De Beers Group

Gahcho Kué Mine

2023 Aquatic Effects Monitoring Program Response Plan for Lake N14

May 2024

REVISION HISTORY

Version	Date	Notes/Revisions
Version 1	May 2024	Submitted to the Mackenzie Valley Land and Water Board (MVLWB) under Part I of the Water Licence MV2005L2-0015.

ABBREVIATIONS AND ACRONYMS

Abbreviation / Acronym	Definition
AEMP	Aquatic Effects Monitoring Program
$CaCO_3$	calcium carbonate
CCME	Canadian Council of Ministers for the Environment
CL	confidence limit
CWQG-PAL	Canadian water quality guidelines for the protection of aquatic life
De Beers	De Beers Canada Inc.
DO	dissolved oxygen
DOC	dissolved organic carbon
ECCC	Environment and Climate Change Canada
e.g.	for example
EIS	Environmental Impact Statement
FEQG	Federal Environmental Quality Guideline
i.e.	that is
IC_{25}	the inhibiting concentration for an x% effect; the concentration of sample estimated to cause 25% reduction in growth or fecundity of the test organisms
LC_{50}	median lethal concentration, the concentration of sample estimated to be lethal to 50% of the test organisms
Mine	Gahcho Kué Mine
MVLWB (the Board)	Mackenzie Valley Land and Water Board
n/a	not applicable
TDS	total dissolved solids
TP	total phosphorus
US EPA	United States Environmental Protection Agency

UNITS OF MEASURE AND SYMBOLS

Unit / Symbol	Definition
%	percent
%v/v	percent sample in the test solution on a volume-to-volume basis
°C	degree Celsius
<	less than
>	greater than
≥	greater than or equal to
±	plus or minus
µg/L	micrograms per litre
µm	micrometre (or micron)
µS/cm	microsiemens per centimetre
ha	hectare
m	metre
mg/L	milligrams per litre
mg-N/L	milligrams of nitrogen per litre
mg-P/L	milligrams of phosphorus per litre

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1 INTRODUCTION

De Beers Canada Inc. (De Beers) monitors hydrology, water and sediment quality, plankton, benthic invertebrates, and fish and fish habitat in lakes and streams near the Gahcho Kué Mine (Mine) as components of the Aquatic Effects Monitoring Program (AEMP). The purpose of the AEMP is to identify potential effects of the Mine on the surrounding aquatic environment and evaluate whether aquatic ecosystems and their uses are adequately protected in areas affected by the Mine. Monitoring under the AEMP is a requirement of Water Licence MV2005L2-0015, issued by the Mackenzie Valley Land and Water Board (MVLWB or the Board; MVLWB 2021).

The 2023 AEMP was conducted according to the approved AEMP Design Plan Version 7.1 (De Beers 2023a), which includes water quality monitoring in Lake N14. Monitoring in Lake N14 was initiated in 2022 as an approved response action to a Low Action Level exceedance in Lake D2/D3 (De Beers 2022a, 2023b). As part of the 2023 AEMP, a special study was conducted in Lake N14 to evaluate the potential for sublethal toxicity[1]. Following collation and review of the 2023 AEMP data (which included the results of the special study), it was determined that the Moderate Action Level criteria related to Lake N14 were met, thus triggering the Moderate Action Level for Lake D2/D3 and Downstream – Toxicological Impairment and Water Quality. Per the AEMP Design Plan and requirements of the Water Licence, the Board was notified on 11 March 2024 that the exceedance was detected and this AEMP Response Plan was submitted within sixty (60) days of notification.

[1] Low Action Level exceedances occurred in Lake D2/D3 in 2021 and 2022; however, sublethal toxicity testing in Lake N14 as a response action was not approved until 17 May 2023.

2 SIGNIFICANCE THRESHOLD

The Significance Thresholds for all waters downstream of Kennady Lake (with the exception of Lake D2/D3) are defined in Section 8.3 of the AEMP Design Plan (De Beers 2023a). The Significance Threshold pertinent to Lake N14 is defined in terms of a corresponding effect on fish communities, as:

- *Ecological function is not maintained (i.e., inadequate food for fish; fish unable to survive, grow and reproduce; and/or sustained absence of a fish species).*

Lake N14 is a small, shallow lake compared to the rest of the waterbodies in the watershed downstream of Lake D2/D3, and was originally a headwater lake that now receives flow from Lake D2/D3 and Lake E1. Baseline information indicates that Lake N14 water was low in ionic strength and nutrient concentrations (and thus likely of low productivity) prior to the overflow from the raised lakes. Lake N14 also likely had low dissolved oxygen (DO) concentrations under ice in winter as also observed in April 2022 and 2023 when DO concentrations were less than 2 mg/L. These physical and water quality conditions suggest that the most likely use of Lake N14 by juvenile and adult fish is as seasonal (open-water) habitat.

Therefore, an effect equivalent to the Significance Threshold in Lake N14 would occur if changes in water quality resulted in juvenile and adult fish no longer able to use Lake N14 as seasonal habitat.

3 PARAMETER DESCRIPTION AND ACTION LEVEL DETERMINATION

Sections 5.4.5.6 and 15.4.1 of the 2023 AEMP Annual Report (De Beers 2024a) outlined how the Low Action Level was exceeded in Lake D2/D3. Specifically, lake-wide average field pH, and concentrations of aluminum, copper, and iron during the 2023 open-water season were significantly increased relative to pre-dyke conditions and were outside or exceeded their respective AEMP benchmarks. These parameters were evaluated against the Moderate Action Level criteria.

The Moderate Action Level criteria for Lake N14 considered whether there were changes in open-water field pH, and concentrations of aluminum, copper, and iron that were outside of AEMP benchmarks, as well as whether there were confirmed sublethal toxic effects to more than one test species in laboratory exposures. The first two criteria were met for total iron: the open-water average concentration (425 µg/L) in Lake N14 was above the upper limit of the baseline normal range of 192 µg/L and exceeded the AEMP benchmark of 300 µg/L (Table 3-1). This AEMP benchmark is based on the Canadian water quality guideline for the protection of aquatic life (CWQG-PAL; CCME 1999).

Table 3-1 Summary of Comparisons for Water Quality Moderate Action Level Related to Toxicological Impairment for Lake N14 – Criteria 1a and 1b

Parameter	Unit	2023 AEMP Open-water Average[(a)]	Baseline Normal Range[(b)]	Magnitude of Increase Relative to Baseline[€]	AEMP Benchmark	Magnitude of Exceedance[(c)]	Meets Criteria 1a and 1b of the Moderate Action Level?
pH	-	6.6	5.9 to 6.9	-	6.0 to 9.0	-	No
Aluminum, total	µg/L	54	6.1 to 52	1 to 4	96 to 435[(d)]	-	No
Copper, total	µg/L	1.5	0.60 to 0.97	1.5	2.0[(e)]	-	No
Iron, total	µg/L	425	20 to 192	2.2	300	1.4	Yes

a) Average concentrations are arithmetic means except for open-water field pH value, which is a geometric mean.

b) From Table C-5 of the 2021 AEMP Response Plan (De Beers 2023b).

c) Magnitude of increase is expressed as a quotient (2023 average divided by the upper bound of the baseline normal range). Magnitude of exceedance is also expressed as a quotient (for parameters with average concentrations greater than the AEMP benchmark).

d) The aluminum AEMP benchmark is pH, DOC, and hardness dependent. The benchmark is calculated based on the individual field pH, DOC, and hardness measurements for each sample, but measurements outside the model bounds have been constrained. The benchmark is applicable to the pH, DOC, and hardness conditions for which the multiple linear regression models were calibrated: pH of 6.0 to 8.1, DOC of 0.1 to 5.0 mg/L, and hardness of 10 to 127 mg/L as $CaCO_3$ (DeForest et al. 2018). During the open-water season, field pH ranged from 6.3 to 7.1, DOC from 9.6 to 11 mg/L, and total hardness (based on total concentrations of calcium and magnesium) from 5.9 to 6.4 mg/L as $CaCO_3$. Thus, the benchmark range is based on a pH of 6.3 to 7.1, DOC of 5.0 mg/L (upper bound of model), and hardness of 10 mg/L (lower bound of model).

e) The copper AEMP benchmark is hardness dependent. The benchmark value shown is based on the hardness range observed in the dataset. The benchmark is calculated based on the individual hardness value for each sample.

AEMP = Aquatic Effects Monitoring Program; DOC = dissolved organic carbon; $CaCO_3$ = calcium carbonate; - = no unit or not calculated.

A special study was conducted in 2023 to evaluate the potential for sublethal toxicity in Lake N14 as a result of water overflowing from Lake D2/D3. Sublethal toxicity to the invertebrate *Ceriodaphnia dubia* and the alga *Raphidocelis subcapitata* was confirmed in at least two consecutive samples collected at least one month apart during the 2023 open-water season (Table 3-2). Per the AEMP Design Plan, a sublethal toxic effect is defined as an IC_{25} of less than the highest test concentration in laboratory tests. The sublethal toxicity tests were presented in Section 13.3.4 in the 2023 AEMP Annual Report (De Beers 2024a).

Table 3-2 Summary of Comparisons for Water Quality Moderate Action Level Related to Toxicological Impairment for Lake N14 – Criterion 1c

Test Species	Endpoint	Test Result (%v/v) (95% CL)			Confirmed in Two Consecutive Samples?	Meets Criterion 1c of the Moderate Action Level?
		July 2023	August 2023	September 2023		
Pimephales promelas (fathead minnow)	7-d LC_{50} (Survival)	>100 (n/a)	>100 (n/a)	>100 (n/a)	No	Yes (Confirmed sublethal toxic effects to more than one test species)
	7-d IC_{25} (Biomass)	**69.7** –31.5 - n/a)	>100 (n/a)	**80.9** (59.4 - >100)		
Ceriodaphnia dubia (water flea)	3-brood LC_{50} (Survival)	>100 (n/a)	>100 (n/a)	>100 (n/a)	Yes	
	3-brood IC_{25} (Reproduction)	**63.5** –22.3 - 82.6)	**56.4** –41.5 - 60.3)	>100 (n/a)		
Raphidocelis subcapitata (alga)	72-hr IC_{25} (Growth)	**34.1** –29.2 - 37.7)	**15.0** –12.5 - 18.1)	**20.4** (5.3 - 38.9)	Yes	

Notes: **Bolded** values and shaded cells indicate a sublethal toxic effect, defined as an IC_{25} of less than the highest test concentration (100%v/v for fathead minnow or *C. dubia*; 91% for *R. subcapitata*).

%v/v = percent sample in the test solution on a volume to volume basis; 95% CL = 95% confidence limits associated with the point estimate; LC_{50} = median lethal concentration, the concentration of sample estimated to be lethal to 50% of the test organisms; IC_{25} = the inhibiting concentration for a 25% effect; it is the concentration of a sample estimated to cause a 25% reduction in growth or fecundity of the test organisms and the endpoint is estimated by statistical fit to the underlying response data; > = greater than; n/a = confidence limit could not be derived.

4 LIKELY CAUSES AND LINES OF EVIDENCE

4.1 Changes in Water Quality

The most likely cause of the changes in water quality in Lake N14 is from the flow of water from Lake D2/D3. Changes in water quality occurred in Lake D2/D3 as a result of flooding of surrounding tundra. Lake D2 and Lake D3 are located within the D watershed and were two separate, but connected, small lakes prior to construction of Dyke F. As part of the water management plan during the construction phase of the Mine, the D watershed was impounded by Dyke F to divert site water away from the controlled mine area; this diversion directed flow through the D watershed to the N watershed. The construction of Dyke F in the connected stream downstream of Lake D2 was initiated in November 2015 and was completed by May 2016. As a result, the water level in Lake D3 started to rise in 2016 and in July 2016, Lake D2 and Lake D3 joined to form a single waterbody (Lake D2/D3) with two basins: Basin D2 and Basin D3.

Lake D2/D3 reached its full supply level in June 2019, when it overflowed to Lake N14 from the deeper Basin D3. Overflow from Lake D2/D3 to Lake N14 occurred during the open-water season every year from 2019 to 2021. Dry climatic conditions in 2022 and 2023 resulted in limited surface flow from Lake D2/D3 to Lake N14 (i.e., limited to the spring freshet). No surface hydrological connection was observed between Lake D2/D3 and Lake N14 during the last two open-water water quality sampling visits of 2023 (from the end of July to September). The magnitude of mean daily runoff from the watershed reporting to Lake N14 in 2023 was the lowest since 2018 because of dry climatic conditions (Section 4 in De Beers 2024a).

Monitoring results in Lake N14 show that water quality has changed from baseline to be more similar to that of Lake D2/D3. These changes are consistent with the qualitative Environmental Impact Statement (EIS) water quality projections (De Beers 2010, 2011, 2012, 2023a). Concentrations of several parameters have increased in Lake N14 compared to baseline normal range (Table 4-1).

Table 4-1 Comparison of Lake N14 Open-water Mean/Median Concentrations in Water to Normal Ranges, 2023

Parameter	Unit	Upper Bound of the Normal Range[a]	Mean/Median[b]	Magnitude of Exceedance[c]
Field Parameters				
Field pH	pH	5.9 to 6.9[d]	6.6	n/a[e]
Field specific conductivity	µS/cm	14.0	14.5	1.0
Conventional Parameters				
Total hardness, as $CaCO_3$	mg/L	5.0	6.3	1.3
Total alkalinity, as $CaCO_3$	mg/L	4.25	4.27	1.0
Total dissolved solids, calculated	mg/L	6.65	7.19	1.1
Total suspended solids	mg/L	1.0	1.9	1.9
Major Ions				
Calcium	mg/L	1.03	1.24	1.2
Magnesium	mg/L	0.6	0.75	1.3
Potassium	mg/L	0.5	0.88	1.8
Sodium	mg/L	0.67	0.73	1.1
Nutrients				
Total phosphorus	mg-P/L	10	13	1.3
Total nitrogen	mg-N/L	510	575	1.1
Total organic carbon	mg/L	7.86	10.1	1.3

Table 4-1 Comparison of Lake N14 Open-water Mean/Median Concentrations in Water to Normal Ranges, 2023

Parameter	Unit	Upper Bound of the Normal Range[(a)]	Mean/Median[(b)]	Magnitude of Exceedance[(c)]
Dissolved organic carbon	mg/L	7.96	10.3	1.3
Total Metals, Metalloids, and Non-metals				
Aluminum	µg/L	52.0	53.6	1.0
Arsenic	µg/L	0.22	0.36	1.6
Barium	µg/L	2.54	3.37	1.3
Chromium	µg/L	0.1	0.18	1.8
Cobalt	µg/L	0.11	0.15	1.4
Copper	µg/L	0.97	1.48	1.5
Iron	µg/L	192	425	2.2
Manganese	µg/L	6.71	11.1	1.7
Mercury	µg/L	0.00074	0.0015	2.0
Nickel	µg/L	0.64	1.31	2.0
Strontium	µg/L	6.4	7.36	1.2
Thallium	µg/L	0.003	0.0041	1.4
Uranium	µg/L	0.025	0.042	1.7

a) Normal ranges were reported in Table 7.4-5 and Table 5D-7 of the 2023 AEMP Annual Report (De Beers 2024a).

b) The lake-wide average concentration is defined as either the mean or median value, depending on the underlying statistical distribution, as discussed in Section 6.2.3.5 for water quality of the AEMP Design Plan (De Beers 2023a). Average concentrations are arithmetic means except for the open-water field pH value, which is a geometric mean, and total hardness and total suspended solids, which are medians.

c) Magnitude of exceedance is expressed as a quotient (mean/median concentration divided by the upper bound of the normal range).

d) The lower and upper bound of the normal range is presented for pH.

e) Average pH is within the lower and upper bound of the normal range.

n/a = not applicable; µS/cm = microsiemens per centimetre; mg-P/L = milligrams of phosphorus per litre; mg-N/L = milligrams of nitrogen per litre.

Lake N14 also received flow from Lake E1, which is expected to have a lower impact on water quality than the flow from Lake D2/D3. Lake E1 was raised by the construction of Dyke G, which was completed in 2016. It is smaller than Lake D2/D3 (i.e., 27 ha compared to 103 ha), and was predicted to have smaller depth changes (approximately 0.8 m compared to 2.8 m in Lake D2/D3) and smaller surface area changes (i.e., an approximate increase of 6.7 ha compared to 52 ha in Lake D2/D3). Lake E1 also reached the maximum raised level within a year of diversion. Thus, the effects of flooding of tundra vegetation and soil on water quality were expected to be much greater in Lake D2/D3 compared to Lake E1.

Lake N14 is likely more affected by flow from Lake D2/D3 than from Lake E1. It is estimated that the relative contribution of waters to Lake N14 has changed from 100% from surface runoff from the N14 watershed prior to the creation of the raised lakes to approximately 65% from Lake D2/D3, approximately 20% from Lake E1, and the rest from N14 watershed. Given the small size of Lake N14 and the relatively high contribution of flow from Lake D2/D3, it is expected that Lake N14 water quality is heavily influenced by inflow water quality from Lake D2/D3. Consistent with this expectation, concentrations of elevated parameters in Lake N14 over the past two open-water seasons have been similar or lower than those observed in Lake D2/D3 (Appendix A).

4.2 Evaluation of Sublethal Toxicity

Detailed methods and results of sublethal toxicity special study were presented in Section 13 of the 2023 AEMP Annual Report (De Beers 2024a). Surface water samples were collected in Lake N14 at Station N14-L1 for toxicity testing at the same time as water quality sampling during the July, August, and September sampling events. The toxicity testing was conducted using the following test protocols:

- 7-d fathead minnow *(Pimephales promelas)* larval development – Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows, Environment Canada, Environmental Protection Series 1/RM/22, February 2011.
- Three brood water flea reproduction – Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*, Environment Canada, Environmental Protection Series 1/RM/21,February 2007.
- 72-hour *Raphidocelis subcapitata* (formerly known as *Selenastrum capricornutum* and *Pseudokirchneriella subcapitata*) growth inhibition – Biological Test Method: Growth Inhibition Test Using a Freshwater Alga, Environment Canada, Environmental Protection Series 1/RM/25, March 2007.

The toxicity testing yielded the following observations (Table 3-2; Appendix B, Table B-1):

- Algal growth was reduced in all three samples but the effects on fathead minnow and *C. dubia* were inconsistent, with toxicity to fathead minnow observed in the July and September samples and toxicity to *C. dubia* observed in the July and August samples.
- In samples with sublethal toxicity, effects on fathead minnow and *C. dubia* occurred only in the full-strength (100%) sample; dilution with laboratory water to 50%v/v[2] resulted in no adverse effects on survival, growth, or reproduction.
- Fathead minnow survival was affected in the July sample; control-adjusted survival[3] was 65% in the full-strength sample. This resulted in reduced biomass (combined survival and growth endpoint[4]), with a percent adverse effect of 33% relative to the laboratory control. However, there was no effect on dry weight (i.e., growth measured as average dry weight per surviving fish[5]).
- No effect on fathead minnow survival or biomass was observed in the August sample. No effect on survival was observed in the September sample, but biomass and dry weight was reduced in the full-strength sample.
- *C. dubia* survival and reproduction were reduced in the full-strength (100%) sample collected in August. In the July sample, only reproduction was reduced. No effects on survival or reproduction were observed in the September sample.

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[2] %v/v = percent sample in the test solution on a volume to volume basis.

[3] Control-adjusted values are percent adverse effect in the highest test concentration (i.e., 100% for fathead minnow and *C. dubia*, and 91%v/v for *R. subcapitata*) relative to the laboratory control.

[4] Biomass is a measure of growth that considers the original number of fish exposed. It is calculated as the total dry weight of the surviving fish divided by the number of fish originally exposed (i.e., ten).

[5] Dry weight is a measure of growth of surviving organisms. It is calculated as the total dry weight of surviving fish divided by the number of surviving fish.

- All three samples had to be filtered through a 60 µm Nitex screen to remove native invertebrates prior to initiating the *C. dubia* tests. For the September sample, the toxicology laboratory noted that these aquatic invertebrates included small grey and large brown/red invertebrates with tails and antennas.

The cause(s) of the observed toxicity is unknown. It is possible that the cause of toxicity varied between the test species. Based on the water quality measurements and the above observations, the following factors were evaluated further:

- Elevated metal concentrations;
- Pathogen or predator interference; and
- Low ionic strength.

Each of these factors are discussed further below.

Elevated Metal Concentrations

Lake N14 waters were elevated in metals (e.g., aluminum, copper, iron, etc.). However, concentrations of toxicologically relevant metals were below AEMP benchmarks (except total iron; Table 4-2). The AEMP benchmarks are based on site-specific water quality objectives, CWQG-PAL, or Federal Environmental Quality Guidelines (FEQGs), which are intended to be protective of aquatic life. For example, the toxicity dataset used to generate these objectives and guidelines consist of no effect concentrations from chronic exposures. Thus, they are intended to be protective of all forms of aquatic life (i.e., all species and life stages) for indefinite periods, and there is high confidence that measured concentrations below those values would not adversely affect aquatic life.

Total iron concentrations ranged from 218 to 642 µg/L, with the concentrations in July and August above the AEMP benchmark of 300 µg/L. As noted above, this AEMP benchmark is based on the CWQG-PAL. In preparation of a draft FEQG, Environment and Climate Change Canada (ECCC) assessed the aquatic toxicity of iron based on available toxicity data (ECCC 2019). The draft FEQG was developed following CCME (2007) and included the use of no effect concentrations to generate a species sensitivity distribution. The toxicity dataset used in the guideline derivation focussed on total iron because this is the fraction that best correlates with toxicity (ECCC 2019). ECCC identified pH and dissolved organic carbon (DOC) as key exposure and toxicity modifying factors for iron, and so the FEQG is expressed as an equation that incorporates pH and DOC rather than a single value. Using sample-specific pH and DOC for Lake N14, measured total iron concentrations were about an order of magnitude lower than the sample-specific FEQG, which ranged from 3,647 to 4,181 µg/L[6]. This suggests that measured total iron concentrations in the toxicity test samples were unlikely to have caused the observed toxicity.

[6] The draft FEQG is applicable within the range of 0.3 to 9.9 mg/L for DOC and pH 6.1 to 8.1. Because the July and August samples had DOC concentrations greater than 9.9 mg/L, the value of 9.9 mg/L was used when calculating the sample-specific FEQG.

Table 4-2 Lake N14 Open-water Season Water Quality Summary, 2023

Parameters	Units	AEMP Benchmarks	Lake N14-L1				% Samples Outside Benchmarks
			July	August	September	Mean/Median[a]	
Field Measured							
pH	-	6.0 - 9.0	7.1	6.3	6.5	6.6	-
Specific conductivity	µS/cm	-	14.6	13.5	15.6	14.5	-
Conventional Parameters							
Total hardness, as $CaCO_3$	mg/L	-	6.3	5.9	6.4	6.3	-
Total alkalinity, as $CaCO_3$	mg/L	-	3.7	4.9	4.2	4.3	-
Total dissolved solids (calculated)	mg/L	500	7.0	7.4	7.2	7.2	-
Total suspended solids	mg/L	6.8	<1.0	3.4	1.9	1.9	-
Total organic carbon	mg/L	-	10	9.8	10	10	-
Dissolved organic carbon	mg/L	-	11	11	9.6	10	-
Major Ions							
Total calcium	mg/L	-	1.3	1.2	1.3	1.2	-
Total magnesium	mg/L	-	0.75	0.72	0.79	0.75	-
Total potassium	mg/L	41	0.90	0.84	0.91	0.88	-
Total sodium	mg/L	-	0.73	0.70	0.75	0.73	-
Total Metals, Metalloids, and Non-metals							
Aluminum	µg/L	96 - 435[b]	79	48	33	54	-
Arsenic	µg/L	5.0	0.36	0.37	0.35	0.36	-
Barium	µg/L	1,000	3.5	3.5	3.1	3.4	-
Chromium	µg/L	5.0	0.24	0.16	0.13	0.18	-
Cobalt	µg/L	3.2[c]	0.16	0.15	0.14	0.15	-
Copper	µg/L	2.0[c]	1.6	1.4	1.4	1.5	-
Iron	µg/L	300	**642**	**414**	218	**425**	67
Manganese	µg/L	200 – 250[b,d]	12	11	11	11	-
Mercury	µg/L	0.026	0.0019	0.0015	0.00096	0.0015	-
Nickel	µg/L	25[c]	1.4	1.3	1.2	1.3	-
Strontium	µg/L	2,500	7.4	7.3	7.4	7.4	-
Thallium	µg/L	0.80	0.0047	0.0046	0.0031	0.0041	-
Uranium	µg/L	15	0.047	0.042	0.038	0.042	-
Zinc	µg/L	15 – 26[b,d]	1.3	0.85	0.68	0.95	-

Notes: **Bolded** values indicate concentrations above or outside the acceptable range of the AEMP Benchmark. Water quality data and benchmarks shown in this table were rounded to two significant figures after comparisons to benchmarks. Therefore, values slightly above benchmarks may be displayed as being equal to the benchmarks and identified as exceedances. Measured concentrations equal to the benchmark values were not identified as exceedances.

a) The lake-wide average concentration is defined as either the mean or median value, depending on the underlying statistical distribution, as discussed in Section 6.2.3.5 for water quality of the AEMP Design Plan (De Beers 2023a). Average concentrations are arithmetic means except for the open-water field pH value, which is a geometric mean, and total hardness and total suspended solids, which are medians.

b) Benchmark is pH, DOC, and hardness dependent. Benchmark is calculated based on the individual field pH, DOC, and hardness measurements for each sample, but measurements outside the model bounds have been constrained.

c) Guideline is hardness dependent. The guideline range shown is based on the hardness range observed in the dataset. The guideline is calculated based on the individual hardness value for each sample.

d) Dissolved manganese and dissolved zinc benchmarks conservatively applied to total concentration.

AEMP = Aquatic Effects Monitoring Program; CCME = Canadian Council of Ministers of the Environment; DOC = dissolved organic carbon; < = less than; - = not applicable; $CaCO_3$ = calcium carbonate; µS/cm = microsiemens per centimetre.

Pathogen or Predator Interferences

Surface water samples contain natural complements of aquatic organisms that can affect toxicity test organism survival and confound toxicity test results. The toxicity test methods recommend filtering effluent or receiving water samples, if needed, to remove potential predators and competitors for fathead minnows and *C. dubia* tests (Environment Canada 2007a, 2011) and filtering though a 0.45 µm filter is required for the algae test (Environment Canada 2007b). As noted above, water samples from Lake N14 had to be filtered to remove native invertebrates prior to test initiation.

Despite these filtering steps, microbes may persist and may interfere with the toxicity tests. A typical example is the occurrence of "sporadic mortality phenomenon" in the fathead minnow test (Grothe and Johnson 1996; Downey et al. 2000; US EPA 2002). This phenomenon is characterized by a non-monotonic concentration-response relationship with the highest mortality in the lowest test concentrations, large variation in organism survival among replicates and test concentrations, and onset of mortality around the third or fourth day of the seven-day test. Atypical swimming and fungal growth on the fish may be observed. The fathead minnow test appears to be particularly prone to issues with microbial growth in surface water samples due to the warm test temperatures (25°C ± 1°C), daily water renewals (75% of the test solutions replaced), daily feeding, and a sufficiently long exposure period (seven days). Excessive microbial growth can occur in non-toxic samples without sufficient levels of toxicants to suppress the microbe population (e.g., below the toxicity threshold for the test organisms but above that for the microbes).

Microbial growth on dead fish and atypical swimming were observed in the fathead minnow test of the July sample. Atypical swimming of fish was also observed in the August and September samples. A copper amendment test was conducted with the September sample, whereby an aliquot was spiked with 10 µg/L of copper and tested along with a spiked laboratory control. This copper concentration has been shown to suppress the microbial growth in surface water samples while not causing toxicity to the test organism (De Beers 2018). Survival and biomass were higher in the copper-spiked sample than in the unspiked sample (Appendix B, Table B-2), suggesting that microbial growth confounded the toxicity test results of the September sample.

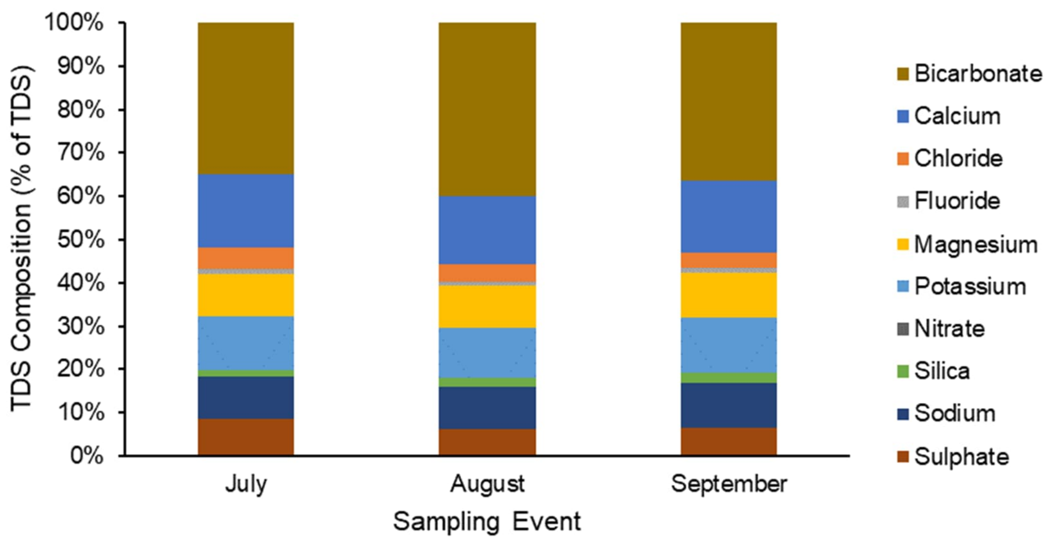
Pathogen interference was unlikely to have affected the *C. dubia* and algae tests. Some microbial growth in the *C. dubia* test may actually be beneficial as an additional food source (*C. dubia* are fed daily with *R. subcapitata* and yeast, Cerophyll™, and trout chow [YCT]). As noted above, algal tests are filtered and no evidence of microbial growth at test termination was noted by the toxicology laboratory.

Low Ionic Strength

Waters that are too soft (i.e., low hardness) or too low in alkalinity may cause osmotic stress of the test organisms, which would manifest as sublethal toxicity in the toxicity tests. For example, the *C. dubia* test method states that water used for culturing and water used for the laboratory control and dilution water of the toxicity test should have hardness that is within 20% to avoid erroneous results due to osmotic stress (Environment Canada 2007a). The toxicity test methods do not require the measurement of total dissolved solids (TDS), total hardness, and total alkalinity in control/dilution waters.

The TDS composition of the Lake N14 waters was similar among sampling events and was dominated by calcium and bicarbonate (Figure 4-1). However, TDS concentrations were very low, ranging from 7.2 to 7.4 mg/L, which corresponded to field specific conductivity ranging from 14 to 16 µS/cm, total hardness ranging from 5.9 to 6.4 mg/L, and total alkalinity ranging from 3.7 to 4.9 mg/L, respectively (Table 4-2). In comparison, the toxicity tests used control/dilution waters with substantially higher ionic strength, as shown by specific conductivity measurements (Table 4-3). The large difference in ionic strength (specific conductivity) was reduced in test solutions that were prepared by diluting the full-strength sample with laboratory water. In addition, toxicity was limited to the 100% test concentration for fathead minnows and *C. dubia*, which suggests that increasing the ionic strength of the test solution improved test response. For algae, adverse effects (more than 25% growth inhibition) were observed in the 46% v/v test concentrations[7], which suggests more dilution was required to improve the test response.

Figure 4-1 Total Dissolved Solids Composition in Water Samples from Lake N14, 2023



TDS = total dissolved solids.

[7] Note that the highest test concentration is 91%v/v due to the addition of nutrients to the test solutions prior to test initiation; thus 46%v/v is the next highest test concentration.

Table 4-3 Specific Conductivity in the Toxicity Tests with Lake N14 Waters, 2023

Test Species	Specific Conductivity in Control / Dilution Water	Specific Conductivity in the Sample Prior to Test Initiation[(a)]	Specific Conductivity in the 100% Test Concentration[(b)]	Specific Conductivity in the 50%v/v Test Concentration[(c)]
Pimephales promelas (fathead minnow)	347 to 433[(d)]	13	20 to 50	193 to 243
Ceriodaphnia dubia (water flea)	177 to 226[(e)]	16	28 to 85	112 to 152
Raphidocelis subcapitata (algae)	not measured[(f,g)]	15	not measured[(g)]	not measured[(g)]

Notes: Units are microsiemens per centimetre.

a) As measured by the toxicology laboratory prior to test initiation.

b) As measured by the toxicology laboratory in the 100% treatment prior to water renewal.

c) As measured by the toxicology laboratory in the 50%v/v test concentration (50% Lake N14 water + 50% laboratory control water) prior to water renewal.

d) The type and source of control/dilution water for the fathead minnow tests was dechlorinated City of Calgary tap water amended with 4 mg/L potassium chloride.

e) The type and source of control/dilution water for the *Ceriodaphnia dubia* tests was 20% Perrier water and 80% deionized water supplemented with vitamin B12 (2 µg/L) and sodium selenate (5 µg Se/L).

f) The type and source of control/dilution water for the *Raphidocelis subcapitata* tests was 85% deionized water and 15% dechlorinated City of Calgary tap water supplemented with nutrients according to the test protocol for testing mine effluent.

g) The test method does not require measurement of specific conductivity in the control or test waters.

%v/v = percent sample in the test solution on a volume to volume basis.

The sensitivity of *C. dubia* to low ionic strength water or to water with different TDS composition to culture water is known (e.g., Lasier et al. 2006; Environment Canada 2011). However, the sensitivity of fathead minnows or algae to low ionic strength water is not as well studied. Fathead minnows can be cultured and tested in soft water (hardness of 40 to 48 mg/L) but the reconstituted water recipe recommended by the Environment Canada test method has a pH 7.4 ± 0.2 (Environment Canada 2011). In comparison, Lake N14 waters have a much lower hardness and lower pH (open-water mean of pH 6.6). In the toxicity tests, the control/dilution waters had a higher pH (7.5 to 8.3) than the 100% test concentrations (6.5 to 7.6). Environment Canada (2011) noted that fathead minnows are intolerant of low pH and prefer pH values of 7.0 or higher.

In conclusion, the cause(s) of the observed toxicity is unknown but is unlikely to be due to total iron concentrations above the AEMP benchmark or pathogen/predator interference. There is insufficient evidence to suggest the responses in the laboratory are indicative of toxicological impairment in Lake N14. A plausible hypothesis is that the large discrepancy in ionic strength between Lake N14 waters and the waters used to culture the test organisms and as laboratory control/dilution waters in the toxicity tests caused osmotic stress, thereby leading to the observed toxicity.

5 ECOLOGICAL IMPLICATIONS

The cause of the observed toxicity in the laboratory exposures is unknown. Although concentrations of some metals were elevated, they were below chronic toxicity thresholds. There are other potential causes of the observed toxicity in the laboratory, such as the effects of low ionic strength water on test organism response. Further investigation is warranted to understand what is causing the toxicity.

It is likely that seasonal habitat use in Lake N14 is unaffected by the changes in water quality. The presence of aquatic invertebrates in the Lake N14 samples submitted for toxicity testing suggests that zooplankton are present in Lake N14. The biological monitoring results in Lake D2/D3 (the main source of water to Lake N14) also support that there is likely to be a functioning and healthy aquatic ecosystem in Lake N14 that can support fish during the open-water season:

- Water quality has changed in Lake D2/D3 with recent years showing a decline or stabilization in metals and nutrients. Concentrations of nutrients and metals are higher in Lake D2/D3 than in Lake N14.
- Sediment quality has also changed in Lake D2/D3 with increased concentrations of total phosphorus (TP) and some metals. However, mean/median concentrations of those metals remain below AEMP benchmarks, or where applicable, alternate reference values used to evaluate aquatic risk.
- Ecological function within the plankton community in Lake D2/D3 appears to be maintained, based on the ability of the plankton community to sustain itself and transfer energy from phytoplankton to zooplankton. Zooplankton biomass has remained at or above baseline (i.e., 2015) values, and above values observed in the core and reference lakes. Although phytoplankton biomass has decreased since baseline, the decrease is likely related to higher grazing pressure from zooplankton. Overall phytoplankton biomass appears to have stabilized since 2019.
- Since 2019, zooplankton biomass in Lake D2/D3 has been greater than that observed in the core and reference lakes, and phytoplankton biomass has been within the range of the reference lakes (i.e., Lake 3). This suggests that if the communities in the core and reference lakes are healthy and functioning well, then the plankton community in Lake D2/D3 can be considered a functioning community showing no adverse effects on ecological function.
- The response in the benthic invertebrate community in Lake D2/D3 is most consistent with effects due to physical habitat alteration, specifically, lower DO concentrations during the ice-cover season resulting in a shift in community composition to dominance by a low DO tolerant midge genus, particularly in Basin D2. However, a diverse benthic invertebrate community persists in Basin D2, despite the changes in water and sediment quality since 2015.

6 RESPONSE ACTIONS

The main response actions are to:

- continue water quality monitoring in Lake N14 and Lake N17 per the currently approved AEMP Design Plan (De Beers 2023a);
- repeat the sublethal toxicity testing in Lake N14 as a special study in 2024;
- investigate the cause(s) of the observed toxicity to algae and invertebrates; and
- investigate management options.

Further discussion of these response actions is provided below.

No changes to the Moderate or High Action Levels are proposed at this time. The current Action Levels are appropriate to identify the need for further investigation given the monitoring results. Changes to the Action Levels may be proposed upon conclusion of the toxicity investigation described in Section 6.3.

6.1 Monitoring in Lake N14 and Lake N17

Water quality monitoring in Lake D2/D3, Lake N14, and Lake N17 will continue per the AEMP Design Plan to evaluate the potential for downstream effects of overflow from Lake D2/D3. Even though the Moderate Action Level for Lake N17 was not exceeded, flow from Lake N14 may impact water quality in Lake N17, and therefore continued monitoring and evaluation against the Moderate Action Level criteria is warranted.

There are three administrative edits relative to the sampling design for Lake N14 and Lake N17 that could be applied to the AEMP Design Plan:

- Table 6.2-1 of the AEMP Design Plan states that Lake N14 and Lake N17 will be sampled in April/May and August. However, Table 5.4-2 states that that Lake N14 and Lake N17 will be monitored for water quality during one ice-cover and three open-water events. This is consistent with the proposed edits provided in Appendix B of the 2021 AEMP Response Plan for Lake D2/D3 – Version 1.2, which was approved by MVLWB. Thus, it is recommended that this administrative edit (i.e., four sampling events) is made to Table 6.2-1 for consistency.
- Table 6.2-1 of the AEMP Design Plan also indicates that Lake N14 and Lake N17 will be sampled for microcystin-LR. However, this was not part of the sampling design for these lakes, as described in Section 5.2.3 and 5.2.4 of the 2021 AEMP Response Plan for Lake D2/D3 – Version 1.2. This sampling design detail was not correctly captured in Appendix B of the 2021 AEMP Response Plan for Lake D2/D3 – Version 1.2. Thus, it is recommended that this administrative edit (i.e., no microcystin-LR sampling) is made to Table 6.2-1 for consistency.
- In the revision history and in several other locations in the AEMP Design Plan, it is stated that water samples from Lake N14 will be collected at mid-depth (e.g., Table 5.4-2 of De Beers 2023a). However, Section 8.4.3.4 of the AEMP Design Plan states that water samples for the special study of sublethal toxicity in Lake N14 will be collected at 0.2 m below water surface. Thus, it is recommended that this administrative edit (i.e., sampling at 0.2 m depth) is made to Table 6.2-1 for consistency.

6.2 Sublethal Toxicity Testing in Lake N14

The sublethal toxicity testing in Lake N14 should be repeated as a special study in the 2024 AEMP, according to the methods described in the AEMP Design Plan. Water samples will be collected at each of the three open-water sampling events and submitted to the toxicology laboratory for analysis of sublethal toxicity to fathead minnows, *C. dubia*, and *R. subcapitata*. A copper amendment test can be added to the fathead minnow test to evaluate the potential for sporadic mortality phenomenon to affect the observed response. Specifically, an aliquot of the surface water sample could be treated with 10 µg/L of copper and tested for effects on survival and growth of fathead minnow larvae. The copper-treated sample would be tested at 100% (i.e., no dilution) along with a laboratory control spiked with 10 µg/L of copper. This concentration of copper has been shown to be non-toxic to the fish and is approved for use in testing SNP-02 operational discharge under the Water Licence (De Beers 2018; MVLWB 2018, 2021).

6.3 Toxicity Investigation

Based on the evaluation in Section 4, the low ionic strength of surface waters may be causing or contributing to the observed toxicity in the Lake N14 samples. The toxicity investigation will address this study question:

- Could low ionic strength that is lower than the standard control/dilution water used in the laboratory tests be the cause of the observed toxicity?

The investigation has three laboratory components:

- Test Lake N14 water amended to double hardness (increase ionic strength);
- Test reference lake samples with similar ionic strength but lower metal concentrations; and
- Test synthetic water (mimic Lake N14 water but with no metals).

Component 1: Amend Lake N14 Water (Increase Ionic Strength)

For this component, aliquots of the Lake N14 water samples collected for the special study described in Section 6.2 will be amended with reagent-grade salts to approximately double the hardness from the expected 6 mg/L as $CaCO_3$ to approximately 12 mg/L as $CaCO_3$. The water recipe in Environment Canada (2000) will be used to guide the selection of salts and their ratios to achieve the desired hardness. The amended samples will be analyzed for hardness, alkalinity, TDS, major ions, DOC, and total metals. In addition, at test initiation in the *C. dubia* test (after food has been added to the test solutions), subsamples will be collected for analysis of TDS, major ions, and DOC to evaluate how food addition affects ionic strength and composition[8].

The hardness-amended samples will be tested for sublethal toxicity to fathead minnows, *C. dubia*, and algae at 100% only (no dilution) concurrently with the unamended samples (Section 6.2).

Component 2: Test Other Small Reference Lake Samples

The purpose of this component is to understand whether other small reference lakes, with similar ionic strength but lower metal concentrations, yield the same or similar toxicity response. Up to three reference

[8] An increase in specific conductivity was observed in the full-strength (100%) sample at test initiation (Table 4-3).

lakes will be selected for sampling. One of these lakes will likely be Lake I1, which is a small lake similar in size to Lake N14 and was also used to support the baseline normal range calculations for Lake N14 (De Beers 2023b). Another lake could be Lake 3, which is a larger lake but has similar low ionic strength (mean field specific conductivity and total hardness in the 2023 open-water season was 12 µS/cm and 5.2 mg/L as $CaCO_3$, respectively). Similarly, East Lake had mean field specific conductivity of 16 µS/cm and total hardness of 6.3 mg/L as $CaCO_3$ in the 2023 open-water season.

Water samples will be collected from one station within each lake concurrently with the AEMP water quality open-water sampling events (i.e., July, August, and September per the AEMP Design Plan [De Beers 2023a]). The reference lake samples will be tested for sublethal toxicity to fathead minnows, *C. dubia*, and algae at 100% only (no dilution) concurrently with the hardness-amended and unamended Lake N14 samples. As for the hardness-amended samples in Component 1, subsamples will be collected for analysis of hardness, alkalinity, TDS, major ions, DOC, and total metals.

Component 3: Test Synthetic Water

Component 3 will test a synthetic water sample prepared to mimic the Lake N14 water in terms of ionic strength and composition. The synthetic water will be prepared at the toxicology laboratory by spiking deionized reverse osmosis-treated water with additions of standard reagent-grade salts as recommended by Environment Canada (2000) for the preparation of reconstituted water. Prior to use in the toxicity tests, subsamples will be analyzed to confirm that the TDS concentration and composition approximates that of the Lake N14 waters. This synthetic water would be tested as a single concentration test (i.e., 100% full-strength sample along with a standard laboratory control water). Subsamples from the laboratory control and synthetic water will be collected at test initiation (after food addition in the *C. dubia* test and after nutrient addition in the algae test) for analysis of TDS, major ions, and DOC.

The results of the laboratory testing program outlined above will be evaluated against the study question.

6.4 Management Options

Identifying, implementing, and refining potential mitigation strategies as a component of the management process to reduce the risk of significant adverse risk to aquatic life are a suggested response action in Section 8.4.3.4 of the AEMP Design Plan.

The main mitigation option relevant to Lake N14 is to stop the flow of water from Lake D2/D3 (and the other raised lake, Lake E1) to Lake N14 and then to Lake N17. This option is currently being considered by De Beers and may be the considered in a future Water Licence amendment (De Beers 2024b). Specifically, De Beers is considering pumping water from Lake D2/D3 and Lake E1 to supplement the Water Management Pond; this pumping would result in ceasing overflow from these raised lakes to Lake N14. This would prevent any further degradation of Lake N14 water quality by the addition of waters from Lake D2/D3 and Lake E1, and would initiate the earlier recovery of Lake N14 water quality. Water quality monitoring in Lake N14 would continue to occur under the currently approved AEMP Design Plan.

7 SUMMARY AND CONCLUSIONS

The changes in water quality observed in Lake N14 are consistent with the qualitative EIS projections (De Beers 2010, 2011, 2012, 2023a) due to the flow of water from the Raised Lakes D2/D3 and E1. Specific conductivity and concentrations of TDS, nutrients (e.g., TP and DOC), and metals (e.g., aluminum, copper, iron) have increased in Lake N14 compared to baseline conditions. However, concentrations of toxicologically relevant parameters are below AEMP benchmarks or other guidelines for the protection of aquatic life. Sublethal toxicity to fathead minnows, *C. dubia*, and *R. subcapitata* was observed in laboratory toxicity tests. The cause of the toxicity is unknown but may be due to the lower ionic strength in the Lake N14 waters compared to the laboratory culture and test waters.

The changes in water quality and observations of laboratory toxicity do not suggest that seasonal habitat for fish is affected in Lake N14. The main response actions are to continue water quality monitoring in Lake N14 and Lake N17, repeat the special study of sublethal toxicity testing in Lake N14, and conduct a toxicity investigation about the potential effects of low ionic strength waters. The toxicity investigation will include three components: testing of hardness-amended Lake N14 samples, testing of reference lake samples that also have low ionic strength but also low metal concentrations, and testing of a synthetic water designed to mimic the ionic strength of Lake N14 waters. The results of continued water quality monitoring and the toxicity investigation will be used to evaluate whether further response actions are necessary.

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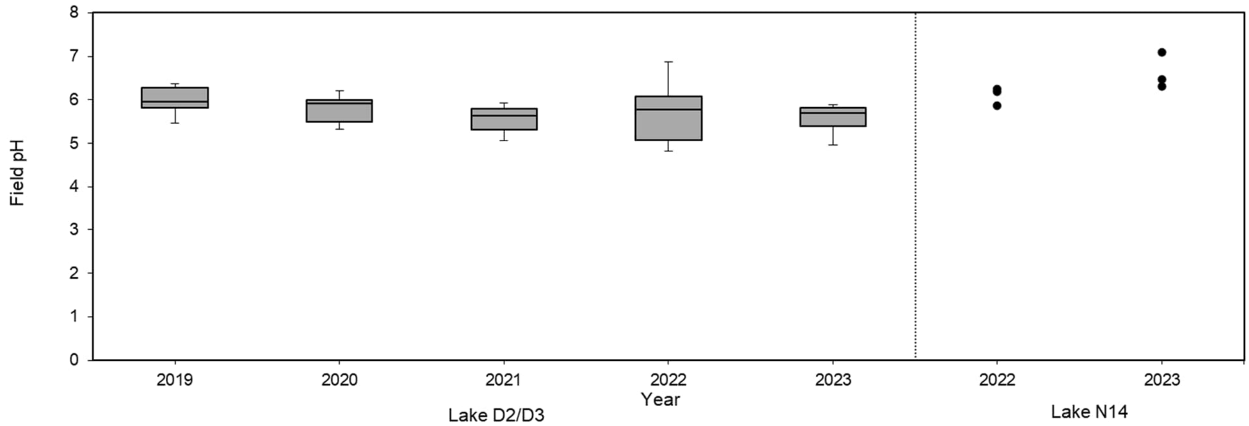
Appendix A

Water Quality Plots of Lake D2/D3 and Lake N14

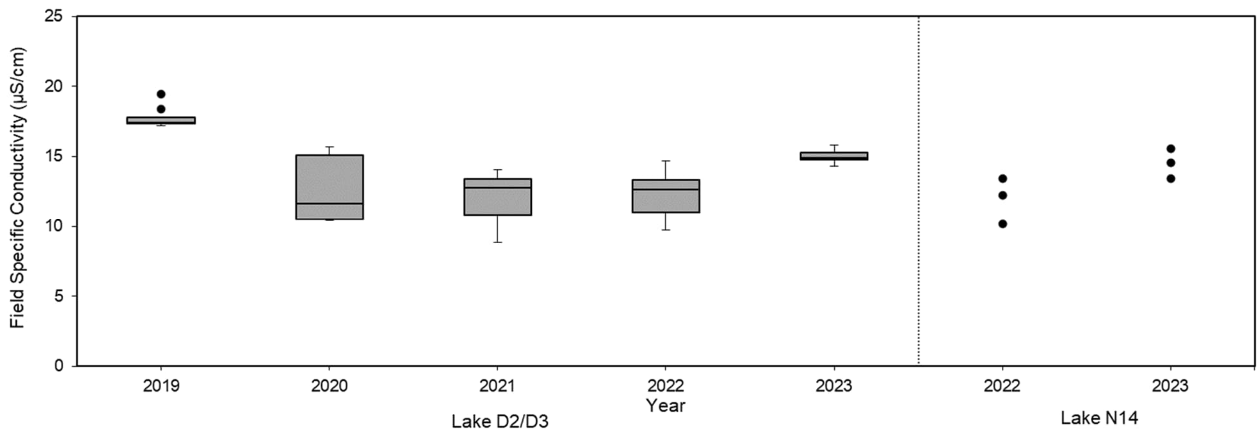
LIST OF FIGURES

Figure A-1 Time Series Plot for Field pH in Lake D2/D3 and Lake N14, 2019 to 2023



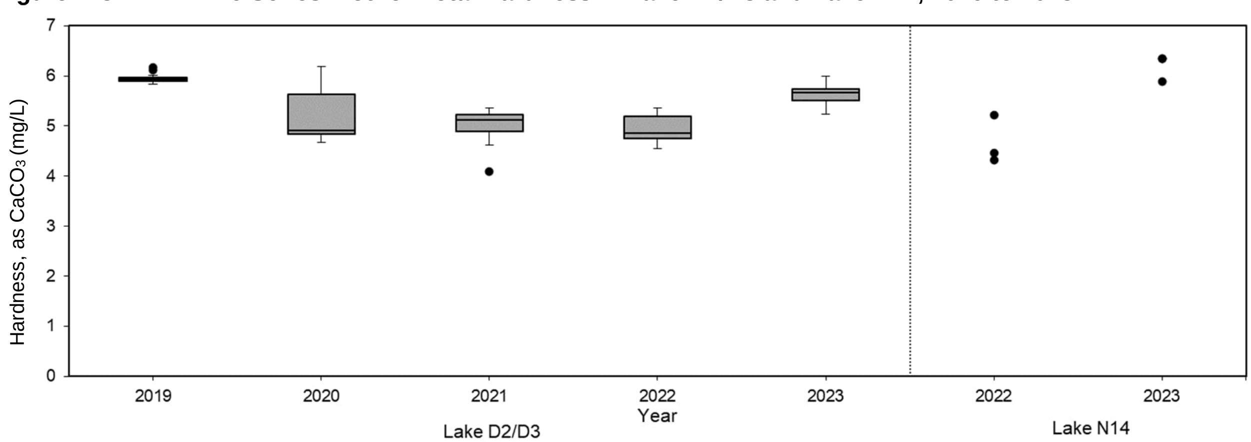
Note: Field data corresponds to the in-situ measurement at the depth where the water sample was collected.

Figure A-2 Time Series Plot for Field Specific Conductivity in Lake D2/D3 and Lake N14, 2019 to 2023



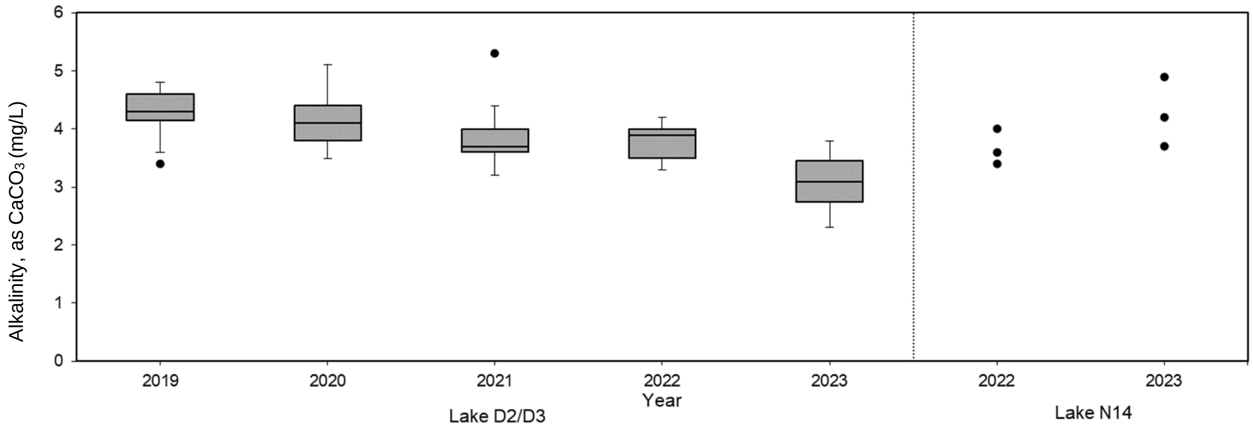
Note: Field data corresponds to the in-situ measurement at the depth where the water sample was collected.

Figure A-3 Time Series Plot for Total Hardness in Lake D2/D3 and Lake N14, 2019 to 2023



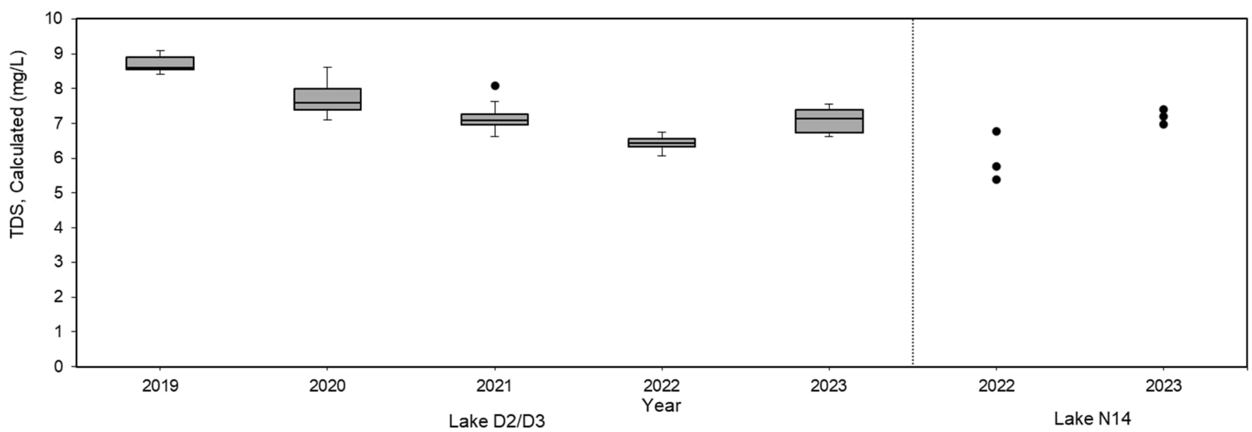
$CaCO_3$ = calcium carbonate.

Figure A-4 Time Series Plot for Total Alkalinity in Lake D2/D3 and Lake N14, 2019 to 2023



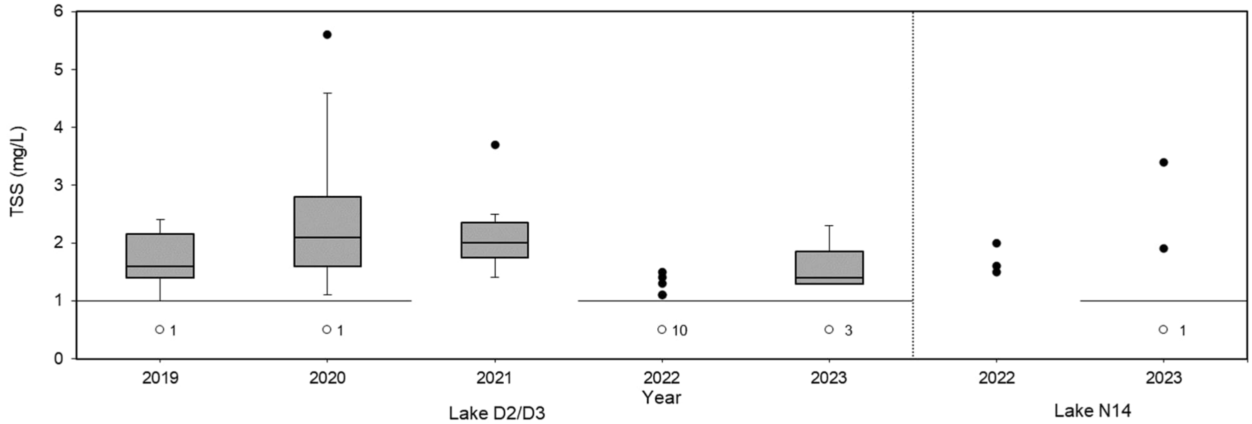
$CaCO_3$ = calcium carbonate.

Figure A-5 Time Series Plot for Total Dissolved Solids (Calculated) in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Calculated TDS is preferred to measured TDS because measured TDS is typically biased high.
Lake D2/D3 AEMP Benchmark = 500 mg/L; Lake N14 AEMP Benchmark = 500 mg/L.
AEMP = Aquatic Effects Monitoring Program; TDS = total dissolved solids.

Figure A-6 Time Series Plot for Total Suspended Solids in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Detection limit is indicated with horizontal line. Open circles indicate values below detection limit with the number of values below the detection limit to the right of the open circle.

Lake D2/D3 AEMP Benchmark = 8.3 mg/L; Lake N14 AEMP Benchmark = 6.8 mg/L; AEMP = Aquatic Effects Monitoring Program.

Figure A-7 Time Series Plot for Total Calcium in Lake D2/D3 and Lake N14, 2019 to 2023

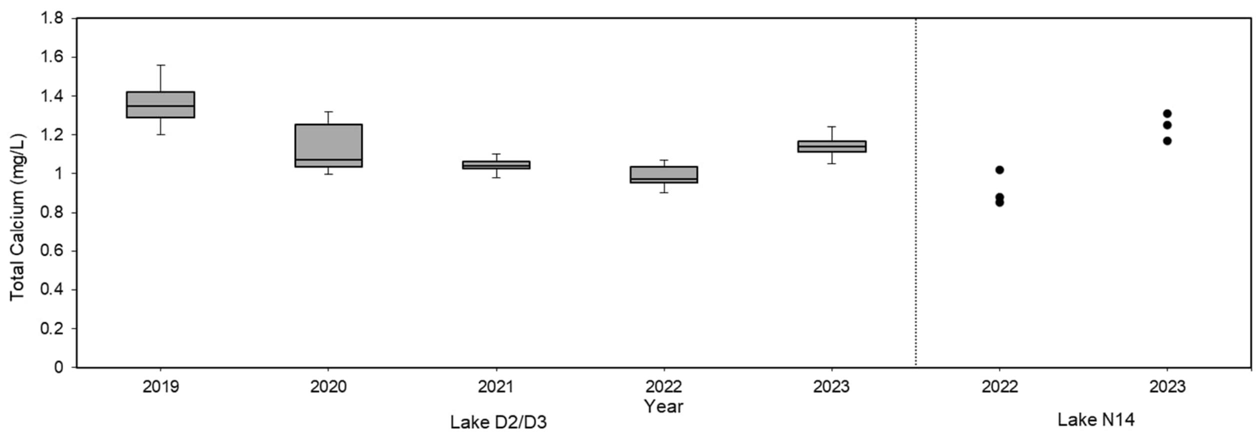


Figure A-8 Time Series Plot for Total Magnesium in Lake D2/D3 and Lake N14, 2019 to 2023

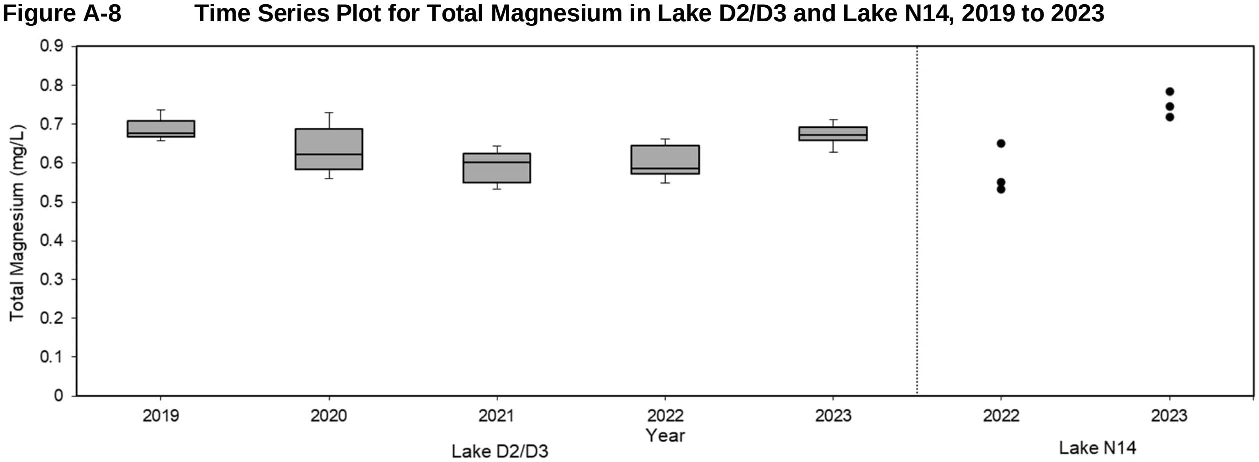
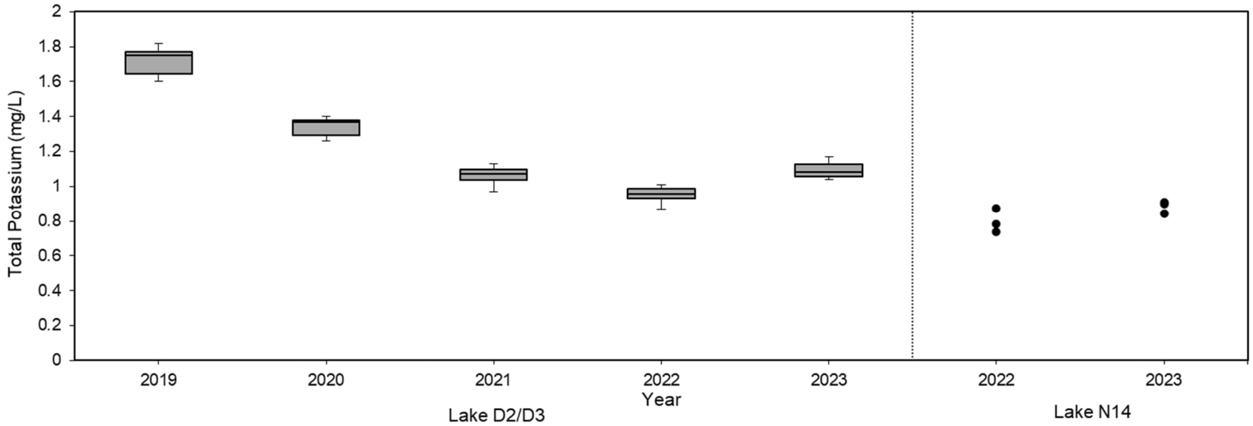


Figure A-9 Time Series Plot for Total Potassium in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Lake D2/D3 AEMP Benchmark = 41 mg/L; Lake N14 AEMP Benchmark = 41 mg/L; AEMP = Aquatic Effects Monitoring Program.

Figure A-10 Time Series Plot for Total Sodium in Lake D2/D3 and Lake N14, 2019 to 2023

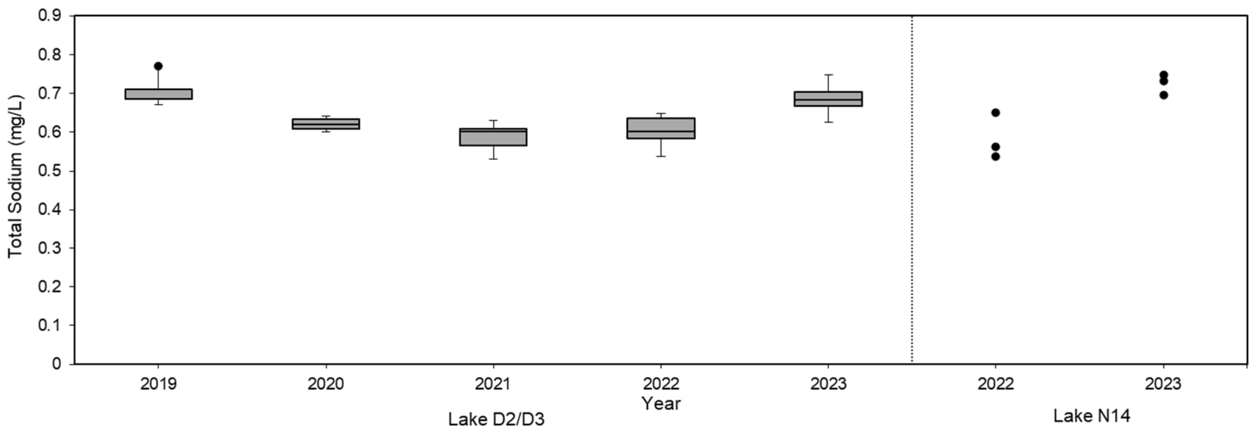
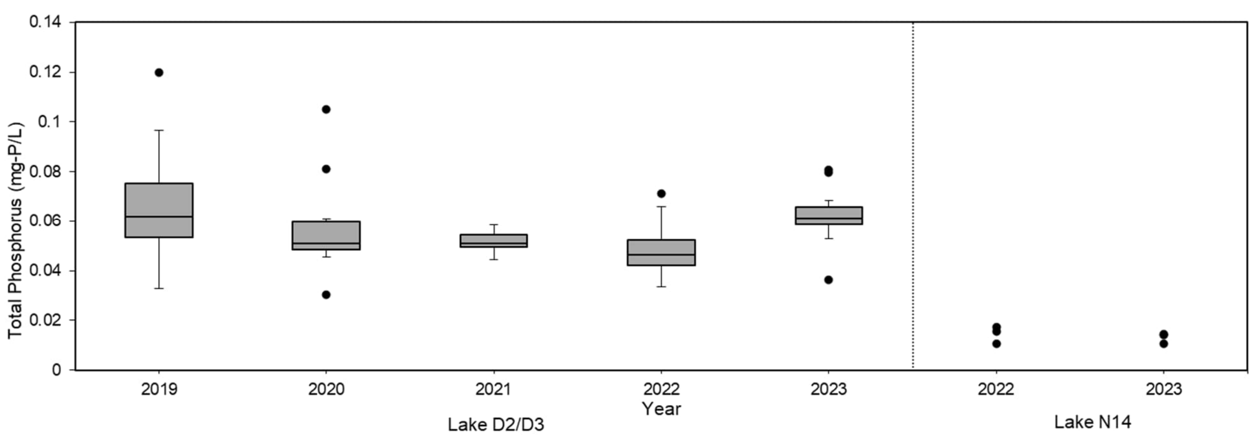
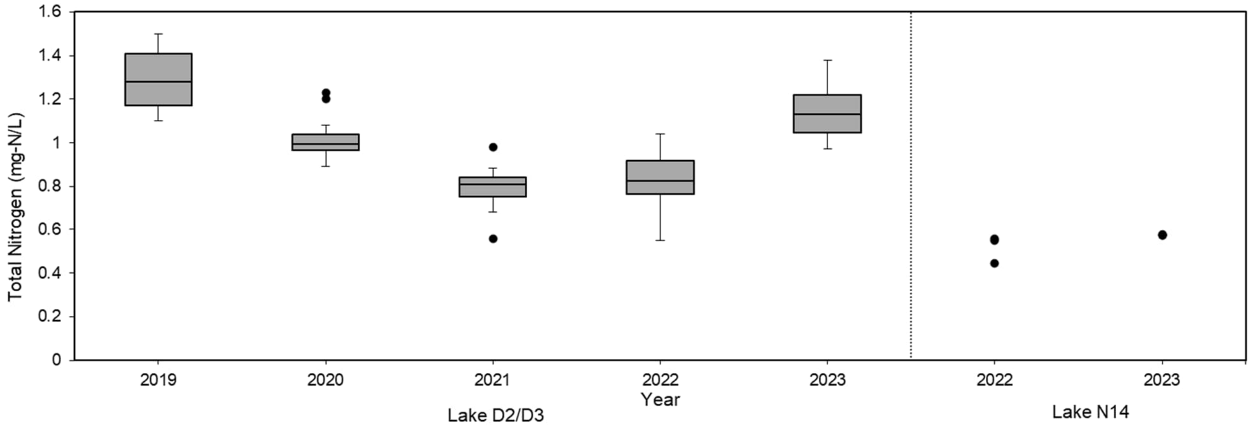


Figure A-11 Time Series Plot for Total Phosphorus in Lake D2/D3 and Lake N14, 2019 to 2023



mg-P/L = milligrams of phosphorus per litre.

Figure A-12 Time Series Plot for Total Nitrogen in Lake D2/D3 and Lake N14, 2019 to 2023



mg-N/L = milligrams of nitrogen per litre.

Figure A-13 Time Series Plot for Total Organic Carbon in Lake D2/D3 and Lake N14, 2019 to 2023

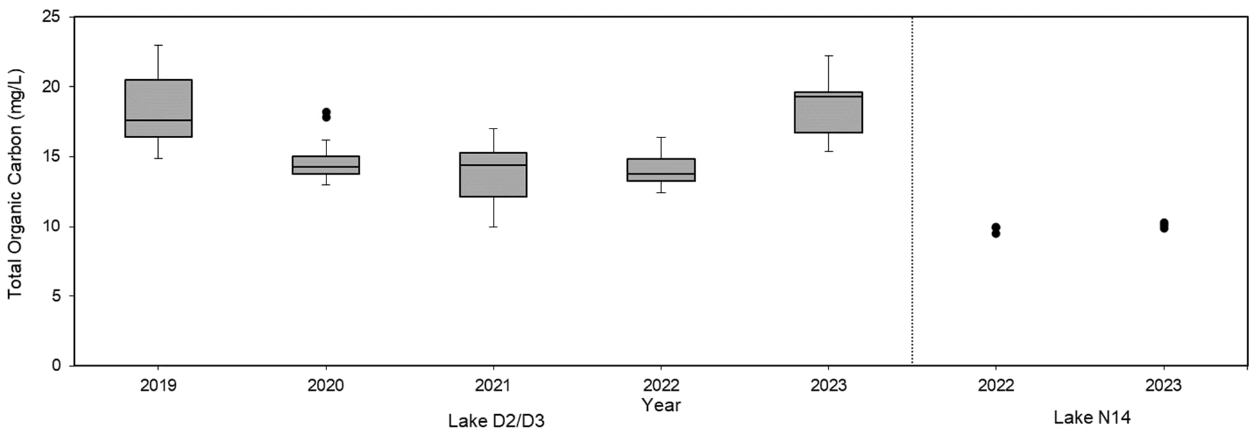


Figure A-14 Time Series Plot for Dissolved Organic Carbon in Lake D2/D3 and Lake N14, 2019 to 2023

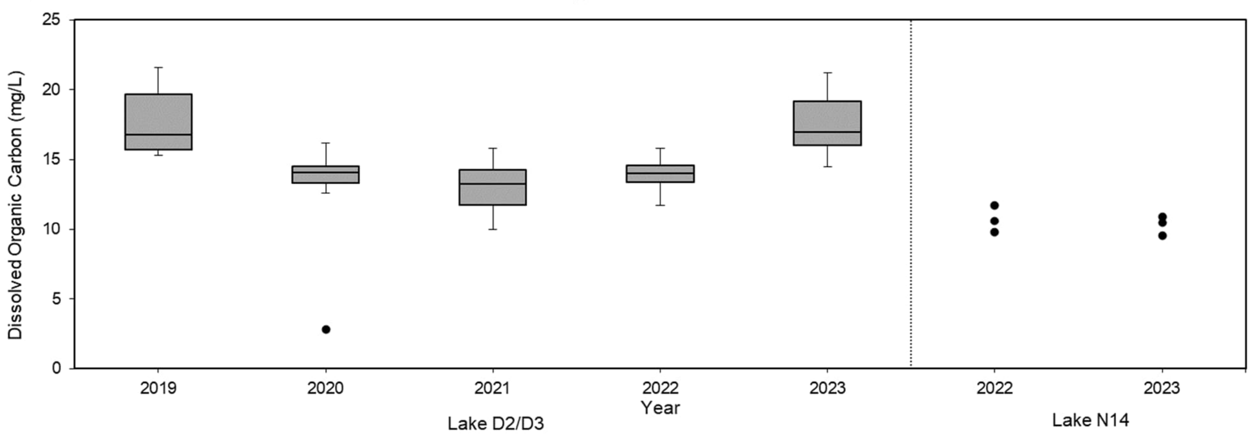
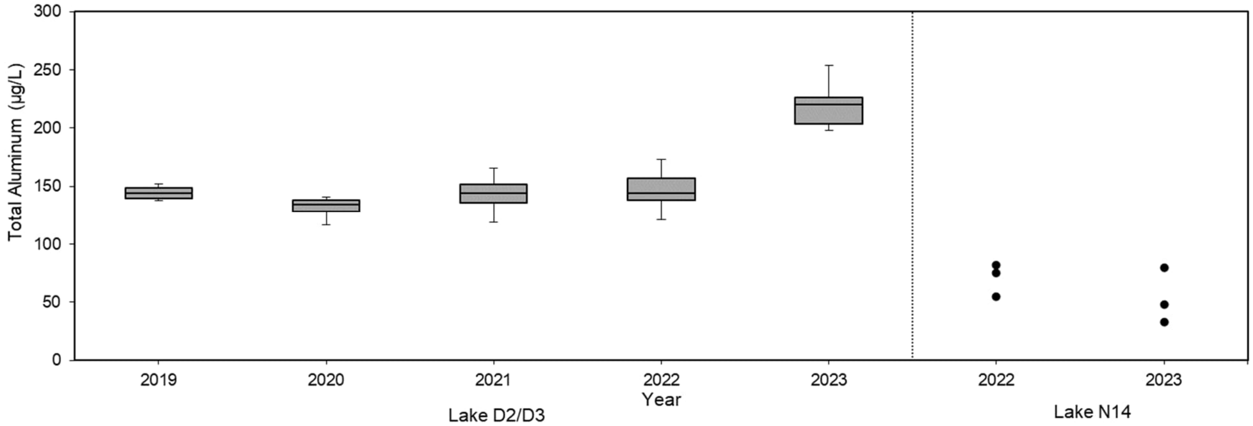
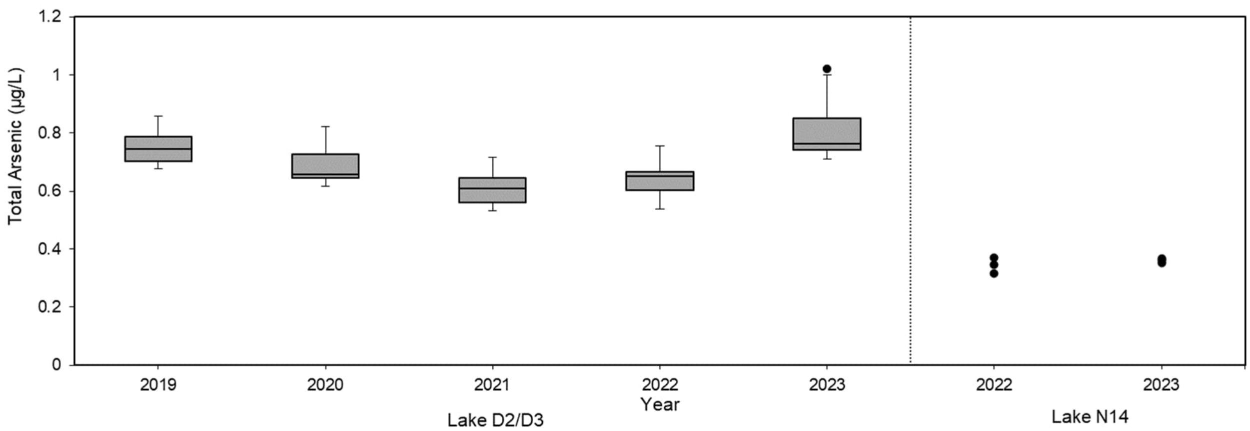


Figure A-15 Time Series Plot for Total Aluminum in Lake D2/D3 and Lake N14, 2019 to 2023



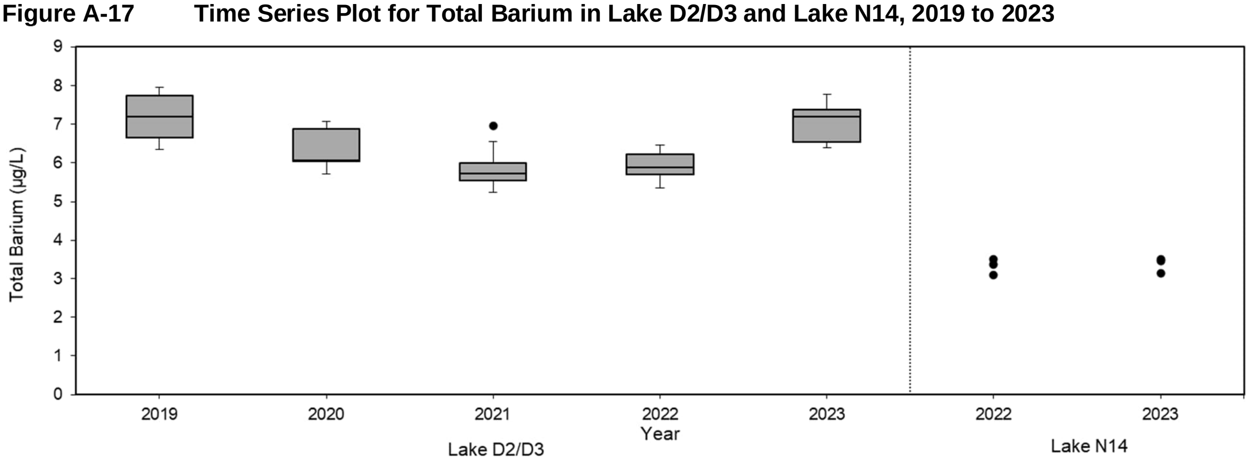
Notes: Lake D2/D3 AEMP Benchmark = 46 µg/L; Lake N14 AEMP Benchmark = 96 - 435 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-16 Time Series Plot for Total Arsenic in Lake D2/D3 and Lake N14, 2019 to 2023



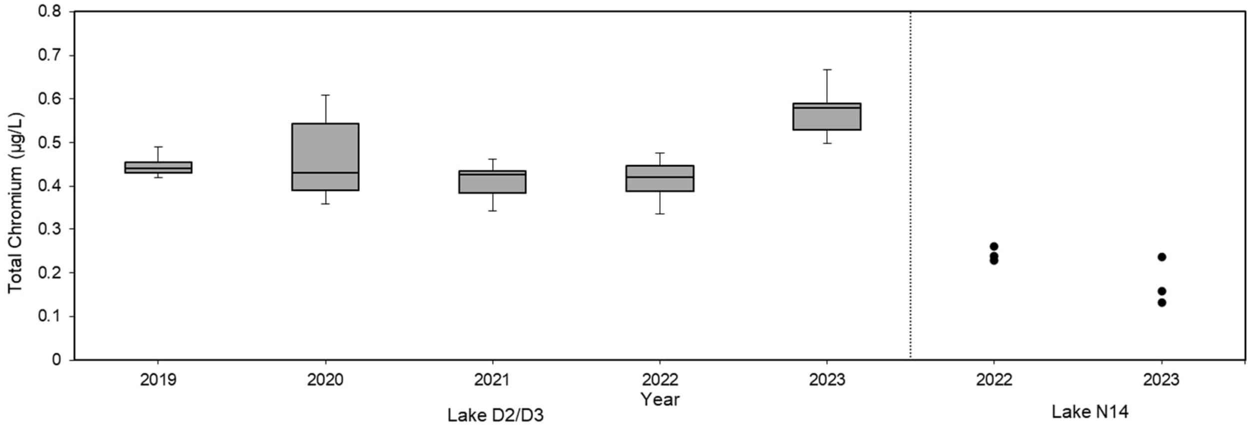
Notes: Lake D2/D3 AEMP Benchmark = 5.0 µg/L; Lake N14 AEMP Benchmark = 5.0 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-17 Time Series Plot for Total Barium in Lake D2/D3 and Lake N14, 2019 to 2023



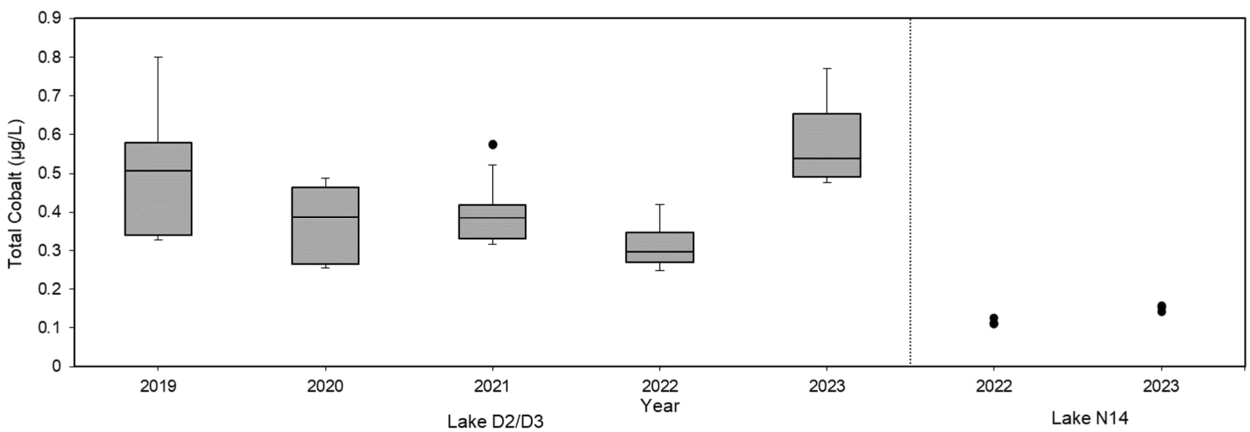
Notes: Lake D2/D3 AEMP Benchmark = 1,000 µg/L; Lake N14 AEMP Benchmark = 1,000 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-18 Time Series Plot for Total Chromium in Lake D2/D3 and Lake N14, 2019 to 2023



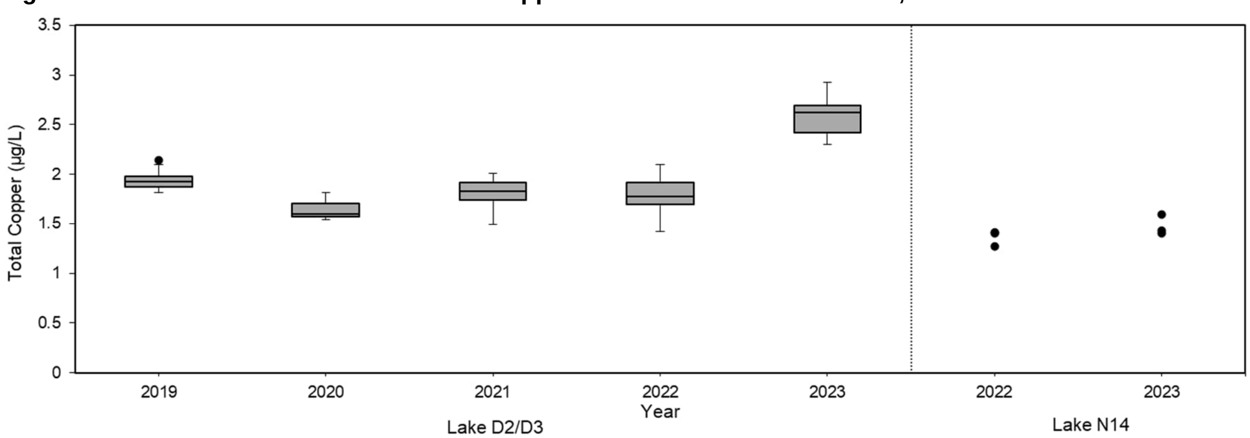
Notes: Lake D2/D3 AEMP Benchmark = 5.0 µg/L; Lake N14 AEMP Benchmark = 5.0 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-19 Time Series Plot for Total Cobalt in Lake D2/D3 and Lake N14, 2019 to 2023



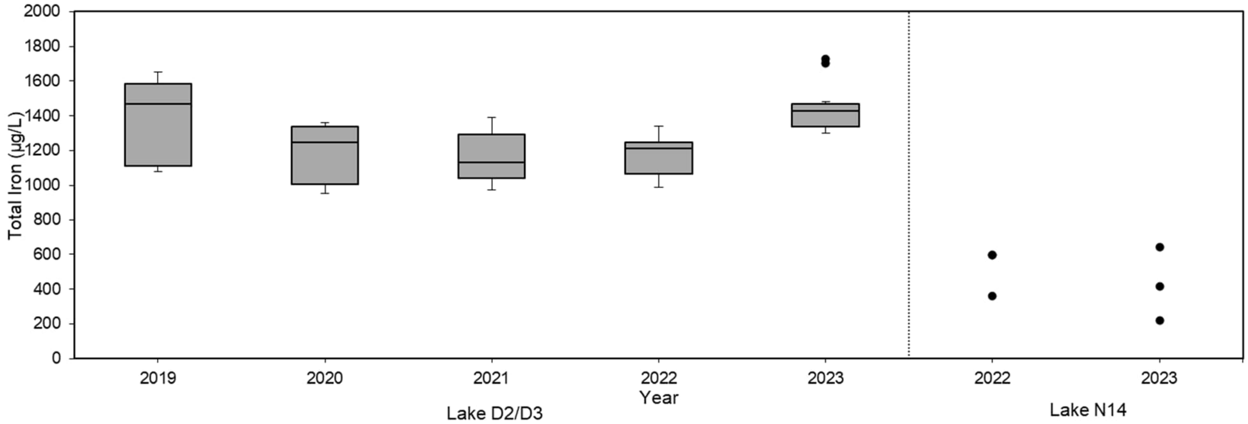
Notes: Lake D2/D3 AEMP Benchmark = 3.2 µg/L; Lake N14 AEMP Benchmark = 3.2 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-20 Time Series Plot for Total Copper in Lake D2/D3 and Lake N14, 2019 to 2023



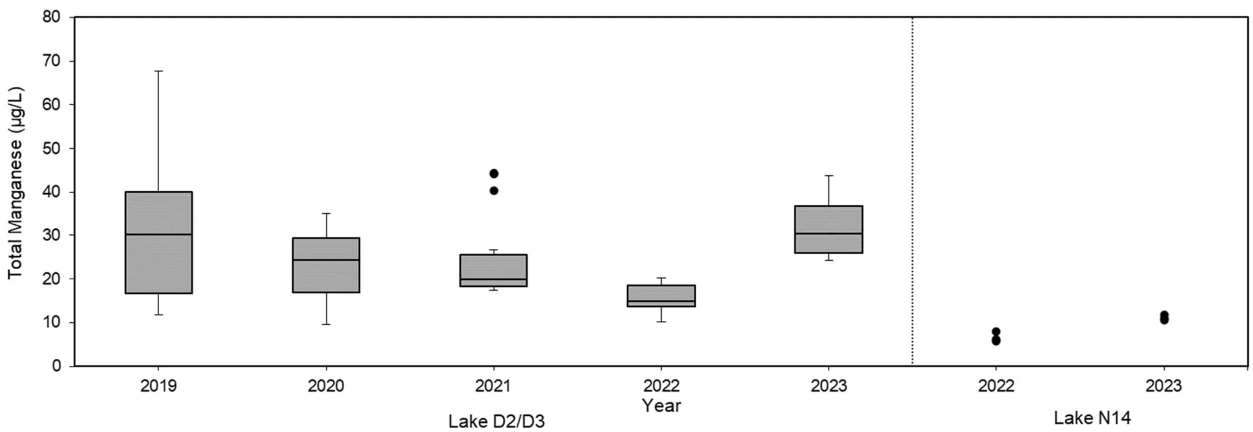
Notes: Lake D2/D3 AEMP Benchmark = 2.0 µg/L; Lake N14 AEMP Benchmark = 2.0 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-21 Time Series Plot for Total Iron in Lake D2/D3 and Lake N14, 2019 to 2023



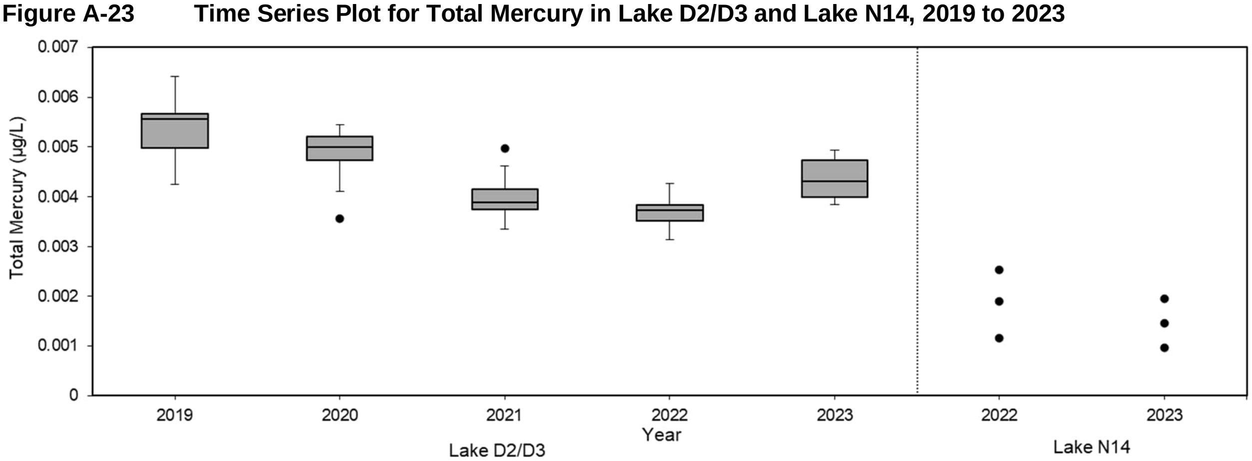
Notes: Lake D2/D3 AEMP Benchmark = 670 µg/L; Lake N14 AEMP Benchmark = 300 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-22 Time Series Plot for Total Manganese in Lake D2/D3 and Lake N14, 2019 to 2023



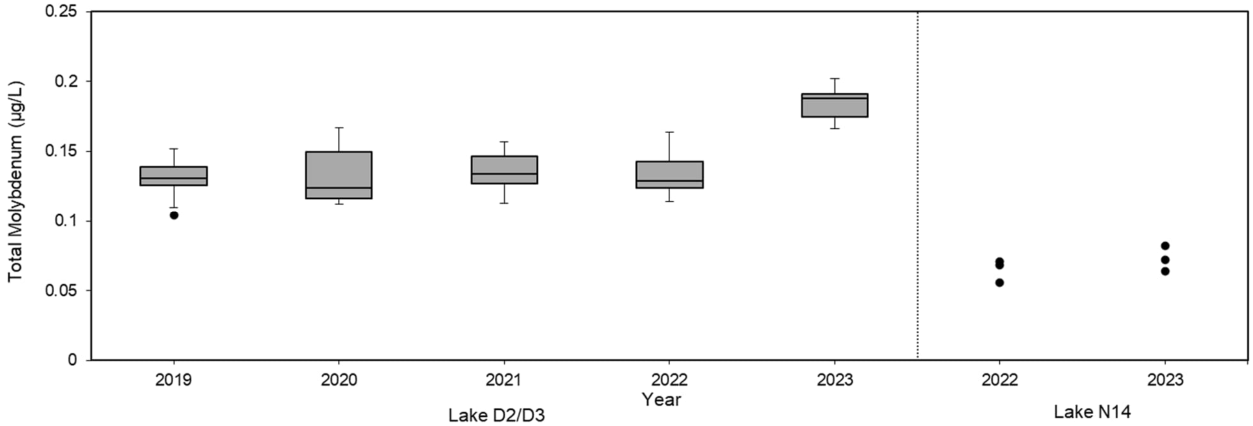
Notes: Lake D2/D3 AEMP Benchmark = 190 µg/L; Lake N14 AEMP Benchmark = 200 - 250 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-23 Time Series Plot for Total Mercury in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Lake D2/D3 AEMP Benchmark = 0.026 µg/L; Lake N14 AEMP Benchmark = 0.026 µg/L.
AEMP = Aquatic Effects Monitoring Program.

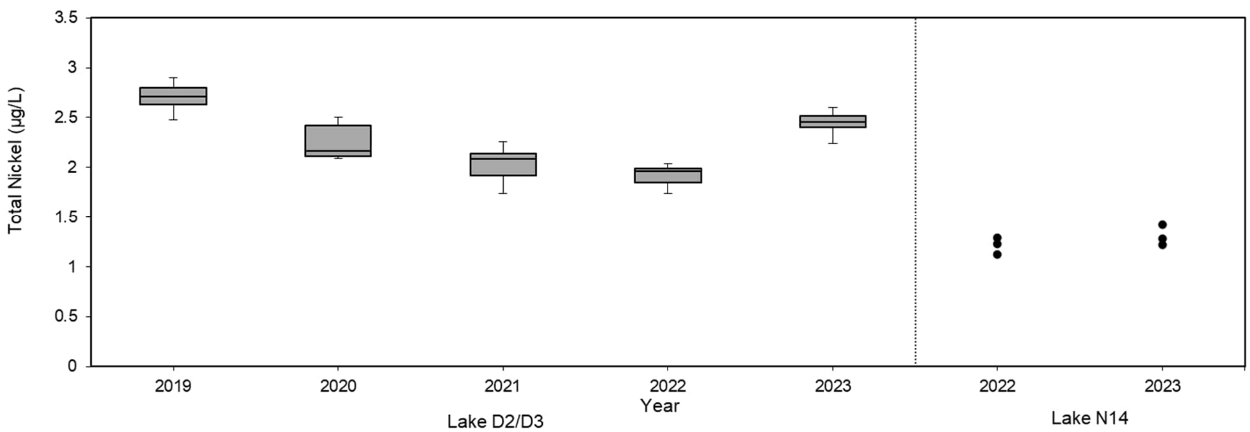
Figure A-24 Time Series Plot for Total Molybdenum in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Lake D2/D3 AEMP Benchmark = 73 µg/L; Lake N14 AEMP Benchmark = 73 µg/L.

AEMP = Aquatic Effects Monitoring Program.

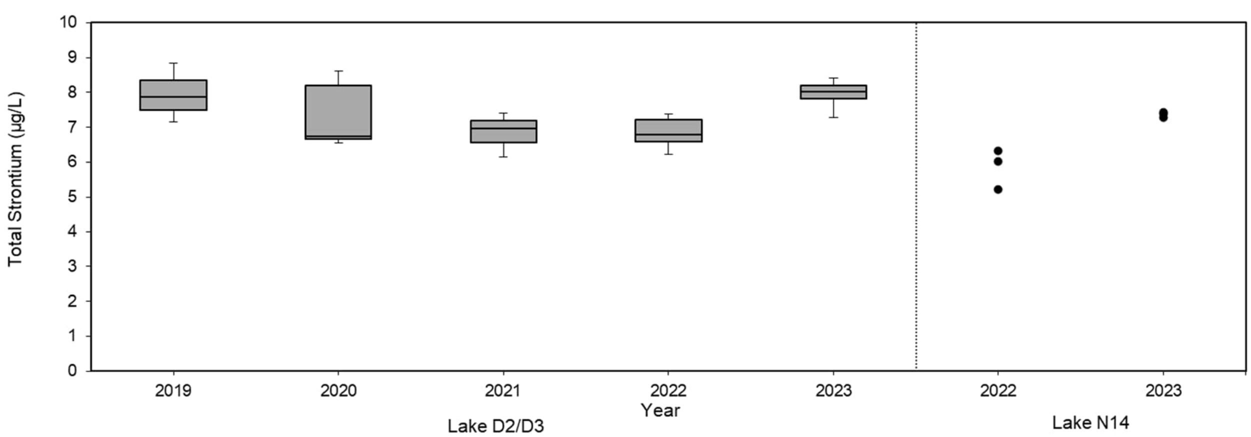
Figure A-25 Time Series Plot for Total Nickel in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: The 2019 outlier of 18.2 µg/L from Lake D2/D3 is not shown on plot. Lake D2/D3 AEMP Benchmark = 25 µg/L; Lake N14 AEMP Benchmark = 25 µg/L.

AEMP = Aquatic Effects Monitoring Program.

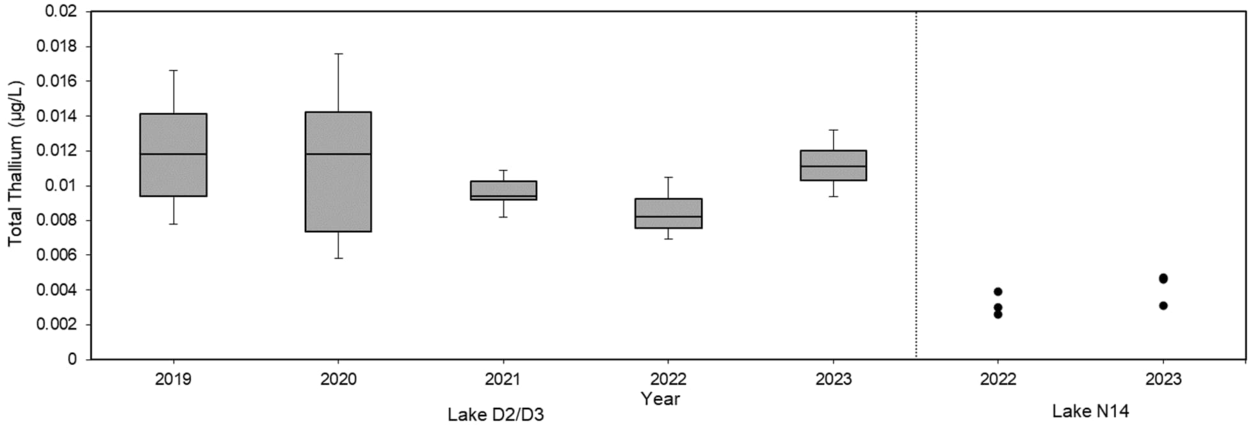
Figure A-26 Time Series Plot for Total Strontium in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Lake D2/D3 AEMP Benchmark = 2,500 µg/L; Lake N14 AEMP Benchmark = 2,500 µg/L.

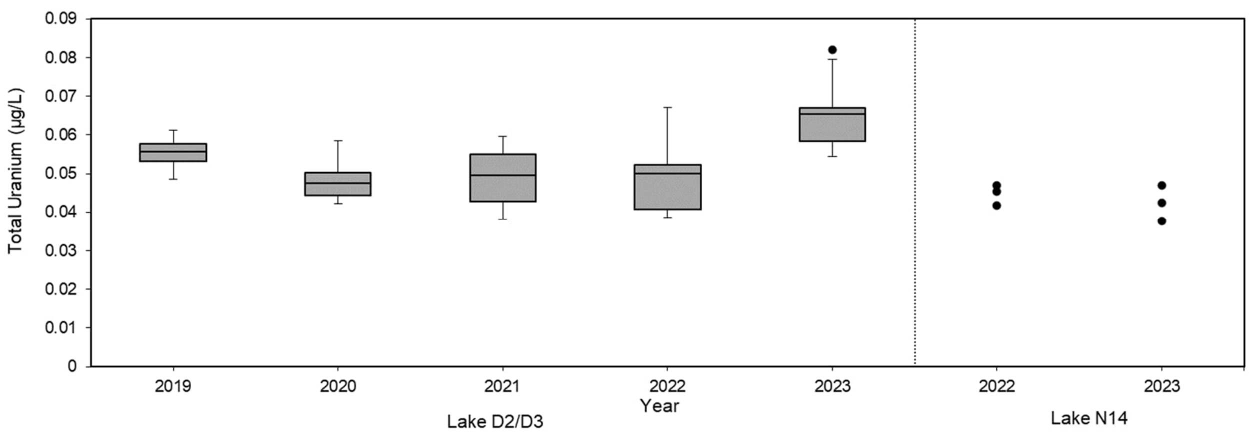
AEMP = Aquatic Effects Monitoring Program.

Figure A-27 Time Series Plot for Total Thallium in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Lake D2/D3 AEMP Benchmark = 0.80 µg/L; Lake N14 AEMP Benchmark = 0.80 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Figure A-28 Time Series Plot for Total Uranium in Lake D2/D3 and Lake N14, 2019 to 2023



Notes: Lake D2/D3 AEMP Benchmark = 15 µg/L; Lake N14 AEMP Benchmark = 15 µg/L.
AEMP = Aquatic Effects Monitoring Program.

Appendix B

Lake N14 Toxicity Responses

LIST OF TABLES

Table B-1 Percent Adverse Responses in Lake N14 Samples from the July, August, and September 2023 Sampling Events

Test Species	Type of Response	Test Concentration (%v/v)	Percent Adverse Response (Relative to Laboratory Control)		
			July	August	September
Pimephales promelas (fathead minnow)	Reduction in Survival	1.6	—	9%	3%
		3.2	0%	0%	13%
		6.3	5%	—	8%
		12	—	—	—
		25	—	—	3%
		50	22%	6%	0%
		100	**35%**	6%	11%
	Inhibition of Growth (Biomass)[a]	1.6	2%	4%	6%
		3.2	14%	16%	9%
		6.3	15%	8%	4%
		12	—	13%	10%
		25	2%	0%	8%
		50	18%	21%	—
		100	**33%**	22%	**34%**
	Inhibition of Growth (Dry Weight)[b]	1.6	8%	—	3%
		3.2	15%	16%	—
		6.3	11%	12%	—
		12	—	20%	13%
		25	10%	11%	5%
		50	—	16%	—
		100	—	16%	**26%**
Ceriodaphnia dubia (water flea)	Reduction in Survival	1.6	0%	10%	20%
		3.2	1%	10%	0%
		6.3	—	0%	0%
		12	—	10%	0%
		25	11%	10%	0%
		50	—	10%	10%
		100	11%	**30%**	0%
	Inhibition of Reproduction	1.6	—	5%	**26%**
		3.2	—	11%	1%
		6.3	—	6%	—
		12	—	8%	—
		25	6%	4%	—
		50	—	12%	8%
		100	**42%**	**88%**	10%
Raphidocelis subcapitata (alga)	Inhibition of Growth	1.4	n/a[c]	—	6%
		2.8	—	1%	18%
		5.7	—	3%	17%
		11	0%	20%	17%
		23	11%	**31%**	**26%**
		46	**32%**	**50%**	**47%**
		91	**35%**	**55%**	**48%**

Notes: **Bolded** values indicate effects (i.e., percent adverse response ≥25%). Control-adjusted values are percent effect in the highest test concentration relative to the laboratory control; for *R. subcapitata*, the highest test concentration is 91%v/v.

a) Biomass is calculated as the total dry weight divided by the total number of fish exposed. The biomass endpoint represents a combination of sublethal effect (reduced total dry weight of surviving fish) and mortality.

b) Dry weight is calculated as the average dry weight of surviving fish.

c) The result for this concentration was not enumerated in July 2023.

%v/v = percent sample in the test solution on a volume to volume basis; — = no adverse response because stimulation was observed; n/a = not applicable.

Table B-2 Toxicity Responses in Copper Amendment Test with Fathead Minnows on the September Sample from Lake N14

Type of Response	Test Concentration	Percent Adverse Response (Relative to Laboratory Control)
Reduction in Survival	100%v/v	11%
	Cu-spiked 100%v/v	6%
Inhibition of Growth (Biomass)[a]	100% v/v	**34%**
	Cu-spiked 100%v/v	17%
Inhibition of Growth (Dry Weight)[b]	100%v/v	**26%**
	Cu-spiked 100%v/v	13%

Notes: **Bolded** values indicate effects (i.e., percent adverse response ≥25%). Control-adjusted values are percent adverse effect in the highest test concentration relative to the laboratory control; the unspiked laboratory control was used for the unspiked 100%v/v test concentration and the copper-spiked laboratory control was used for the copper-spiked 100%v/v test concentration.

a) Biomass is calculated as the total dry weight divided by the total number of fish exposed. The biomass endpoint represents a combination of sublethal effect (reduced total dry weight of surviving fish) and mortality.

b) Dry weight is calculated as the average dry weight of surviving fish.

%v/v = percent sample in the test solution on a volume to volume basis.