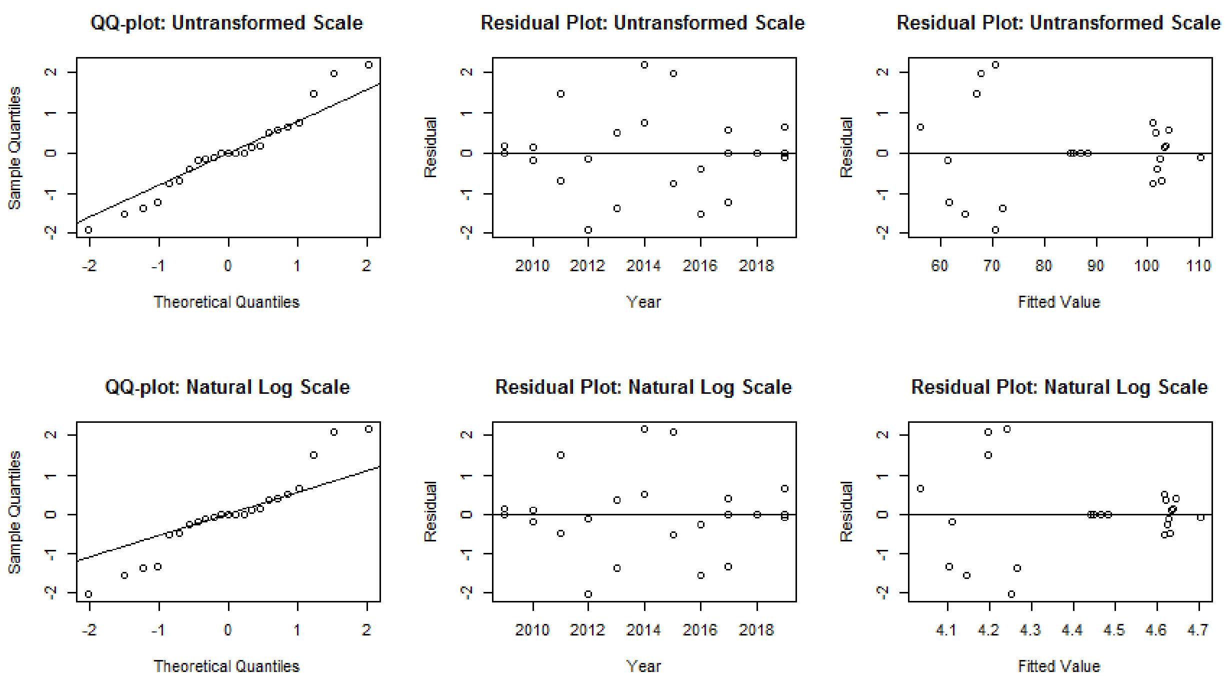
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	30	0	0	0	103.0
Patch	Open-water	12	0	0	0	86.6
Reference B	Open-water	27	0	0	0	59.5

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on natural log scale: None

The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

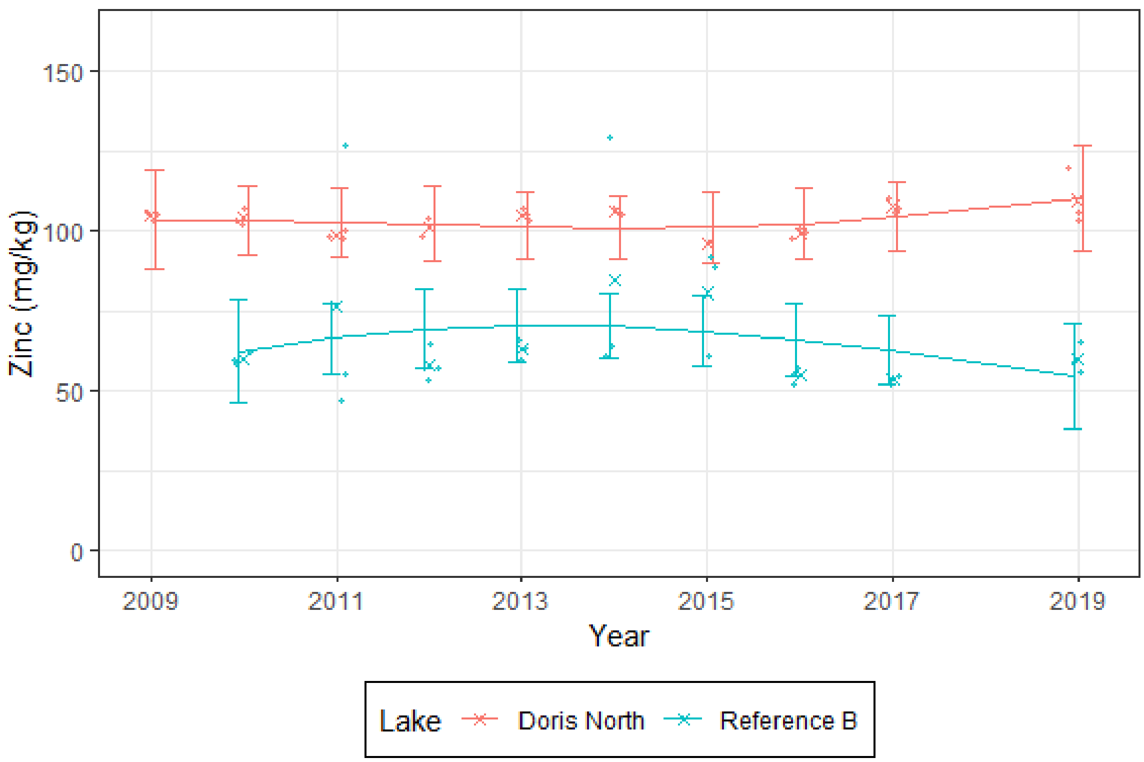
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	1.211	3	0.7503

Doris Lake does not exhibit significant deviation from no trend.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
periodafter	-2.078	1.733	-1.199	0.3533	not sig.

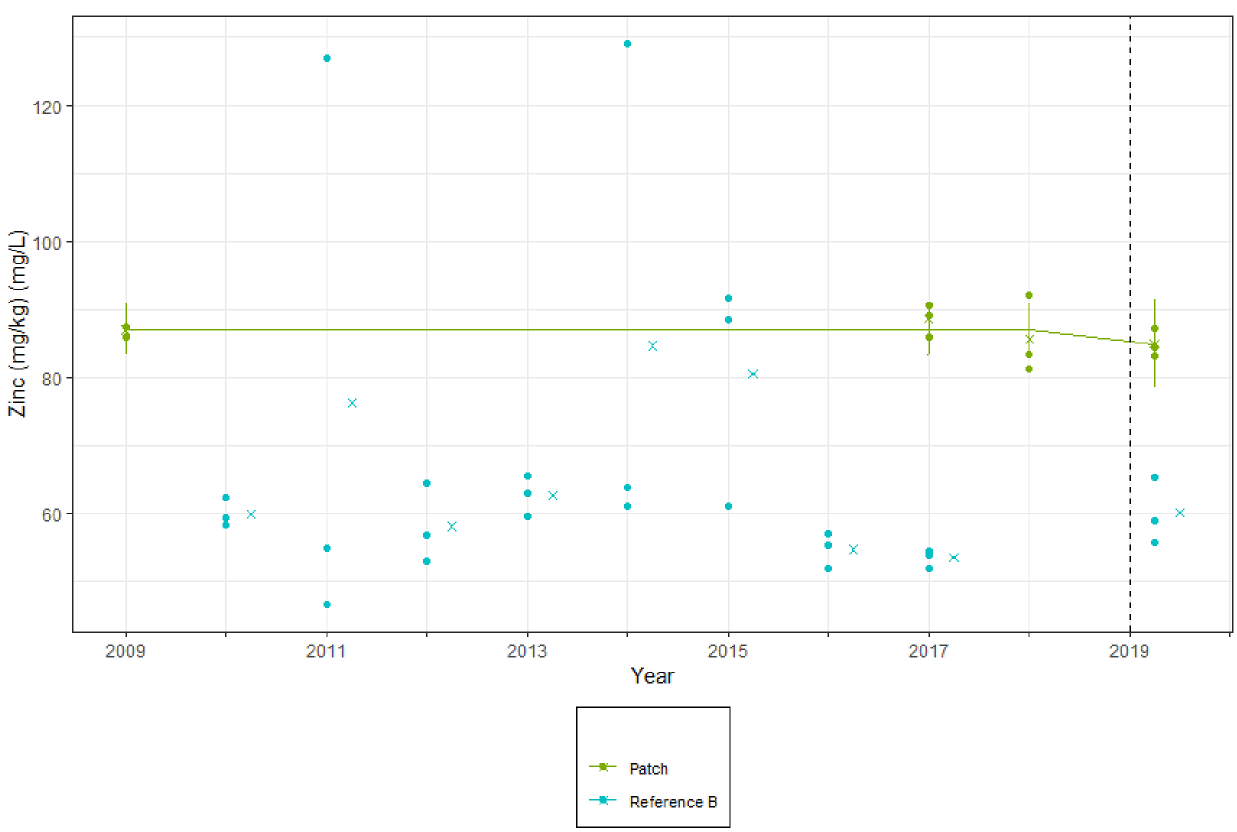
Conclusion:

The change in zinc concentrations in Patch Lake from *before* to *after* was not significantly (p = 0.3533) different.

BACI analysis not performed.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The symbols represent the observed data values (x’s represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



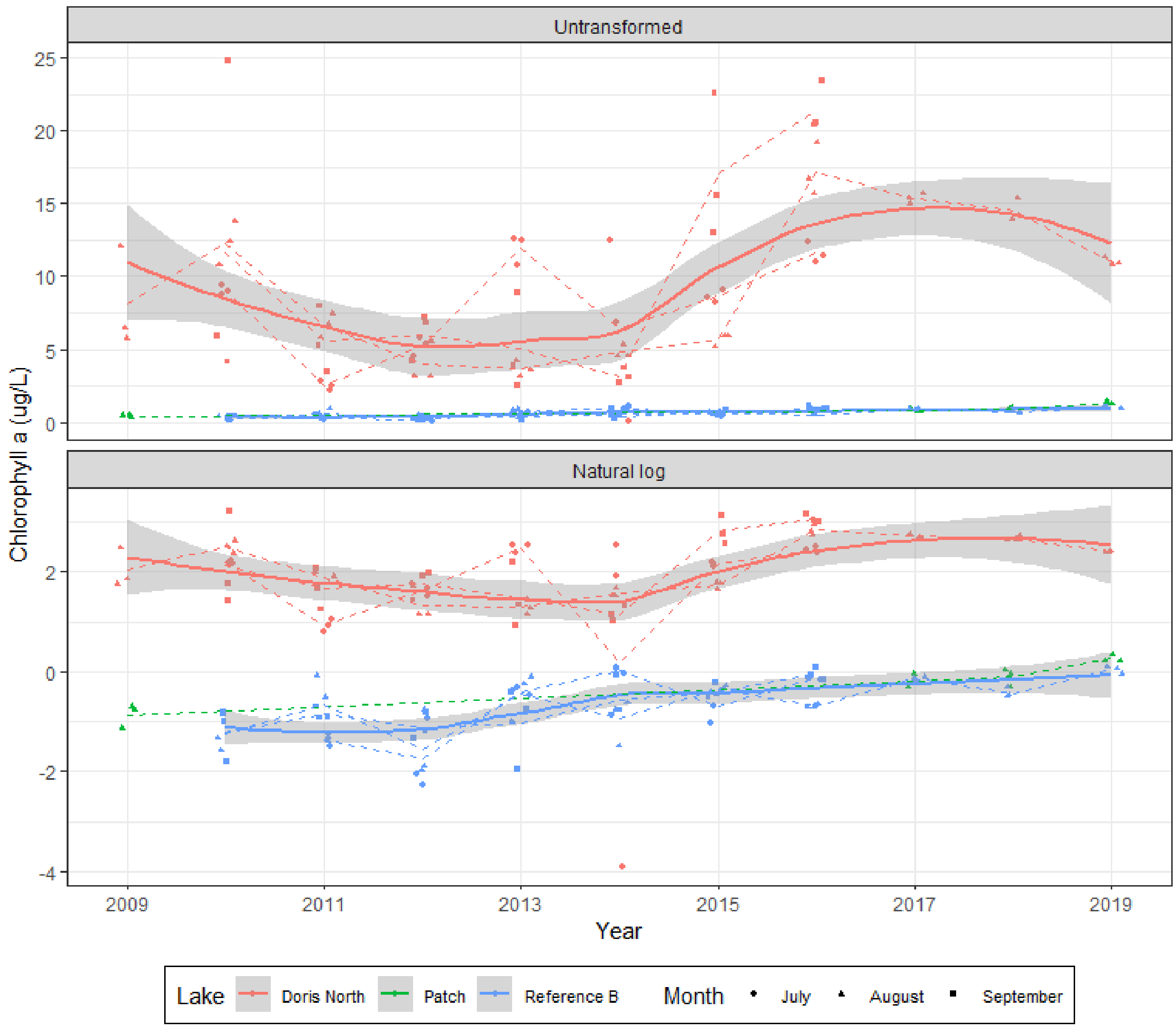
C.3.4 Phytoplankton Biomass (as Chlorophyll a)

Annual and monthly means

Lake	Year	Annual Mean	July	August	September
Doris	2009	8.1133		8.1133	
Doris	2010	11.0056	9.0700	12.3333	11.6133
Doris	2011	4.9400	2.5467	6.6833	5.5900
Doris	2012	5.0900	5.2333	3.9733	6.0633
Doris	2013	6.9067	11.9667	3.6467	5.1067
Doris	2014	4.8267	6.4467	4.8400	3.1933
Doris	2015	10.4667	8.6400	5.6933	17.0667
Doris	2016	16.7600	11.6000	17.2133	21.4667
Doris	2017	15.3845		15.3845	
Doris	2018	14.5417		14.5417	
Doris	2019	11.0524		11.0524	
Patch	2009	0.4290		0.4290	
Patch	2017	0.8257		0.8257	
Patch	2018	0.9129		0.9129	
Patch	2019	1.3038		1.3038	
Reference B	2010	0.3128		0.2997	0.3260
Reference B	2011	0.4274	0.2563	0.5943	0.4317
Reference B	2012	0.2658	0.2070	0.2530	0.3373
Reference B	2013	0.5956	0.6767	0.6833	0.4267
Reference B	2014	0.6873	1.0407	0.4140	0.6073
Reference B	2015	0.6365	0.5180	0.7153	0.6762
Reference B	2016	0.7821	0.8793	0.5090	0.9580
Reference B	2017	0.8727		0.8727	
Reference B	2018	0.6578		0.6578	
Reference B	2019	1.0469		1.0469	

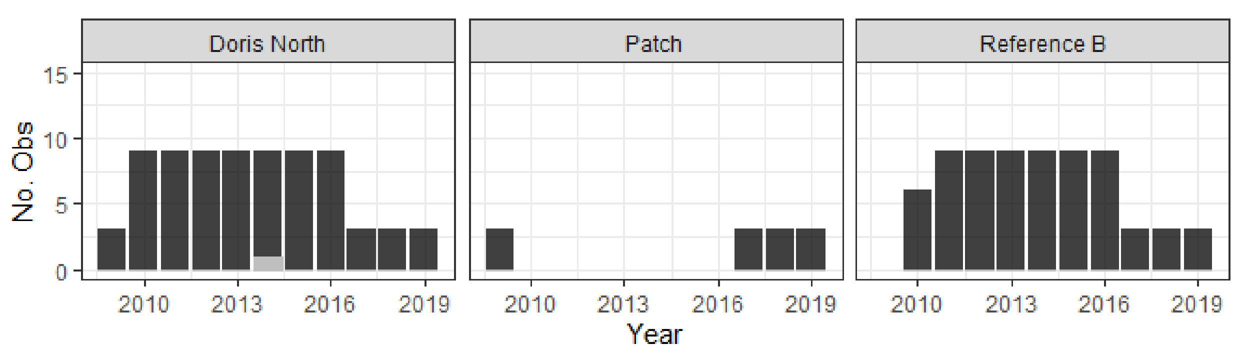
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in July, August, and/or September. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Censored Values and Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake that were less than the detection limit (grey) or greater than the detection limit (black). Observations below the analytical detection limit were considered censored.



Analysis not performed if greater than 50% of observations from a site-season grouping were censored or if 100% of observations from the current assessment year (i.e., 2019) were censored.

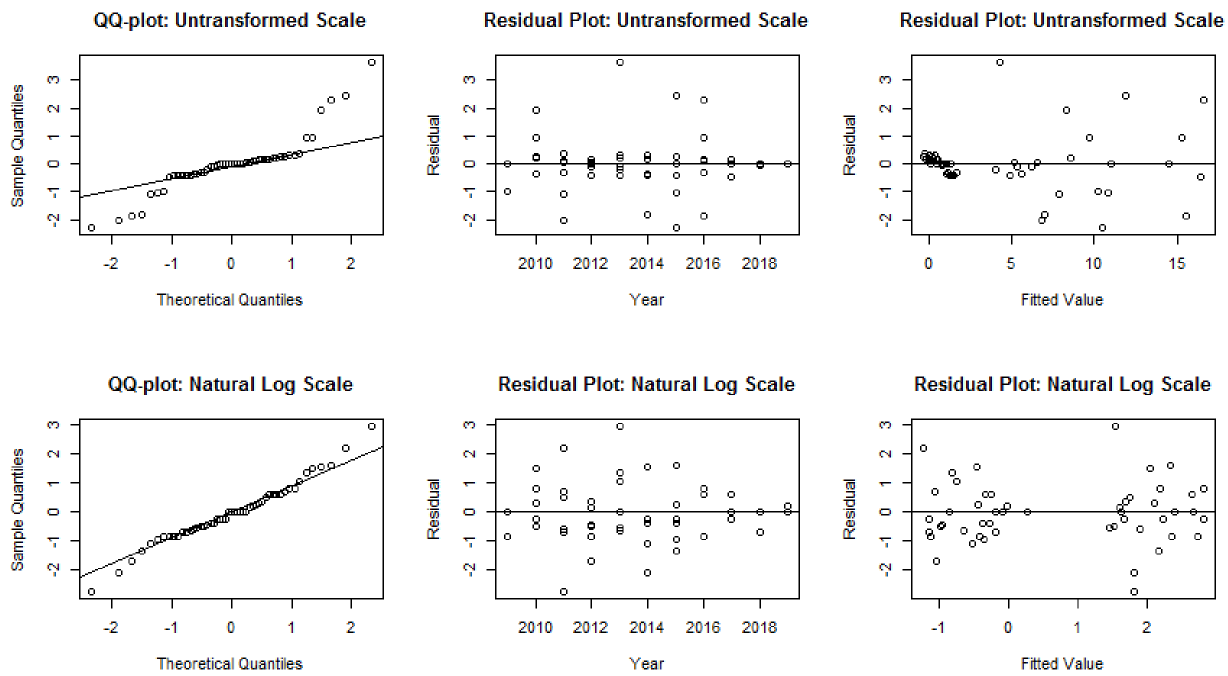
The sample sizes and median values per lake are summarized in the table below.

Lake	Season	# Obs	# Under DL	Prop. Under DL	Prop. Under DL (2019)	Median
Doris	Open-water	75	1	0.01	0	7.9700000
Patch	Open-water	12	0	0.00	0	0.8707143
Reference B	Open-water	69	0	0.00	0	0.5440000

None of the lakes exhibited greater than 10% of data less than the detection limit. The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers are identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.

Outliers on untransformed scale:

	Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
11	Doris	2013	Open-water	Deep	11.96667	4.311854	3.644289

Outliers on natural log scale: None

The natural log data better meets the residual assumptions. Analysis proceeds with natural log data.

Doris Lake

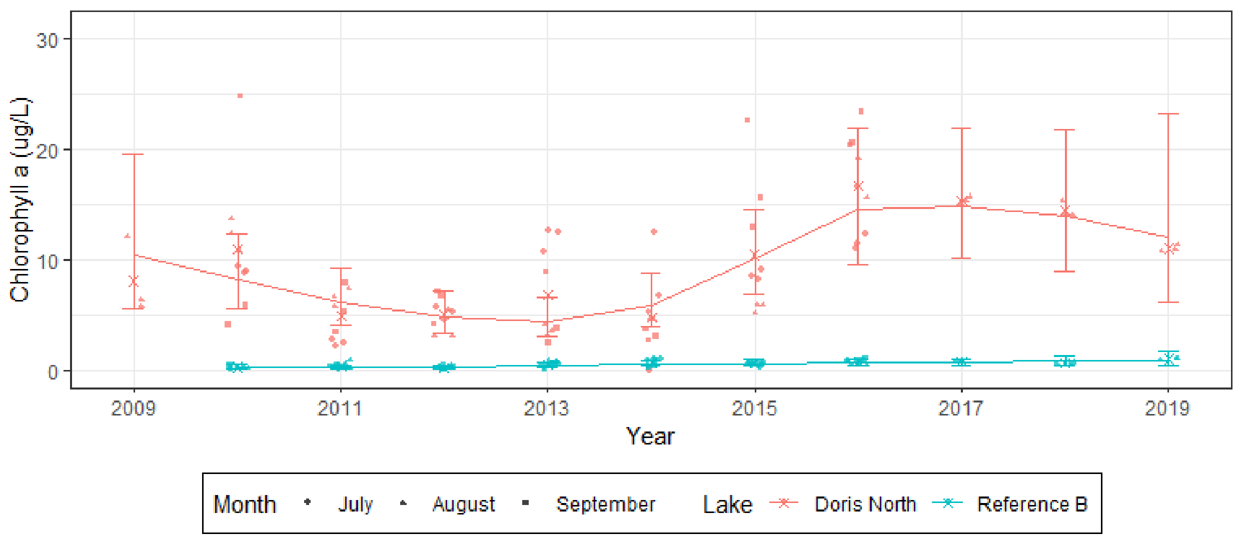
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	39.095	4	0.0000
Compare to Reference B	11.510	4	0.0214

Conclusions:
Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B lake.

Observed Data and Fitted Values

The sampling month was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data, both averaged over month and separated by month to visually assess the differences between samples. The symbols represent the observed data values (x's represent annual observed means). Observations under detection limit are shown by hollow symbols and plotted at half the detection limit. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch Lake.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	t value	p	Significance
Period after	0.6416	0.4736	1.355	0.3082	not sig.

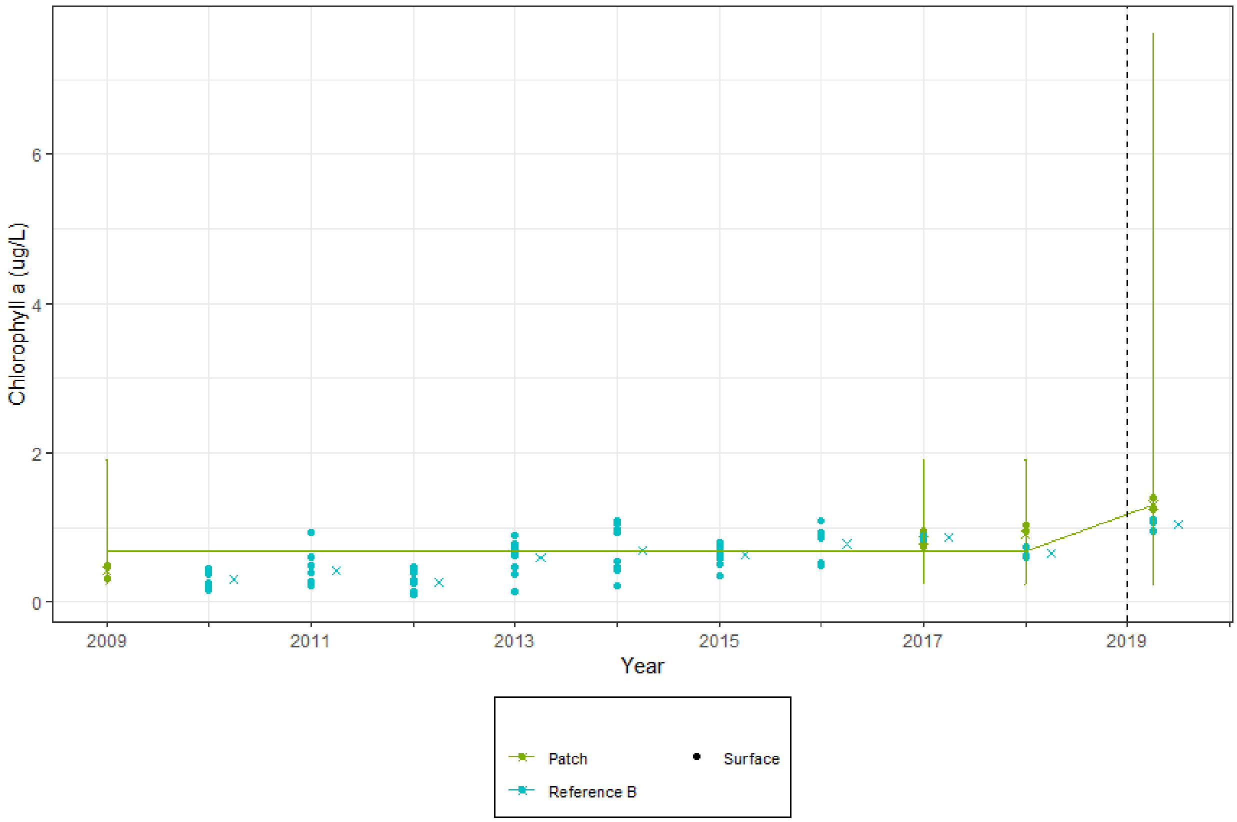
Conclusion:

The change in phytoplankton biomass (as chlorophyll *a*) concentrations in Patch Lake from *before* to *after* was not significantly ($p = 0.3082$) different.

BACI analysis not performed.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.

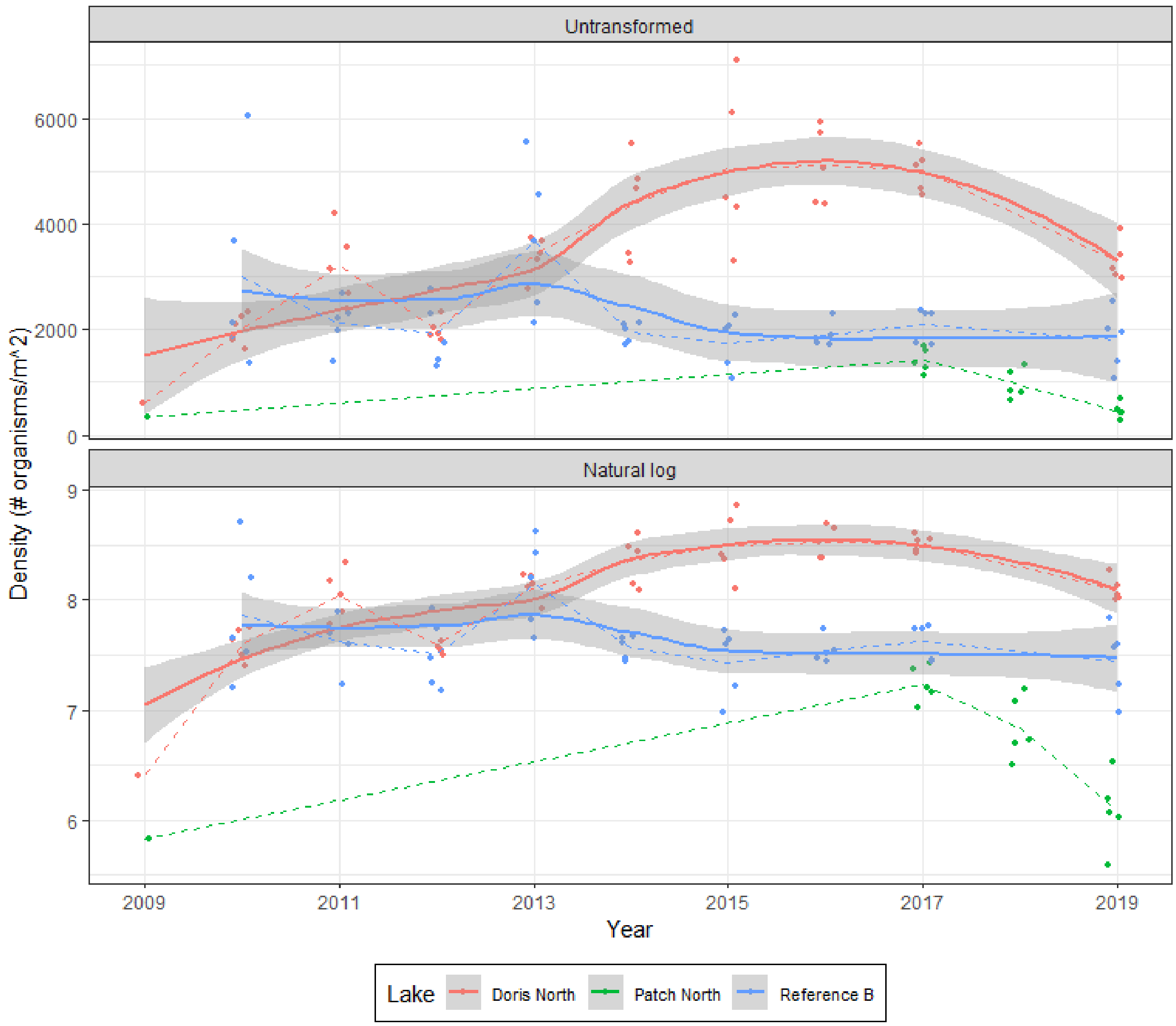

Chlorophyll a (ug/L)
0
2
4
6
2009
2011
2013
2015
2017
2019
Year
Patch
Reference B
Surface

C.3.5 Benthos

C.3.5.1 Benthos Density

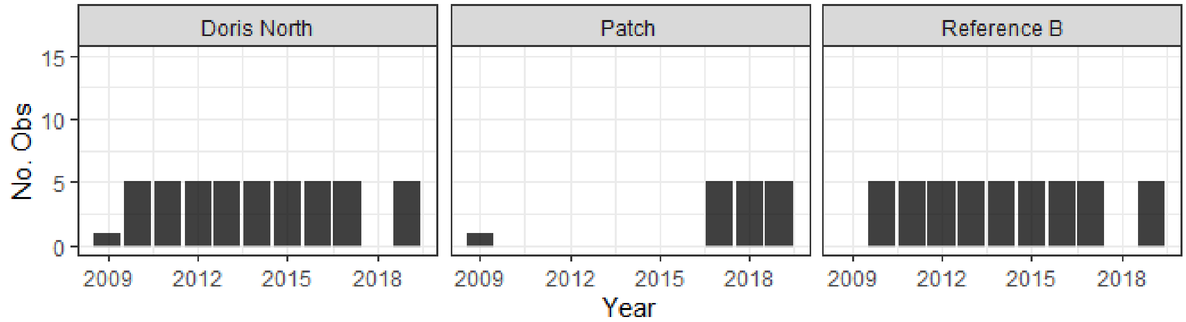
Observed Data

The following plots show all the observed data on the untransformed and natural log scale. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake.



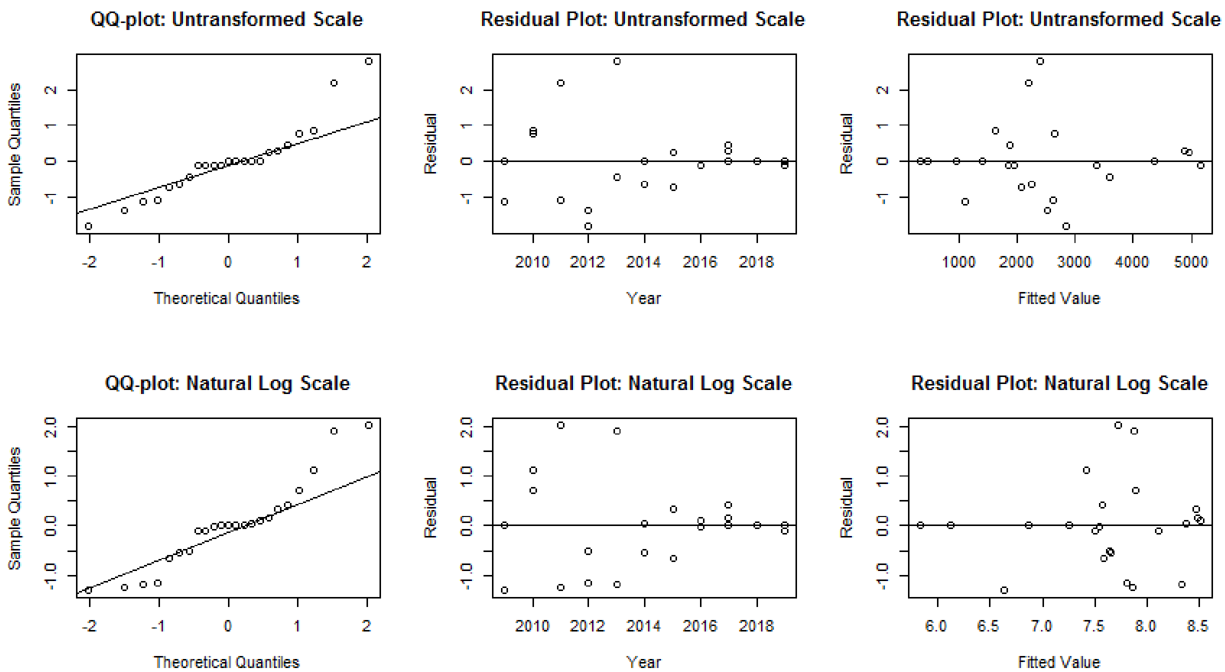
The sample sizes and median values per lake are summarized in the table below.

Lake	Season	# Obs	Median
Doris	Open-water	46	3451.8519
Patch	Open-water	16	822.2222
Reference B	Open-water	45	2014.8148

The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and natural log scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None
Outlier on natural log scale: None
The untransformed and natural log-transformed model fit the data equally well. Analysis proceeds with untransformed data.

Doris Lake

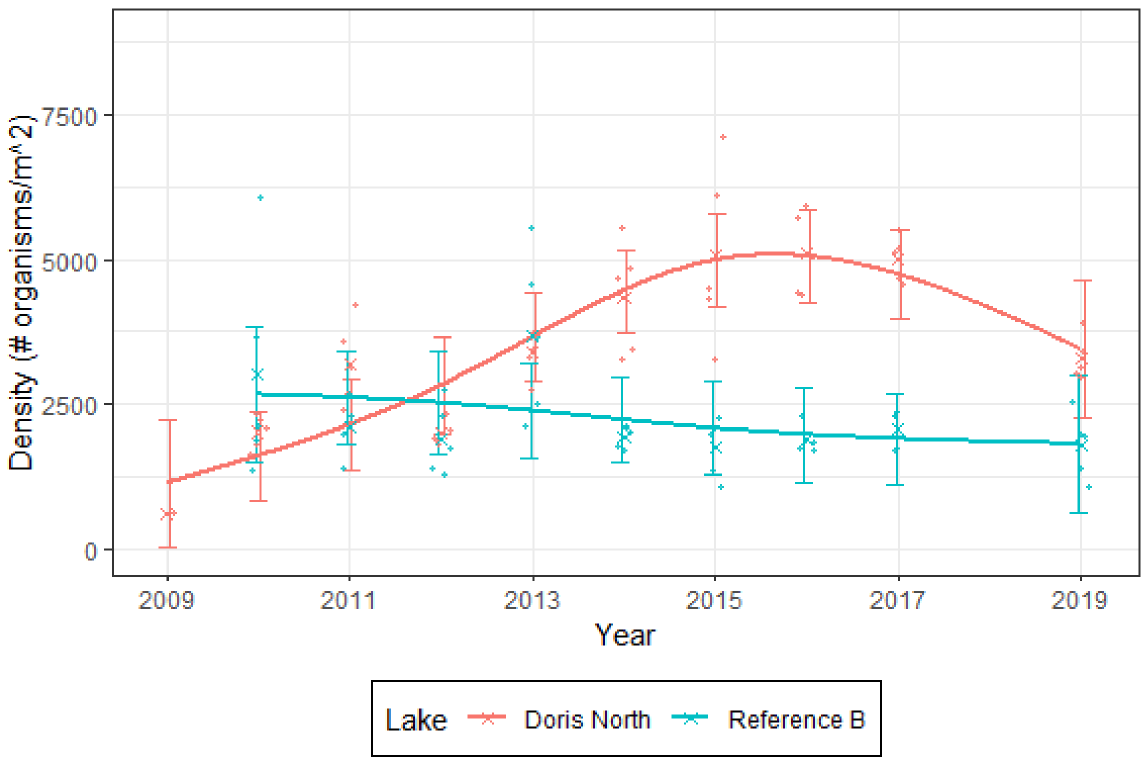
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of DorisLake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	69.311	3	0.0000
Compare to Reference B	38.338	3	0.0000

Conclusions:
Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B Lake.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling wa applied to compare the change in concentrations before and after baseline years between Reference B and Patch Lake.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	-475.6	587.5	1.731	-0.8096	0.5143	not sig.

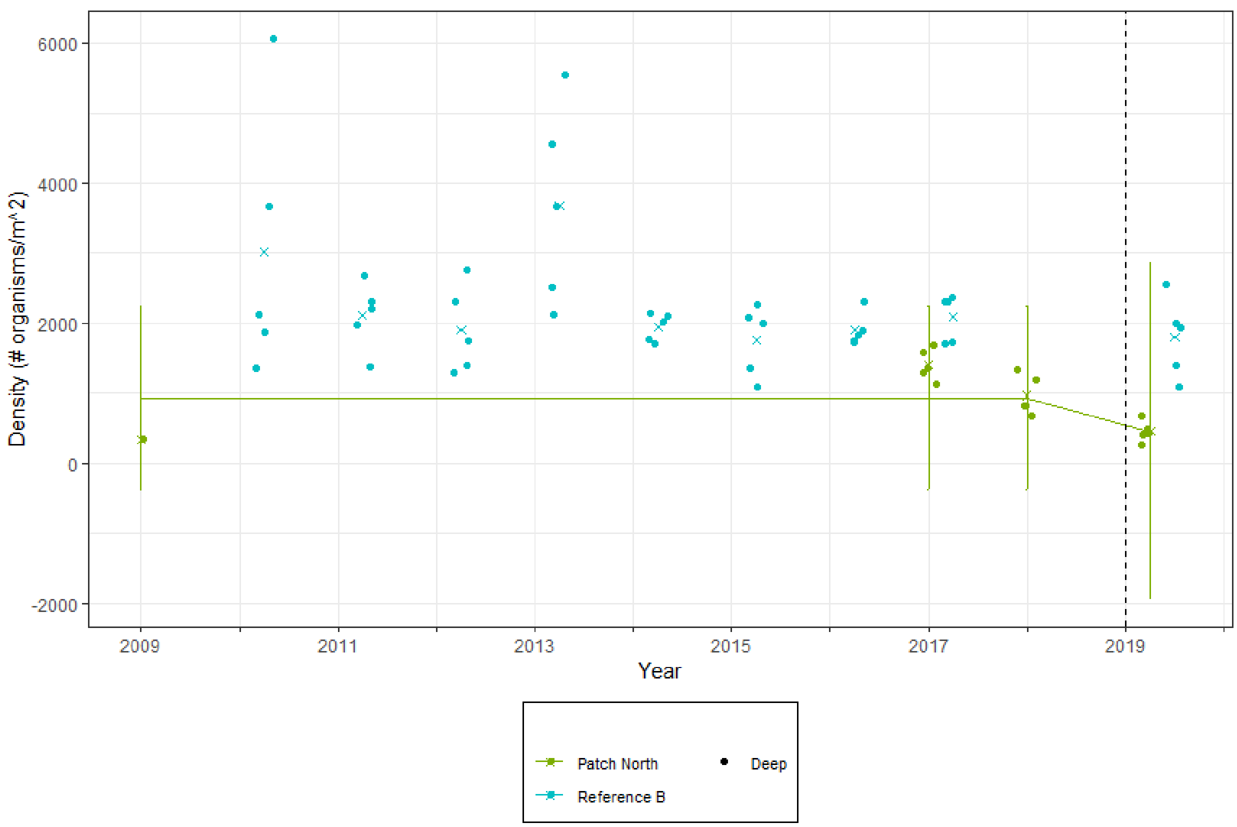
Conclusion:

The change in benthos density in Patch Lake from *before* to *after* was not significantly (p = 0.5143) different.

BACI analysis not performed.

Observed Data and Fitted Values

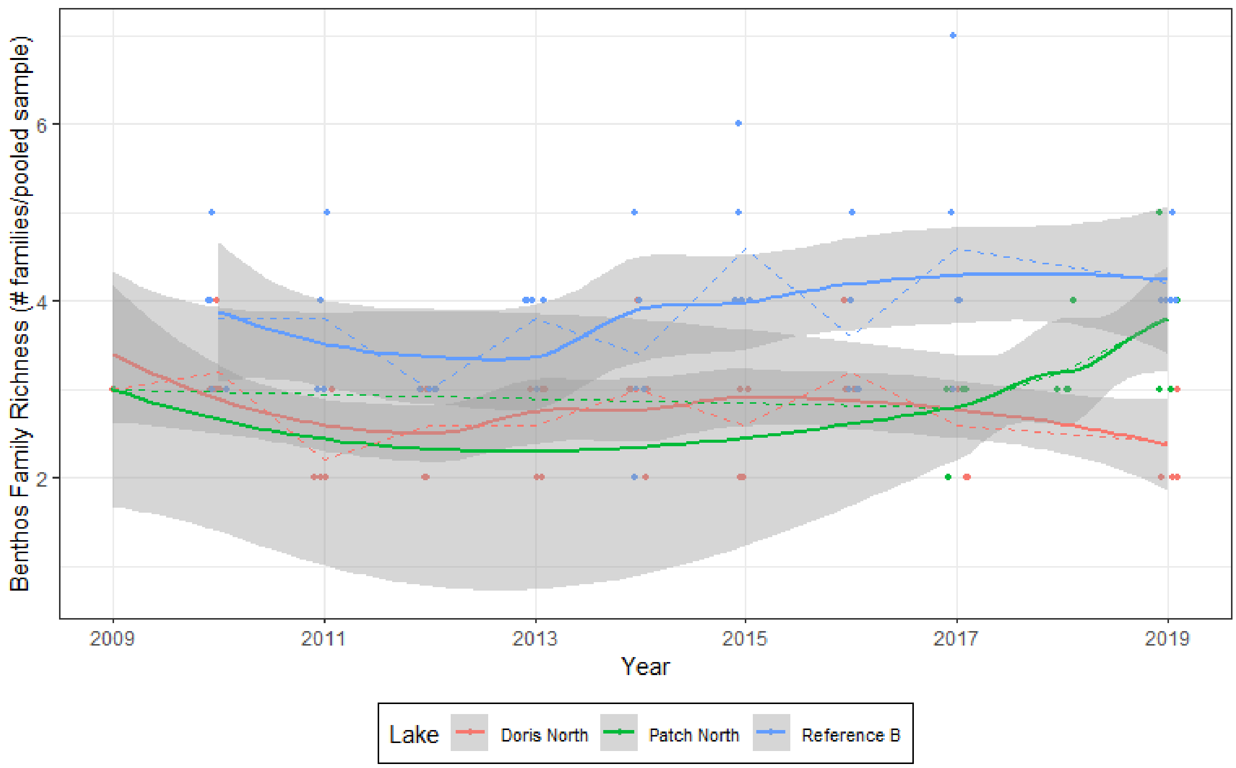
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.5.2 Benthos Family Richness

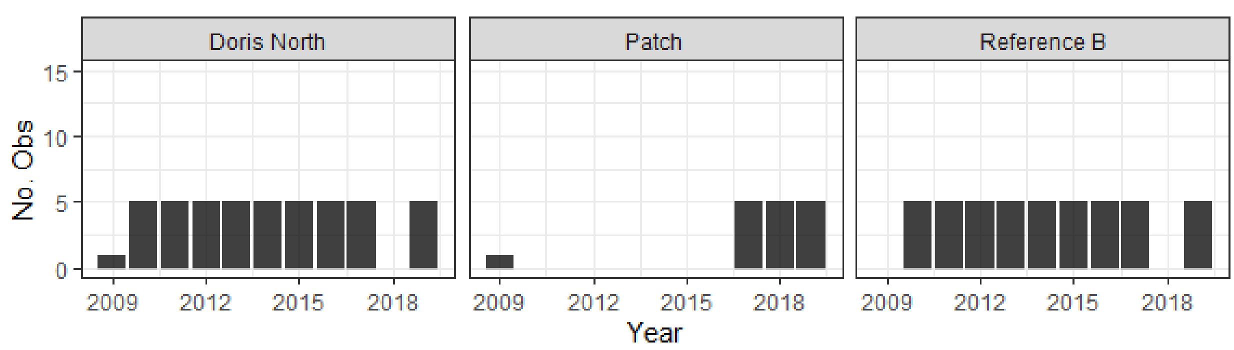
Observed Data

The following plots show all the observed data. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake.



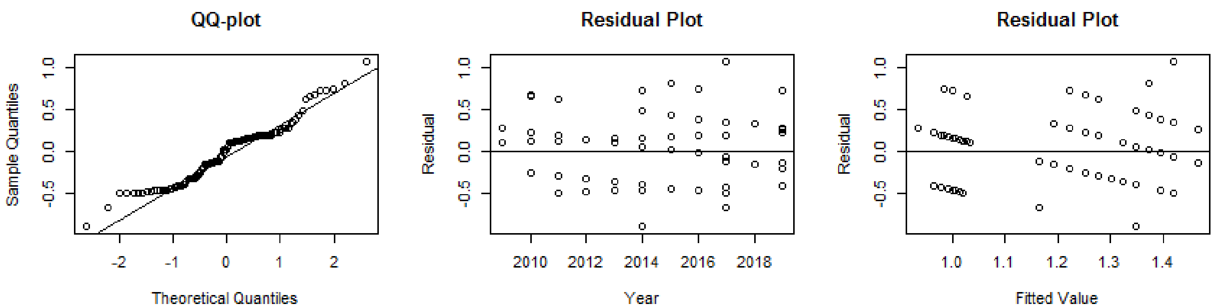
The sample sizes and median values per lake and season are summarized in the table below.

Lake	Season	# Obs	Median
Doris	Open-water	46	3
Patch	Open-water	16	3
Reference B	Open-water	45	4

The analysis proceeds with linear mixed model regression.

Initial Model Fit

Outliers were identified from the fitted model as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers: None

Doris Lake

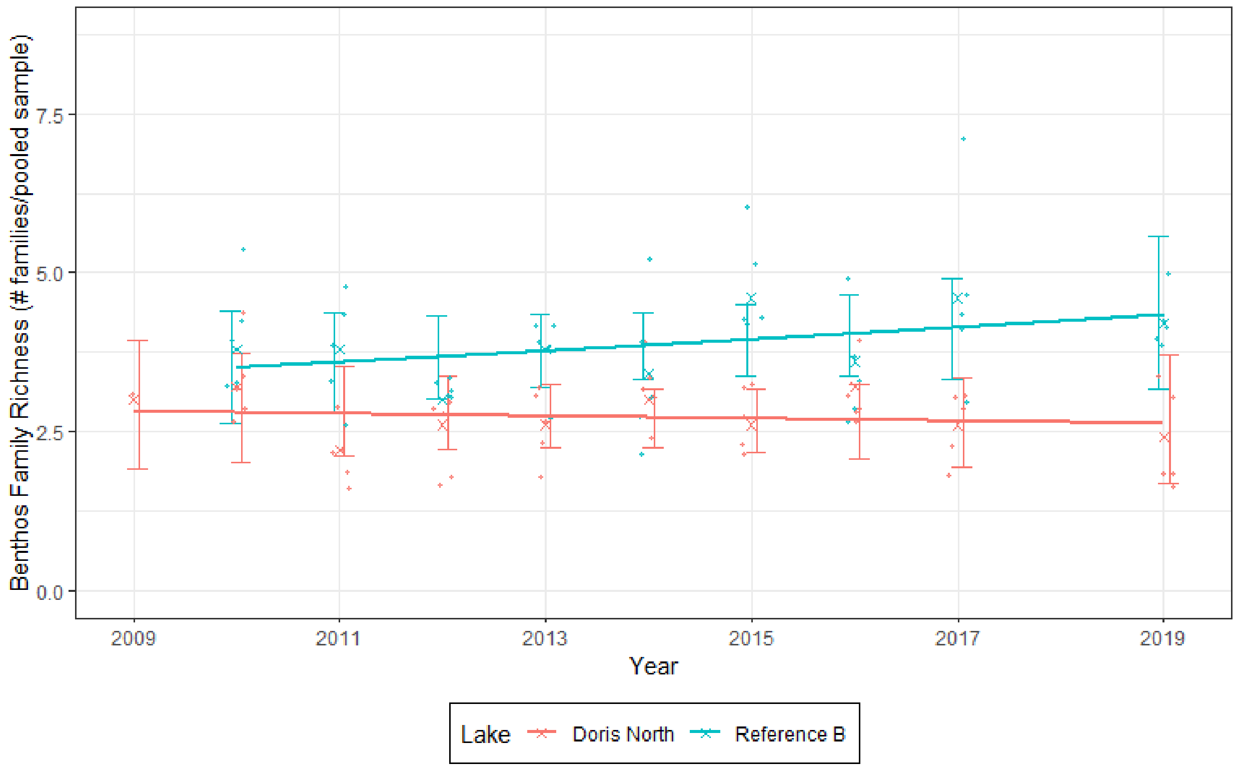
The trend of family richness in Doris Lake over time was assessed. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	0.049	1	0.8253

Conclusions:
Doris Lake did not exhibit significant deviation from no change over time

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch Lake.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	z value	p	Significance
periodafter	0.2364	0.288	0.8208	0.4117	not sig.

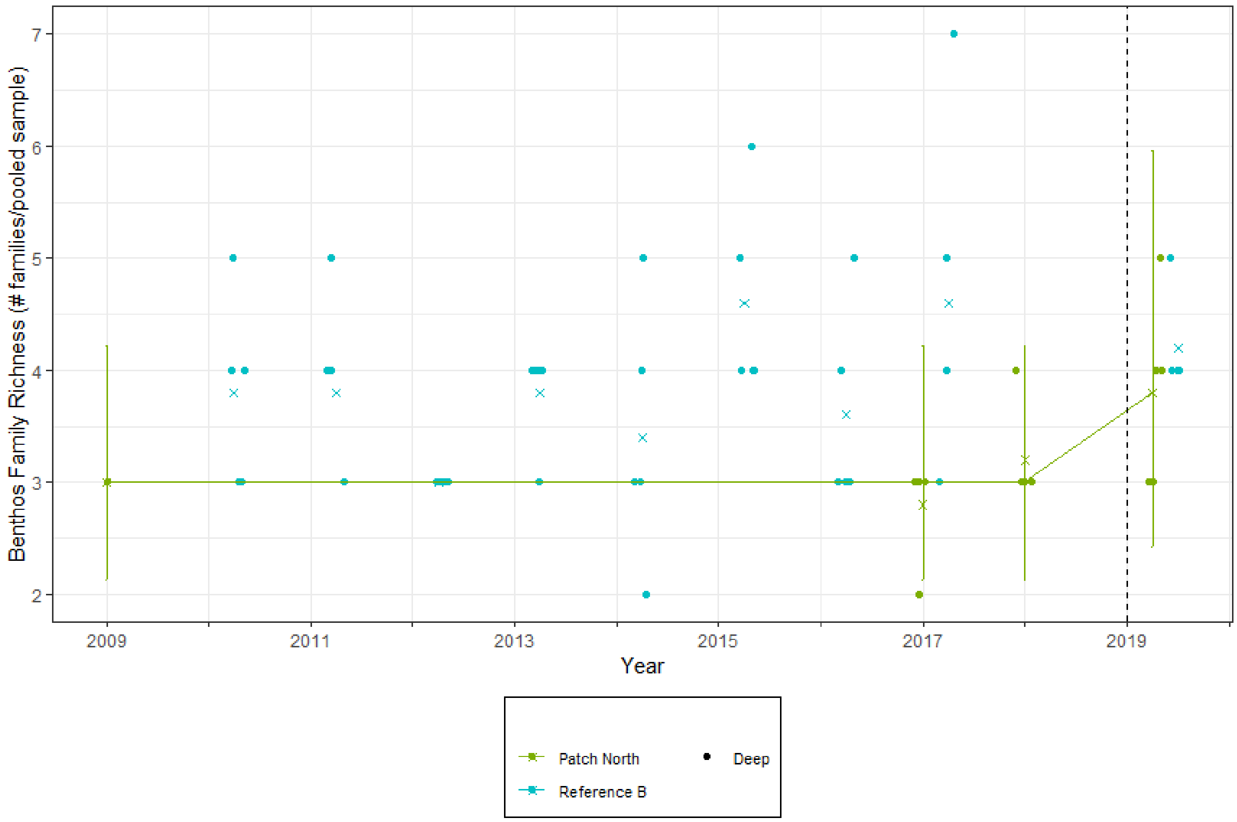
Conclusion:

The change in benthos family richness in Patch Lake from *before* to *after* was not significantly (p = 0.4117) different.

BACI analysis not performed.

Observed Data and Fitted Values

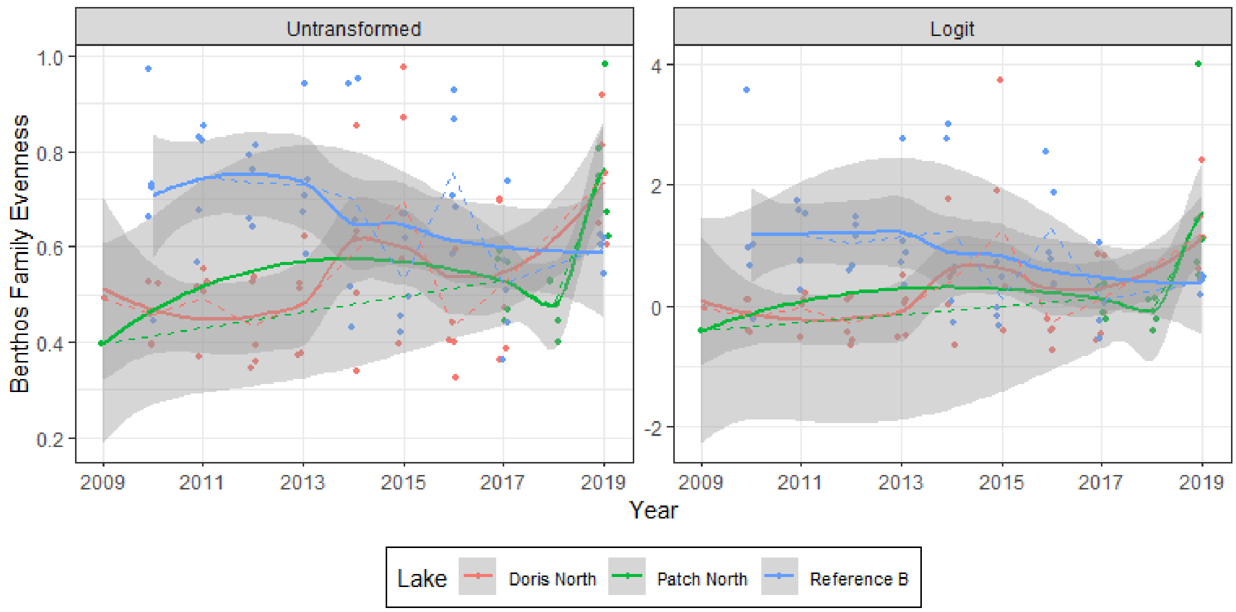
Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.5.3 Benthos Family Evenness

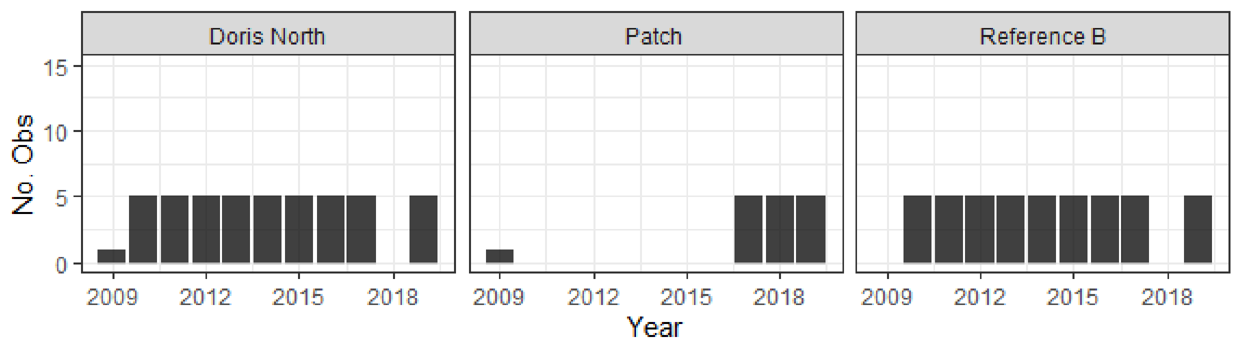
Observed Data

The following plots show all the observed data on the untransformed and logit scale. The logit transformation was selected since the observed data lies in the interval [0, 1]. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake.



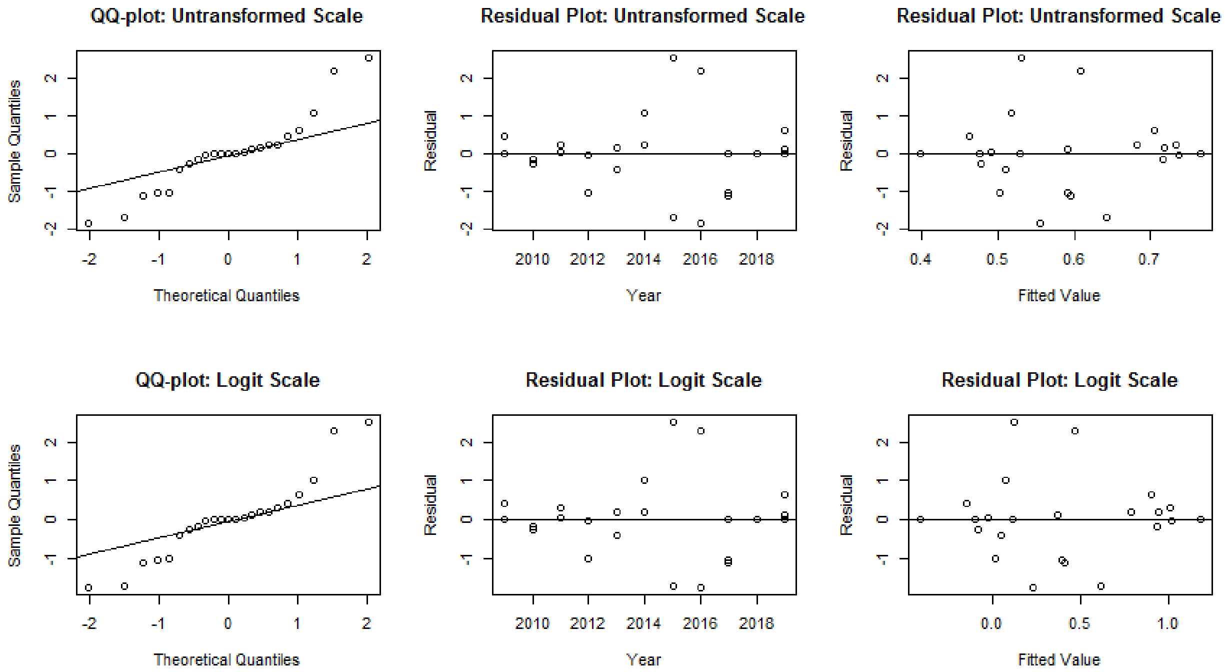
The sample sizes and median values per lake are summarized in the table below.

Lake	Season	# Obs	Median
Doris	Open-water	46	0.5179
Patch	Open-water	16	0.5467
Reference B	Open-water	45	0.6615

The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and logit scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale: None

Outliers on logit scale: None

The logit transformed data better meets the residual assumptions. Analysis proceeds with logit transformed data.

Doris Lake

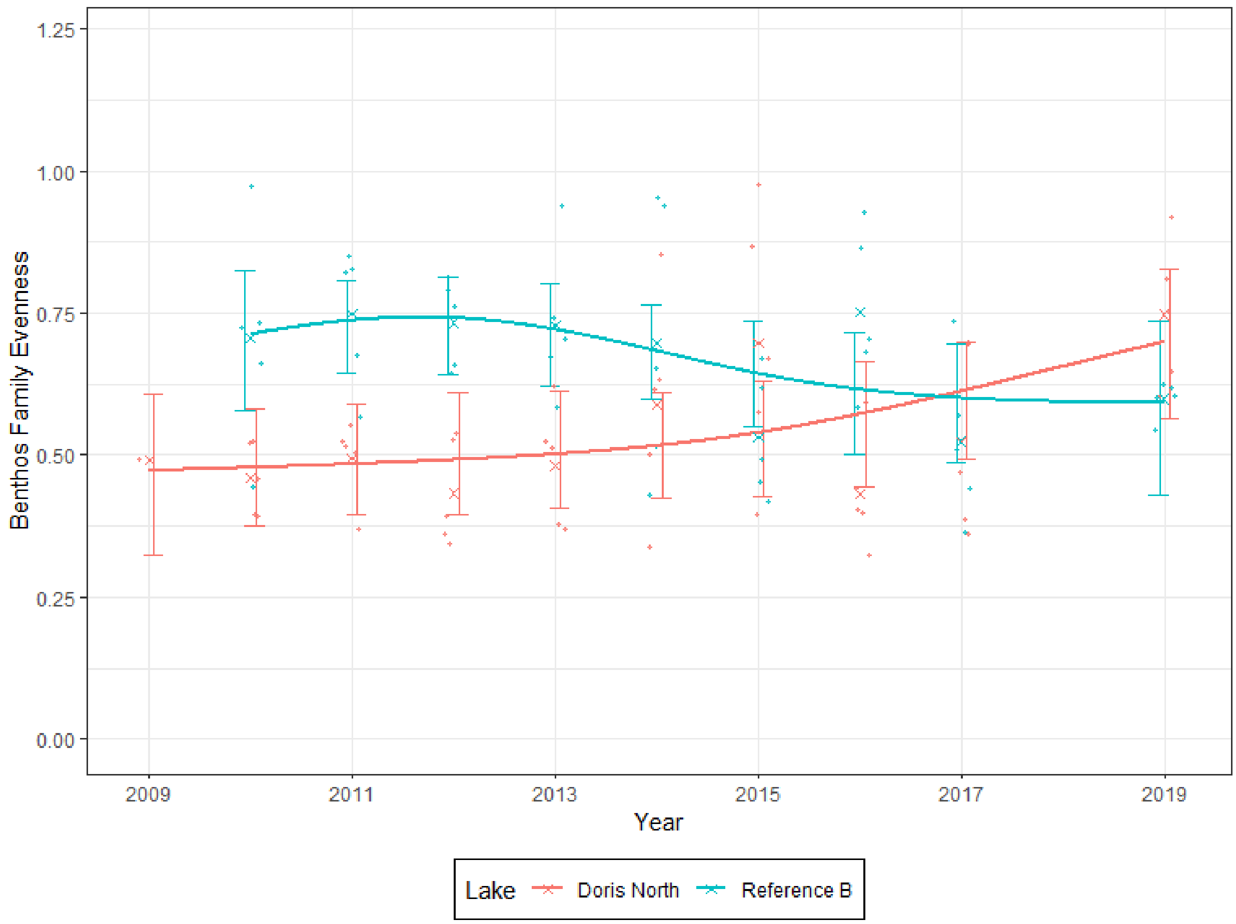
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	8.416	3	0.0382
Compare to Reference B	12.879	3	0.0049

Conclusions:
Doris Lake appears to show significant deviation from no trend. Doris Lake appears to show significant deviation from the trend of Reference B Lake.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch Lake.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.4486	0.1068	0.8374	4.201	0.1849	not sig.

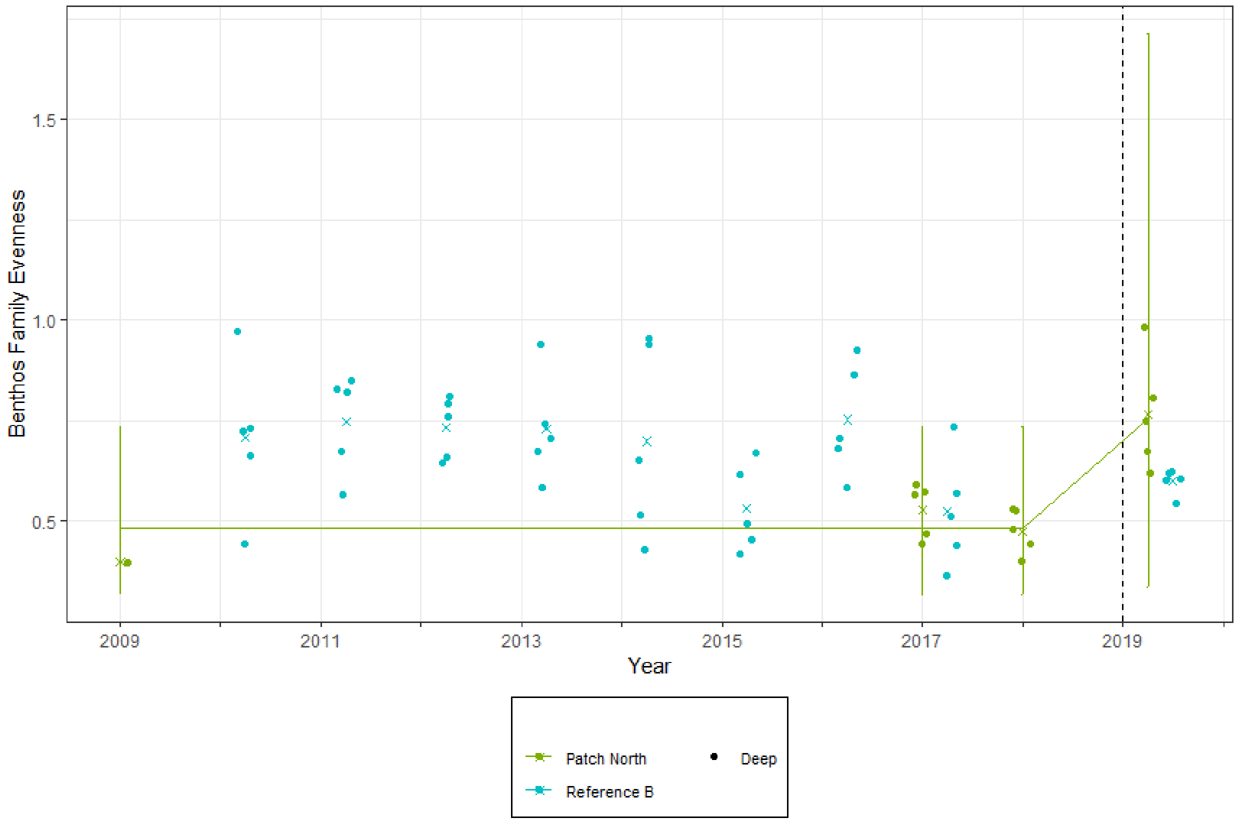
Conclusion:

The change in benthos family evenness in Patch Lake from *before* to *after* was not significantly (p = 0.1849) different.

BACI analysis not performed.

Observed Data and Fitted Values

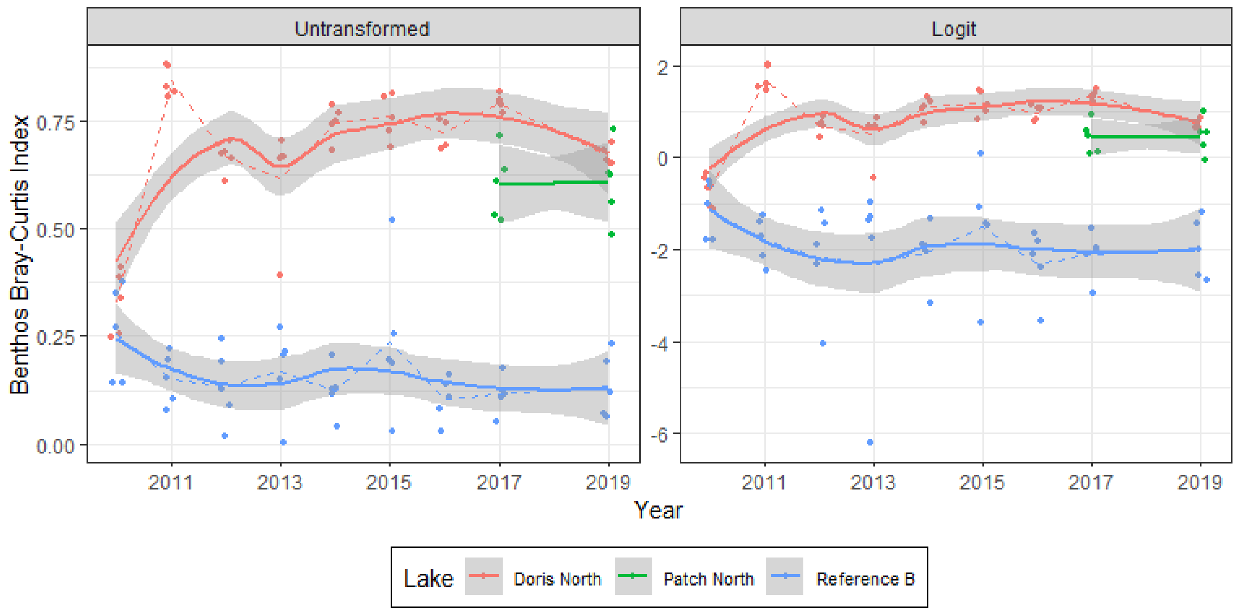
Depth was accounted for in the model but not evaluated since its effect is not of primary interest. Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



C.3.5.4 Benthos Bray-Curtis Index

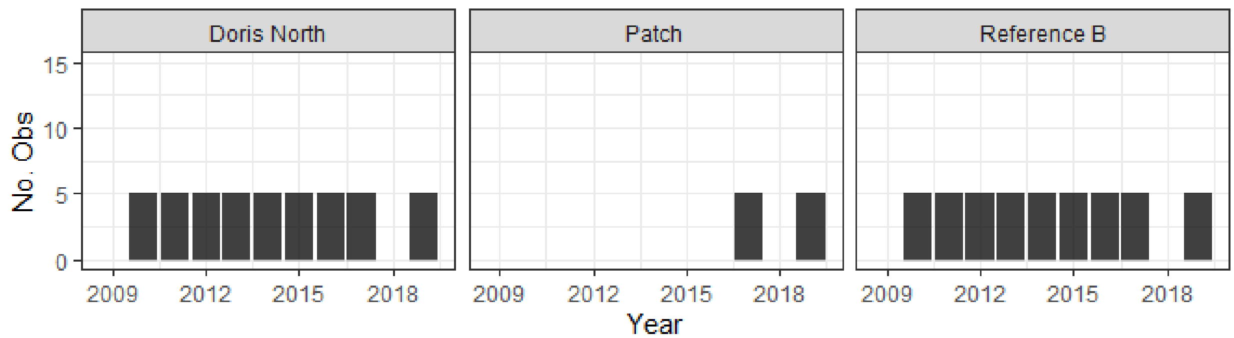
Observed Data

The following plots show all the observed data on the untransformed and logit scale. The logit transformation was selected since the observed data lies in the interval [0, 1]. Samples were collected in August. Observations are slightly jittered along the x-axis for legibility. The lines drawn through the scatter plots represent the annual means. LOESS smoothing curves and corresponding 95% confidence intervals (represented by grey shading) are shown to provide a clearer display of the trends in the observed data.



Sample Sizes

The following plots indicate the number of measurements taken in each year from each lake.



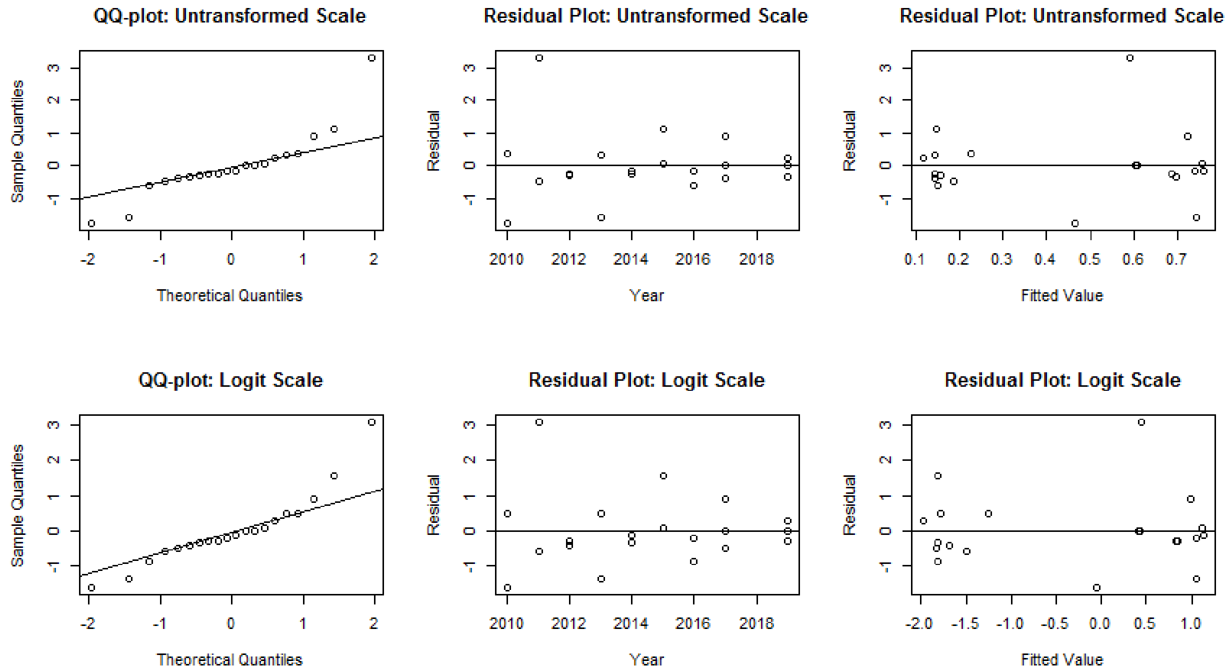
The sample sizes and median values per lake are summarized in the table below.

Lake	Season	# Obs	Median
Doris	Open-water	45	0.7053
Patch	Open-water	10	0.6193
Reference B	Open-water	45	0.1429

The analysis proceeds with linear mixed model regression.

Initial Model Fit

A model was fit both on the untransformed and logit scale to assess the need for transformations. Outliers were identified from the model fit as standardized residuals greater than 3, and flagged to caution interpretation of results but not removed from the analysis.



Outliers on untransformed scale:

	Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
3	Doris	2011	Open-water	Deep	0.8442	0.5892	3.289

Outliers on logit scale:

	Lake	Year	Season	Depth.Zone	Impute	Fitted	Std. Residual
3	Doris	2011	Open-water	Deep	0.8442	0.439	3.095

The logit transformed data better meets the residual assumptions. Analysis proceeds with logit transformed data.

Doris Lake

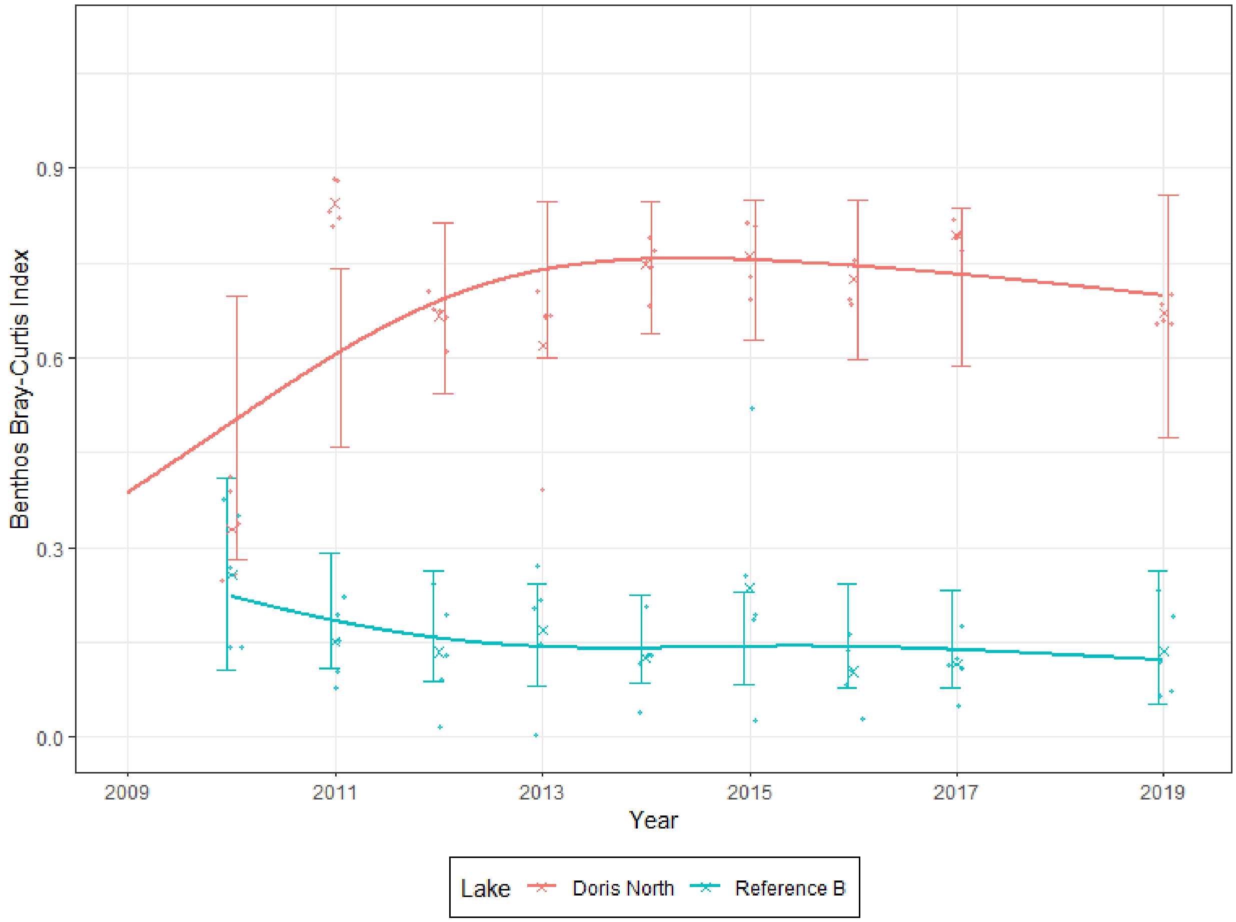
The trend of Doris Lake was compared to a slope of 0. If there was a significant trend, then the trend of Doris Lake was compared to the trend in Reference B. This contrast does not test for differences in intercepts between lakes.

Analysis	Chi.sq	DF	P.value
Compare to slope 0	6.389	3	0.0942

Conclusions:
Doris Lake did not exhibit significant deviation from no trend.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The observed data and means are represented by circles and x's, respectively. Solid lines represent the fitted curves. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations.



Patch Lake

Before-after analyses were first performed to compare the change in concentrations in the before and after period in the exposure site. If a change was detected, then before-after-control-impact linear modeling was applied to compare the change in concentrations before and after baseline years between Reference B and Patch Lake.

Before-vs-After Analysis

Coefficient	Estimate	Std. Error	df	t value	p	Significance
periodafter	0.0043	0.091	8	0.0471	0.9636	not sig.

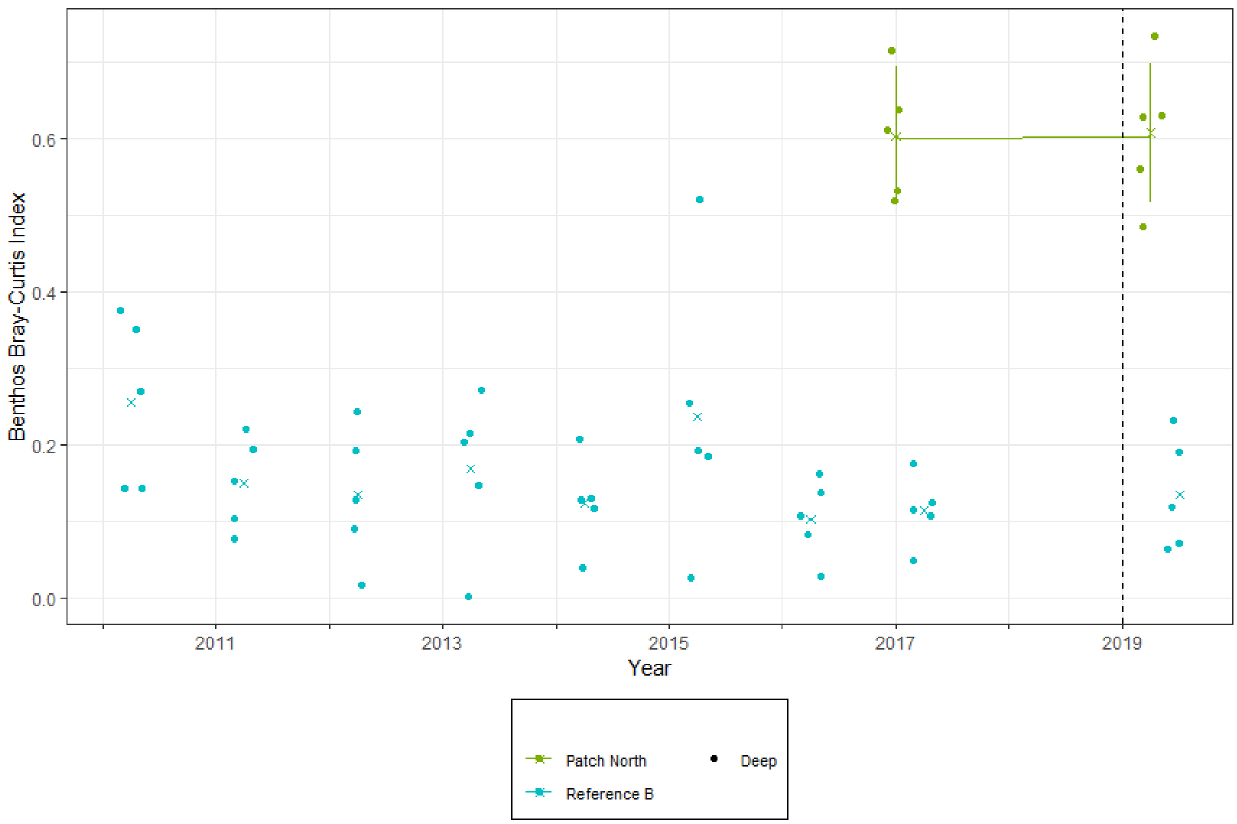
Conclusion:

The change in benthos Bray-Curtis index in Patch Lake from *before* to *after* was not significantly (p = 0.9636) different.

BACI analysis not performed.

Observed Data and Fitted Values

Below are plots of the observed and fitted data. The symbols represent the observed data values (x's represent annual observed means) and hollow symbols at half the detection limit. Solid lines represent the fitted means. Error bars indicate the upper and lower 95% confidence intervals of the modelled concentrations in the before and after periods for the exposure site. Vertical dashed line represents the start of the after period.



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