Hope Bay Mining Limited

DORIS NORTH GOLD MINE PROJECT
2010 Aquatic Effects Monitoring Program Report

NEWMONT NORTH AMERICA

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DORIS NORTH GOLD MINE PROJECT

2010 AQUATIC EFFECTS MONITORING PROGRAM REPORT

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Hope Bay Mining Limited

Prepared by:

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Executive Summary

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Executive Summary

The Doris North Gold Mine Project (the Project) is located approximately 125 km southwest of Cambridge Bay, Nunavut, on the south shore of Melville Sound. The nearest communities are Omingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

Having received all necessary permits, licences, and authorizations for development, Hope Bay Mining Ltd. (HBML) started major construction on the Project site in 2010. The Project is anticipated to move into operations in 2012.

The purpose of this document is to comply with the requirement outlined in the Type A Water Licence to conduct and report on an Aquatic Effects Monitoring Program (AEMP). The following text outlines the requirements in the Doris North Project Type A Water Licence (issued September 19, 2007; NWB Licence #2AM-DOH0713):

- Part K, Item 7. *The Licensee shall submit to the Board for approval..., a proposal for the development of an Aquatic Effects Monitoring Plan (AEMP) in consultation with Environment Canada. The proposal for an AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the Metal Mining Effluent Regulations (MMER);*
- Part K, Item 8. *The Licensee and Environment Canada shall coordinate with the NWB to ensure that the advanced submission of the AEMP meets the requirements of MMER.*

In compliance with Part K, Item 7, HBML along with Rescan Environmental Services Ltd. (Rescan) developed an AEMP Plan in consultation with Environment Canada between December 2009 and February 2010. The final AEMP Plan, *Doris North Gold Mine Project: Aquatics Effects Monitoring Plan*, was submitted to the NWB on February 24, 2010, and the document was approved on March 25, 2010 under Motion 2009-23-L04. This document conformed to the methodologies and practices laid out in the MMER (2002), thus complying with Part K, Item 8 of the Type A Water Licence.

This report presents the results from the first year of the AEMP. As outlined in the Plan, three streams, three lakes, and two marine exposure sites were monitored along with two reference streams, two reference lakes, and one marine reference site. As 2010 was the first year that the program was implemented, some aquatic components were not subjected to an evaluation of effects. Aquatic components evaluated in 2010 included: lake and marine dissolved oxygen; stream, lake, and marine water and sediment quality; and lake and marine phytoplankton biomass. Additional components are planned to be evaluated in 2011.

No Project-related effects on water or sediment quality were apparent in the AEMP streams. There were increases in the concentrations of total aluminum in Doris Outflow and total iron in Roberts Outflow in 2010; however, seasonal variability was high at these sites and parallel increases from historical means also occurred at the reference stream. Thus, there was no evidence that these increases were due to Project activities. Notably, 2010 was a hydrologically “wet” year, as peak flows in some AEMP streams were associated with a 1-in-100 year recurrence interval, which could have contributed to higher concentrations of certain metals in AEMP streams.

No Project-related effects on winter dissolved oxygen levels, water and sediment quality parameters, or phytoplankton biomass were found in the AEMP lakes. Winter dissolved oxygen concentrations were

within historical ranges, and there were no notable changes in sediment quality or phytoplankton biomass in any of the AEMP lakes. This was also the case for water quality, with the exception of total cyanide concentrations.

In AEMP streams and lakes, total cyanide concentrations increased in 2010 compared to historical levels. However, there was no cyanide used on site or brought to site in 2010. Therefore, the increase in cyanide observed in 2010 likely resulted from a natural process (non Project-related) or some analytical error. Cyanide concentrations will be closely monitored in exposure and reference streams and lakes in the following years to determine whether total cyanide concentrations measured in 2010 were anomalously high, or part of an increasing trend in the Project area.

No Project-related effects on winter dissolved oxygen levels, water and sediment quality parameters, or phytoplankton biomass were found in AEMP marine sites. All water quality and dissolved oxygen concentrations at the marine sites during 2010 remained similar to baseline conditions, indicating that 2010 Project-related activities had no effects on the water chemistry in the surrounding marine habitat. Several metals increased in sediments near the Roberts Bay jetty (site RBW) between 2002 and 2010. However, similar or greater increases occurred at the marine reference site (REF-Marine) between 2009 and 2010, indicating that this variability was likely natural. There was some indication that phytoplankton biomass increased in the southeastern section of Roberts Bay (RBE) in 2010 relative to historical levels, but this was driven by the anomalously high chlorophyll *a* concentrations found in August. This may have resulted from benthic re-suspension due to the high winds that were present during sampling. All other 2010 samples in RBE (April, July, and September) were comparable to historical levels. Therefore, it is unlikely that 2010 activities contributed to this August biomass increase in RBE.

Mitigation measures to reduce the potential for adverse effects to stream, lake, and marine habitats in the Doris North area included surface water runoff management, dust abatement measures, site water compliance monitoring, tailings and site geotechnical monitoring, quarry and waste rock monitoring and management, and waste management. 2010 results indicate that these mitigation measures were successful in preventing adverse effects to dissolved oxygen levels, water quality, sediment quality, and phytoplankton biomass levels in Project area waterbodies.

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This report was prepared for HBML by Rescan Environmental Services Ltd. The 2010 aquatic fieldwork was conducted by Rescan scientists Mike Henry (Ph.D.), Melissa Pink (Ph.D.), Carol Adly (M.Sc.), Katsky Venter (M.Sc.), Stephanie Lyons (M.Sc.), Tonia Robb (Ph.D.), Soleil Switzer (M.Sc.), and Mark Van Doorn (B.Sc.). The report was written by Mike Henry, Melissa Pink, and Carol Adly and reviewed by Deborah Muggli (Ph.D., M.Sc., R.P.Bio.). The project was managed by Deborah Muggli.

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Appendix C2-2. Statistical Methodology and Results for Sediment Quality Evaluation of Effects, Doris North Project, 2010

Glossary and Abbreviations

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Abbreviation/Acronym	Definition
ΔT	temperature change
AEMP	Aquatic Effects Monitoring Program
ALS	ALS Laboratory Group
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BACI	before-after-control-impact
Benthos	benthic invertebrates
BC	Bray-Curtis Dissimilarity Index or British Columbia
CCME	Canadian Council of Ministers of the Environment
chl *a*	chlorophyll *a*
CPUE	catch-per-unit-effort
CRM	comparison with reference material
CTD	conductivity, temperature, depth probe
D	Simpson's Diversity Index
DELTs	deformities, erosions, lesions and tumours
DFO	Department of Fisheries and Oceans Canada
DO	dissolved oxygen
D_s	Secchi depth
dw	dry weight
EEM	Environmental Effects Monitoring
Episammic algae	algae attached to sand
F	family (taxonomy)
GSI	Gonadosomatic Index
HBML	Hope Bay Mining Limited
HSI	Hepatosomatic Index
ICPMS	inductively coupled plasma mass spectroscopy
ISQG	interim sediment quality guideline
J	Simpson's Evenness Index
MB	method blank
MDL	method detection limit
MMER	Metal Mining Effluent Regulations

Abbreviation/Acronym	Definition
N	total number of families
n_i	proportion of families
NIRB	Nunavut Impact Review Board
NRI	Nunavut Research Institute
NT	Northwest Territories
NWB	Nunavut Water Board
OF	outflow
PAH	polycyclic aromatic hydrocarbons
PC	principal component
PCA	principal component analysis
PEL	probable effects level
QA/QC	quality assurance/quality control
RMC	reference material comparisons
RPD	relative percent difference
S	family richness
SD	standard deviation
SE	standard error (of the mean)
TIA	Tailings Impoundment Area
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
ww	wet weight
X^2	chi-square

1. Introduction

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1. Introduction

The Doris North Gold Mine Project (the Project) is located approximately 125 km southwest of Cambridge Bay, Nunavut, on the south shore of Melville Sound (Figure 1-1). The nearest communities are Omingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

Having received all necessary permits, licences, and authorizations for development, Hope Bay Mining Ltd. (HBML) started major construction on the Project site in 2010. The Project is anticipated to move into operations in 2012.

The purpose of this document is to comply with the requirement outlined in the Type A Water Licence to conduct and report on an Aquatic Effects Monitoring Program (AEMP). The following text outlines the requirements in the Doris North Project Type A Water Licence (issued September 19, 2007; NWB Licence #2AM-DOH0713):

- Part K, Item 7. *The Licensee shall submit to the Board for approval..., a proposal for the development of an Aquatic Effects Monitoring Plan (AEMP) in consultation with Environment Canada. The proposal for an AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the Metal Mining Effluent Regulations (MMER);*
- Part K, Item 8. *The Licensee and Environment Canada shall coordinate with the NWB to ensure that the advanced submission of the AEMP meets the requirements of MMER.*

In compliance with Part K, Item 7, HBML along with Rescan Environmental Services Ltd. (Rescan) developed an AEMP Plan in consultation with Environment Canada between December 2009 and February 2010. The final AEMP Plan, *Doris North Gold Mine Project: Aquatics Effects Monitoring Plan* (the Plan; Rescan 2010c), was submitted to the NWB on February 24, 2010, and the document was approved on March 25, 2010 under Motion 2009-23-L04. This document conformed to the methodologies and practices laid out in the MMER (2002), thus complying with Part K, Item 8 of the Type A Water Licence.

This report presents the results from the first year of the AEMP. 2010 is considered the first year of construction of the Doris North Project with operations currently planned to start in 2012.

1.1 2010 CONSTRUCTION ACTIVITIES

2010 was the first year of official Project construction. Some construction activities also occurred in 2008 and 2009. For 2010, Project activities included barge and aircraft traffic, quarrying, and pad and road development.

Figure 1.1-1 presents the existing and future infrastructure for the Doris North Project. The main Project activities in 2010 that could have affected the aquatic environment included the following:

- Construction of various pads, including several at Doris North Camp, the helipad, the crush pad, and the upper and lower reagent pads;
- Construction of the Doris-Windy Road and some secondary road construction, such as the North Access Road to Doris North Camp;

Figure 1-1

NEWMONT NORTH AMERICA

Regional Location of the Doris North Project

Figure 1-1

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PROJECT #**1009-002-01** GIS # **HB-15-042** March 3, 2011

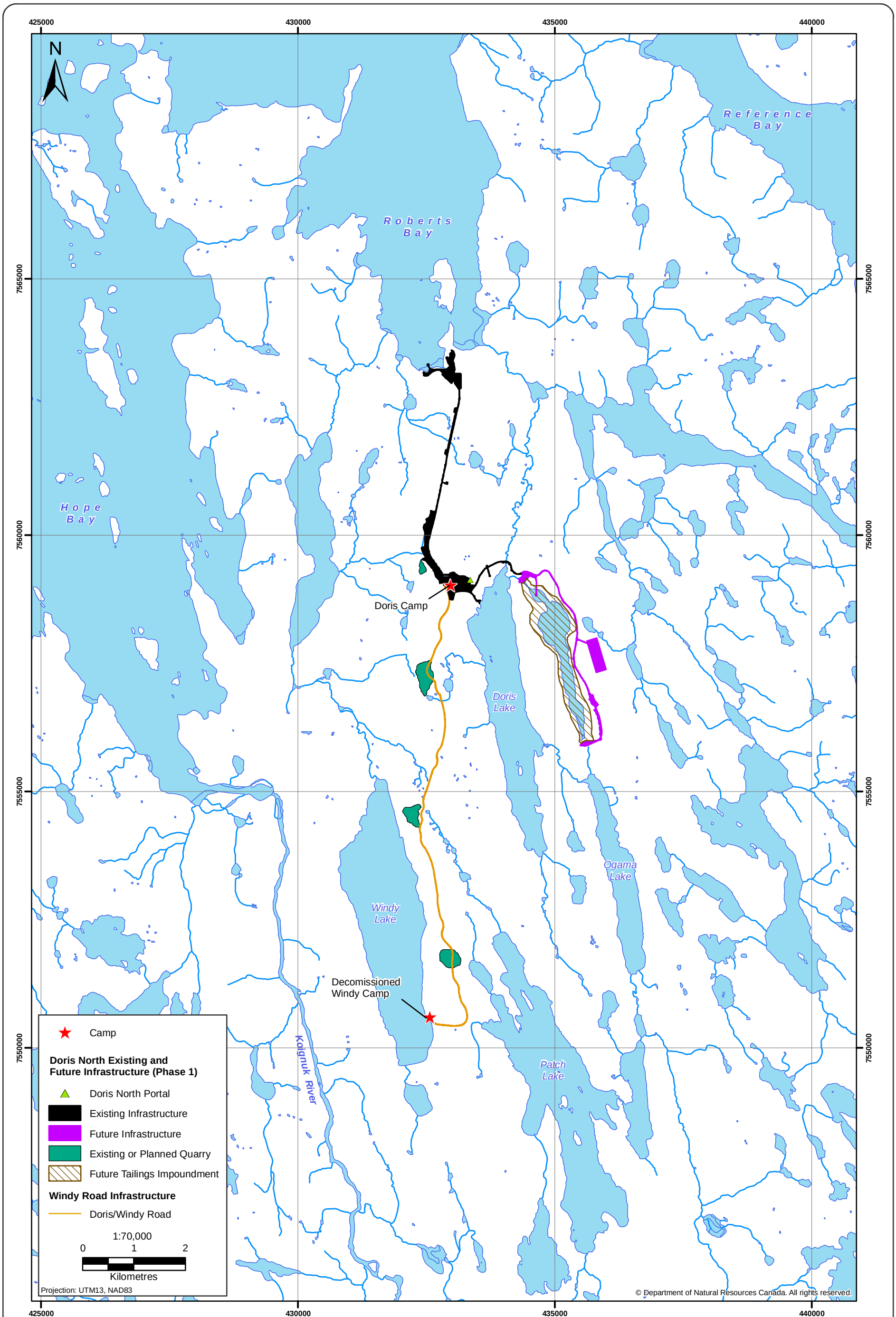

Figure 1.1-1

NEWMONT NORTH AMERICA

Existing and Future Infrastructure, Doris North Project

Figure 1.1-1

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- Primary road widening at the Roberts Bay Laydown Area;
- Barge traffic in Roberts Bay (26 barges brought in construction supplies and fuel to the Project site); and
- The late summer arrival of accommodation barges that are stationed east of the jetty in Roberts Bay.

Infrastructure that already existed in 2010 includes the following: the Roberts Bay jetty, the 5,000,000 L tank farm, the Roberts Bay pad, the road and associated airstrip between Roberts Bay and Doris Camp, the access road to the Doris Lake pump house, and the Doris Camp Pads X and Y (including the camp, generator, and sewage and water treatment system).

The main potential interactions between the Project and the aquatic freshwater and marine environment over the lifetime of the Project are anticipated to be:

- The operation of the Tailings Impoundment Area (TIA, formerly Tail Lake). Treated effluent from this facility is expected to be released into Doris Outflow where it would flow successively through Little Roberts Lake and into Little Roberts Outflow before entering Roberts Bay;
- Shipping activity at the marine jetty in southern Roberts Bay;
- Construction of roads and infrastructure;
- Runoff from site infrastructure, roads, waste rock, explosives facility; and
- Accidental spills.

Mitigation measures in place to reduce the potential for adverse effects to the aquatic environment include surface water runoff management, dust abatement measures, site water compliance monitoring, tailings and site geotechnical monitoring, quarry and waste rock monitoring and management, and waste management. Updated versions of these plans are available from 2010 or 2011, and a summary of current environmental plans can be found in the *Doris North Monitoring and Follow Up Plan* (HBML 2011).

1.2 REPORT STRUCTURE

This document presents the methods, evaluation of effects, and conclusions of the 2010 AEMP. Full details of the 2010 aquatic resources monitoring program (including water quality and water column structure, sediment quality, primary producers, and benthic invertebrates) are provided in Appendix A, full details of the 2010 fish monitoring program are provided in Appendix B, and supplemental information relevant to the 2010 evaluation of effects is provided in Appendix C.

2. Methods

2. Methods

2.1 SUMMARY OF AEMP STUDY DESIGN

The 2010 AEMP was conducted in accordance with the *Doris North Gold Mine Project: Aquatic Effects Monitoring Plan* (Rescan 2010c), which is a requirement of the Doris North Project Type A Water Licence (#2AM-DOH0713).

2.1.1 Objectives of the AEMP

The AEMP study design was driven by the requirements of the MMER and the anticipated location of Project activities during the construction, operation, and closure phase of the mine. The MMER stipulate that mines are required to conduct Environmental Effects Monitoring (EEM) if effluent discharge rates exceed 50 m^3 per day and/or deleterious substances are discharged into any water body as per subsection 36(3) of the *Fisheries Act*. The primary objective of the mining EEM program is to evaluate the effects of mining effluents on fish, fish habitat, and the use of fisheries resources. Thus, the objectives of the Doris North AEMP were to monitor and evaluate potential effects of Project activities on the following parameters in waterbodies within the Doris North Project area:

- water quality and water column structure;
- sediment quality;
- primary producers (phytoplankton and periphyton);
- benthic invertebrate community (abundance and taxonomy); and
- fish.

2.1.2 Study Area and Sampling Locations

The AEMP study area included those areas anticipated to be potentially influenced by mining-related activities as part of the Doris North Project (exposure areas) and those areas beyond any Project influence (reference areas). Three lake and three stream sites were sampled in the exposure areas and two lakes and two streams were sampled as reference sites. In addition, two marine exposure sites and one marine reference site were also sampled. Figure 2.1-1 shows the sampling sites, the parameters collected, and the Doris North Project infrastructure. It also shows the projected flow path of the treated TIA effluent to be released into Doris Outflow. The approved AEMP Plan (Rescan 2010c) includes a description of the site selections. A summary table (Table 2.1-1) and text are provided below.

2.1.2.1 Exposure Sites

Three stream, three lake, and two marine exposure sites are included in the AEMP study design. The principal exposure sites are those waterbodies that will be downstream of the TIA discharge. From upstream to downstream, these locations included Doris Outflow, Little Roberts Lake, Little Roberts Outflow, and Roberts Bay East (Figure 2.1-1).

To best measure the potential effects of the TIA treated effluent, the Doris Outflow sampling station was situated within 100 m of the projected TIA discharge location. Little Roberts Lake was the only lake along the projected effluent path. This is a small, shallow lake (< 0.1 km^2, < 4 m depth) that receives outflow from Doris Lake and Roberts Lake. Because there was historical mining in the

immediate area (an abandoned silver mine), a sampling station was included between Little Roberts Lake and Roberts Lake (Roberts Outflow). This was designed to assess potential confounding influence of the abandoned silver mine as well as inflowing water from Roberts Lake. A final marine station along the effluent path was included in eastern Roberts Bay, where Little Roberts Outflow enters the marine habitat (Roberts Bay East; RBE).

Table 2.1-1. AEMP Sampling Locations, Descriptions, and Purpose, Doris North Project, 2010

Sampling Location	Coordinates (13W)	Description	Purpose
Doris Outflow	434177E 7559910N	Immediately downstream of discharge point from the Tailings Impoundment Facility	First exposure site downstream of effluent discharge location
Little Roberts Lake	434624E 7562747N	Small lake downstream of Doris Outflow	First and only lake exposed to upstream effluent discharge
Little Roberts Outflow	434367E 7563094N	Stream downstream of Little Roberts Lake	Second exposure stream downstream of effluent discharge location
Roberts Bay East	433430E 7563850N	Marine bay where Little Roberts Lake drains into	Marine receiving environment for freshwater system downstream of effluent discharge location
Roberts Outflow	435129E 7562881N	Stream upstream of Little Roberts Lake, which drains the much larger Roberts Lake	To characterize any influence of the abandoned silver mine on Little Roberts Outflow to differentiate this from potential effects of effluent discharge upstream
Doris Lake North	433815E 7558222N	Large lake located south of main Project site. North part of lake is adjacent to Project infrastructure.	Potential exposure site due to close proximity of Project infrastructure and explosives storage
Doris Lake South	434324E 7555120N	Large lake located south of main Project site. South part of lake is 4 km away from Project infrastructure.	South site can be used to characterize any potential changes to the lake (whether local or lake-wide)
Roberts Bay West (Jetty)	432479E 7563346N	Small marine bay where jetty is located.	Potential exposure marine area due to marine activities and infrastructure
Reference Lake D	447566E 7561201N	Small reference lake located west of the Project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Little Roberts Lake
Reference D Outflow	448109E 7562830N	Reference outflow located west of the Project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Little Roberts Outflow
Reference Lake B	424050E 7532000N	Large reference lake located southwest of the Project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Doris Lake
Reference B Outflow	427150E 7530515N	Reference outflow located southwest of the Project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Doris Outflow
Marine Reference Bay	441152E 7563018N	Marine bay located west of the Project	Marine reference area meant to provide a reference for the two potential marine exposure sites (Roberts Bay East, Roberts Bay West (Jetty))

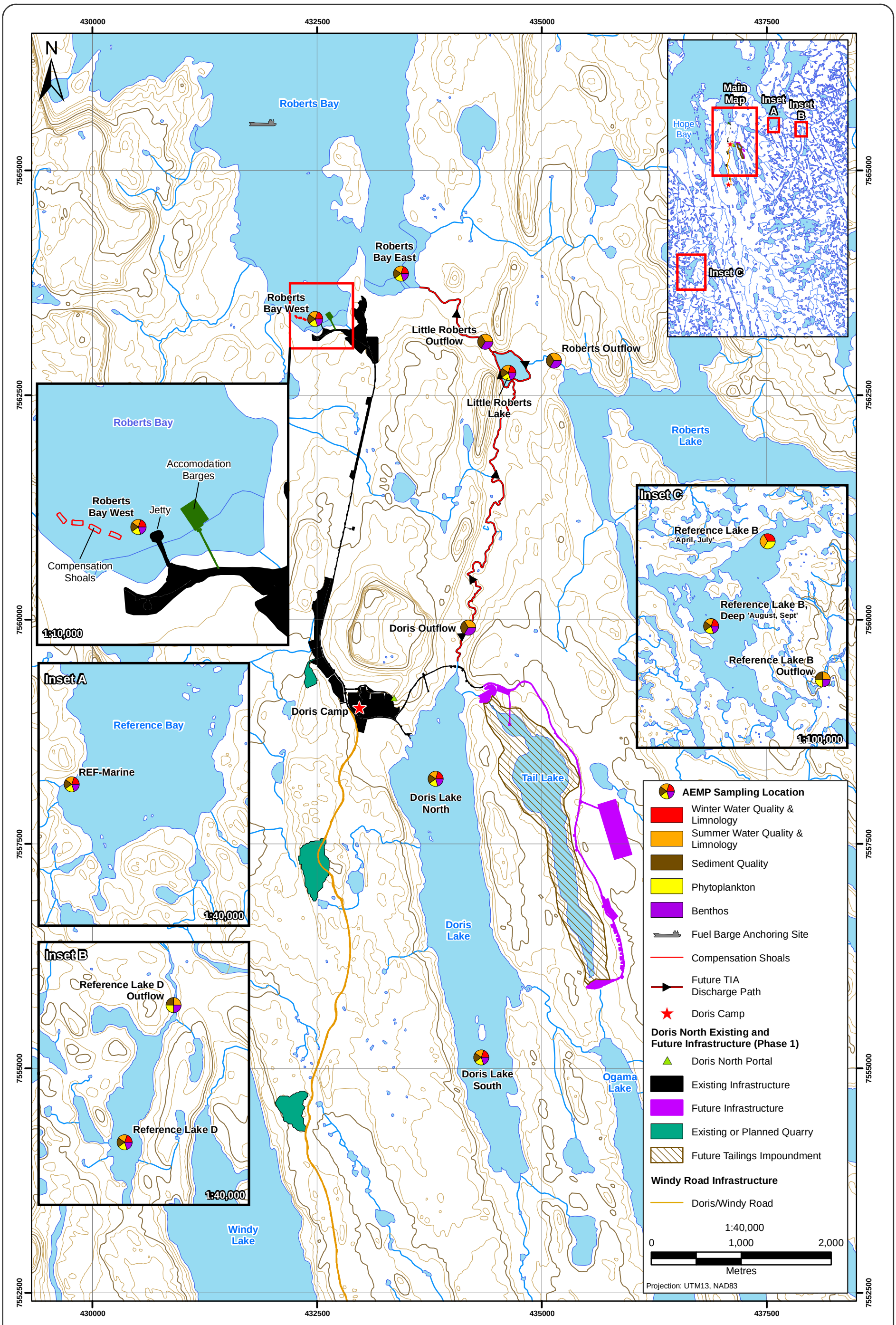

Figure 2.1-1

NEWMONT NORTH AMERICA

2010 AEMP Sampling Locations, Doris North Project

Figure 2.1-1

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Other exposure sites include two sites in Doris Lake (Doris Lake North and Doris Lake South) and a single site in western Roberts Bay near the marine jetty (Roberts Bay West; RBW).

2.1.2.2 Reference Sites

Three reference areas are included in the AEMP. Two are lakes (Reference Lake B and Reference Lake D) that have associated outflow streams (Reference B Outflow and Reference D Outflow). The third reference area is a marine site in southern Reference Bay (Figure 2.1-1). These reference sites were chosen to meet the following criteria:

- the reference areas were located sufficiently far away from the influence of mining activity; and
- the reference areas resembled, as much as possible, the hydrological and habitat features of the exposure areas.

Reference Lake B/Reference B Outflow and Reference Lake D/Reference D Outflow were used as reference sites to compare with exposure freshwater habitats (Figure 2.1-1). Reference Lake D (area: 0.6 km^2) was selected as a suitable reference analogue for Little Roberts Lake (area: < 0.1 km^2) based on its size and a direct linkage to the marine habitat. Reference Lake B (8.6 km^2) was selected as a comparative lake for Doris Lake (3.4 km^2) due to its larger size.

A single marine reference site (REF-Marine) was located in southern Reference Bay for comparability with the two exposure sites in Roberts Bay.

There were no mining activities near the selected reference sites in 2010, and there are no mining activities expected to occur near these reference sites in the future. The major consideration was to place the reference locations outside of watersheds containing anticipated Project activities, as well as beyond any potential wind-borne particulates from mine sources. Hence, Reference Lake D was located 15 km from Doris North infrastructure, Reference Lake B was located 25 km away, and the reference site in Reference Bay was 10 km away. Notably, wind trajectories flow from the Doris North region towards Reference Lake D and Reference Bay (northwest and west) only ~20% of the time.

2.1.3 Overall Schedule

The AEMP is scheduled to run on an annual basis from Project construction to the end of operation in 2013. The full AEMP monitoring schedule is shown in Table 2.1-2. This overall schedule is included in the approved Plan (Rescan 2010c).

2.1.4 2010 Sampling Schedule

For 2010, AEMP sampling commenced in April with the under-ice, physical limnology/oceanography and water quality collection, and ended in late September. Physical characteristics (e.g., temperature, salinity, dissolved oxygen) and water quality (e.g., nutrients and metals) were collected in streams, lakes, and the marine environment four times during the sampling period, not less than one month apart, thereby complying with MMER guidelines (Schedule 5, s.7 (1-2)). Phytoplankton and periphyton biomass (as chlorophyll *a*) were also collected during these four surveys. Sediment quality, benthos, and shellfish samples were collected once in August. All finfish data were collected in July corresponding to the predicted time of full breeding condition of the ninespine stickleback. A summary of the 2010 sampling schedule is provided in Table 2.1-3.

Table 2.1-2. AEMP Monitoring Schedule, Doris North Project

Mine Phase:	Construction		Operation		Closure	
Year:	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
EEM Cycle:				**EEM First Study Design Report**	**EEM Cycle 1 Interpretive Report**	
Monitoring Component						
Lakes					Re-Evaluate AEMP Monitoring Schedule and EEM Cycles	
Water Quality	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Phytoplankton Biomass	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Sediment Quality	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Benthic Invertebrates	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Fish Population/Condition	1 time/yr	-	-	1 time/yr		
Fish Hg/Metal	1 time/yr	-	-	1 time/yr		
Streams						
Water Quality	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Periphyton Biomass	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Sediment Quality	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Benthic Invertebrates	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Fish Population/Condition	1 time/yr	-	-	1 time/yr		
Fish Hg/Metal	-	-	-	-		
Marine						
Water Quality	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Phytoplankton Biomass	4 times/yr	4 times/yr	4 times/yr	4 times/yr		
Sediment Quality	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Benthic Invertebrates	1 time/yr	1 time/yr	1 time/yr	1 time/yr		
Fish Population/Condition	1 time/yr	-	-	1 time/yr		
Fish Hg/Metal	1 time/yr	-	-	1 time/yr		

Table 2.1-3. Summary of the 2010 AEMP Sampling Dates, Doris North Project

Waterbody	Parameter	Sampling Dates
Streams	Water Quality	June 17-19
		July 18-20
		August 8-13
		September 15-16
	Sediment Quality	August 9-20
	Periphyton Biomass	July 17-18
		August 19-20
		September 20
	Benthos	August 8-25

(continued)

Table 2.1-3. Summary of the 2010 AEMP Sampling Dates, Doris North Project (completed)

Waterbody	Parameter	Sampling Dates
Lakes	Physical Limnology	April 19-22
		July 15-19
		August 8-24
		September 12-25
	Water Quality	April 18-22
		July 15-20
		August 8-24
		September 12-25
	Sediment Quality	August 8-25
	Phytoplankton Biomass	April 19-22
		July 12-19
		August 8-24
		September 12-25
	Benthos	August 8-24
	Fish	July 4-13
Marine	Physical Oceanography	April 24
		July 13-20
		August 15-21
		September 28-30
	Water Quality	April 25
		July 13-20
		August 15-19
		September 28-30
	Sediment Quality	August 15-19
	Phytoplankton Biomass	April 24
		July 13-20
		August 17-19
		September 28-30
	Benthos	August 15
	Shellfish	August 22-24

2.2 DETAILED 2010 AEMP METHODS

Table 2.2-1 presents a summary of the AEMP components and methods, including the parameters assessed, the within-year sampling frequency, sampling replication, sampling dates, and the sampling devices used.

2.2.1 Physical Limnology and Oceanography

Physical limnological (e.g., temperature and dissolved oxygen) and oceanographic profiles (e.g., salinity, temperature, and dissolved oxygen) were collected once during the under-ice season (April) and three times during the open-water season (July, August, and September) in 2010. The under-ice sampling was designed to collect 'worst-case scenario' water, i.e., when dissolved oxygen concentrations would be lowest due to reduced photosynthesis and the absence of oxygen

diffusion from the atmosphere, and concentrations of nutrients and metals would be highest due to limited biological uptake and solute extrusion from the formation of the ice cover.

Table 2.2-1. Summary of the 2010 AEMP Environmental Sampling Program, Doris North Project

Monitoring Parameter	Sampling Frequency	Sample Replication and Depths	Sampling Dates/Timing	Sampling Device
Lake and Marine Water Quality				
Physical, nutrients, total metals, dissolved oxygen/temperature profile, Secchi depth	4 x	Lakes: n = 1/site @ 1 m below the surface and 2 m above water-sediment interface + 20% replication; Marine: n = 2/site @ 1m	April, July, August, September	GO-FLO sampling bottle; Conductivity-Temperature-Depth (CTD) probe; DO meter
Lake and Marine Phytoplankton				
Biomass (chlorophyll *a*)	4 x	n = 3/site @ 1 m below the surface	April, July, August, September; coincident with lake and marine water quality	GO-FLO sampling bottle
Lake and Marine Benthos				
Abundance and taxonomy	1 x	n = 5/site (3 replicate subsamples)	August; coincident with August lake and marine survey	Ekman grab (lake); Ponar grab (marine); 500 µm sieve
Lake and Marine Sediment Quality				
Physical, particle size, nutrients, metals, TOC	1 x	n = 3/site	August; coincident with August lake and marine survey	Ekman grab (lake); Ponar Grab (marine)
Stream Water Quality				
Physical, nutrients, total metals, dissolved oxygen, temperature	4 x	n = 2/site	June, July, August, September	Clean water sampling bottles; DO/Temperature meter
Stream Periphyton				
Biomass (chlorophyll *a*)	4 x	n = 3/site	June, July, August, September; coincident with stream water quality	Artificial Samplers (Plexiglas plates)
Stream Benthos				
Abundance and taxonomy	1 x	n = 5/site (3 replicate subsamples)	August; coincident with August stream survey	Hess sampler; 500 µm sieve
Lake Fish Survey				
Condition and reproduction (length, weight, age, DELT, liver weight, gonad weight, egg counts); tissue metals	1 x	n = 60 fish/lake (20 male/20 female/20 immature); 8 fish/site for tissue metals	July; coincident with lake and marine July water quality survey	Minnow traps
Marine Fish Survey (Shellfish)				
Condition (whole animal wet weight, soft tissue wet weight, shell length); tissue metals	1 x	n = 20 shellfish/site (condition); n = 8 shellfish/site (tissue metals)	August	Snorkelling

2.2.1.1 Lakes

Under-ice

The underlying lake water at the April sampling sites was accessed by drilling a 25-cm diameter hole through the ice. The ice thickness was then recorded and the lake bottom depth measured using a weighted, metred line, with care taken to minimize any disturbance to lake sediments. Water column profiling and water quality sampling depths were calculated based on bottom depth.

Measurements of water column structure (including temperature and dissolved oxygen) were collected using a YSI dissolved oxygen/temperature meter. Temperature and dissolved oxygen values were recorded at 1 m intervals. The probe was gently agitated as it was held at a particular depth to ensure a continual flushing of 'new' water. The profiles ended at ~1 m above the sediment surface to reduce suspension of bottom sediments.

Open Water

Summer temperature and dissolved oxygen profiles were measured at the same locations using the same equipment as in winter. Light attenuation was estimated in each lake using a Secchi disk. Measurements were collected at each site by lowering the 20-cm black and white 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 identified as the Secchi depth (D_s).

2.2.1.2 Marine

Under-ice

Marine under-ice water was accessed by drilling a 25-cm diameter hole through the ice. Ice thickness was recorded and the bottom depth measured using a weighted, metred line. A vertical profile of temperature, salinity, and conductivity was collected using an *in situ* conductivity, temperature, and depth probe (CTD; RBR-420). The probe was lowered through the water column (at an approximate speed 0.5 m/s) on a cable to within 1 m of the sea floor. The data logged during this process were immediately transferred to a computer in the field. Data from the downcast were used to derive physical profiles. Following the CTD casts, vertical profiles of dissolved oxygen (DO) concentration and percent saturation were collected using a YSI dissolved oxygen meter lowered at 1 m intervals to within 1 m of the sediments. Samples were not collected at REF-Marine in April due to the unsafe conditions created by melting ice near the shore.

Open Water

CTD and DO profiles were collected from the side of an aluminum boat. The logged and recorded data were processed using the same methodology in April. Light penetration at each site was measured by lowering a 30-cm white Secchi disk over the shaded side of the boat until it disappeared from sight. This was recorded as the Secchi depth.

2.2.2 Water Quality

Water quality samples were collected at the lake and marine sites during the under-ice season in April, and the open-water season in July, August, and September 2010. Stream water quality samples were collected during the June freshet in addition to the three open water months listed above. As much as possible, samples at a specific site were collected more than one month apart to conform to EEM recommendations. The sampling dates and depths for all sites are presented in Table 2.2-2 and the

analyzed parameters are summarized in Table 2.2-3. All sampling locations are presented in Figure 2.1-1. The sampling procedures used for each aquatic habitat are described below.

Table 2.2-2. AEMP Stream, Lake, and Marine Water Quality Sampling Dates and Depths, Doris North Project, 2010

Habitat	Site	Sampling Date	Depth (m)
Stream	Doris Outflow	17-Jun-10	Surface
		20-Jul-10	Surface
		8-Aug-10	Surface
		15-Sep-10	Surface
	Roberts Outflow	18-Jun-10	Surface
		13-Aug-10	Surface
		15-Sep-10	Surface
	Little Roberts Outflow	17-Jun-10	Surface
		20-Jul-10	Surface
		12-Aug-10	Surface
		15-Sep-10	Surface
	Reference B Outflow	19-Jun-10	Surface
		18-Jul-10	Surface
		8-Aug-10	Surface
		16-Sep-10	Surface
	Reference D Outflow	18-Jun-10	Surface
		20-Jul-10	Surface
		13-Aug-10	Surface
		15-Sep-10	Surface
Lake	Doris Lake North	22-Apr-10	1*, 11.5
		15-Jul-10	1, 12
		9-Aug-10	1, 13
		12-Sep-10	1, 11
	Doris Lake South	22-Apr-10	1*
		15-Jul-10	1, 3
		8-Aug-10	1
		12-Sep-10	1
	Little Roberts Lake	22-Apr-10	1*
		20-Jul-10	1
		10-Aug-10	1
		12-Sep-10	1
	Reference Lake B	18-Apr-10	1*, 4.3
		20-Jul-10	1, 3.5
		24-Aug-10	1, 8.75
		17-Sep-10	1, 8.5
	Reference Lake D	18-Apr-10	1*
		20-Jul-10	1
		21-Aug-10	1
		25-Sep-10	1

(continued)

Table 2.2-2. AEMP Stream, Lake, and Marine Water Quality Sampling Dates and Depths, Doris North Project, 2010 (completed)

Habitat	Site	Sampling Date	Depth (m)
Marine	RBE (Roberts Bay)	25-Apr-10	1*
		20-Jul-10	1
		15-Aug-10	1
		30-Sep-10	1
	RBW (Roberts Bay)	25-Apr-10	1*
		20-Jul-10	1
		15-Aug-10	1
		30-Sep-10	1
	REF-Marine (Reference Bay)	13-Jul-10	1
		19-Aug-10	1
		28-Sep-10	1

** April surface water quality samples were collected from 1 m below the ice.*

2.2.2.1 Streams

During the open-water season, water quality samples were collected from three streams within the Doris Watershed (Doris, Roberts, and Little Roberts outflows), and two reference streams outside of the Project area (Reference B and Reference D outflows). Samples were collected on four separate occasions (June, July, August, and September) at each sampling site between June 17 and September 16, 2010. Locations of the 2010 AEMP study streams and sampling sites are presented in Figure 2.1-1.

Water quality samples from streams were collected at one midstream point in the cross section of the flow, with care being taken to prevent sampling artifacts by disturbing bottom sediments and collecting particulate material. Samples were collected from just below the water surface using appropriate plastic bottles provided by ALS Laboratory Group, Burnaby, BC (ALS). The bottles were rinsed three times with site-specific water prior to filling and all samples were collected in duplicate. The appropriate preservatives provided by ALS were added in the field after collection.

All samples were kept cold and in the dark while in the field, and were refrigerated at Doris camp prior to transport. Samples were transported in coolers with freezer packs to ALS in Burnaby, BC for all analyses. The analyzed parameters and their detection limits are presented in Table 2.2-3. Note that sample concentrations within five times of a stated detection limit could indicate analytical error (Clark 2003). Thus, low measurable values could reflect analytical error rather than actual values or contamination.

2.2.2.2 Lakes and Marine

Water quality samples were collected in both lakes and the marine environment during the 2010 AEMP program. Samples were collected from three sites in two lakes within the Doris Watershed (Doris Lake South, Doris Lake North, Little Roberts Lake), and from two reference lakes (Reference Lake B and Reference Lake D). Marine water quality samples were collected from two sites in Roberts Bay (RBE, RBW) and at one reference site in the adjacent inlet, Reference Bay (REF-Marine). Locations of the 2010 AEMP lake and marine sampling sites are presented in Figure 2.1-1.

Table 2.2-3. AEMP Water Quality Parameters and Realized Detection Limits, Doris North Project, 2010

		Realized Detection Limits				Realized Detection Limits	
Parameter	**Units**	**Freshwater**	**Marine**	**Parameter**	**Units**	**Freshwater**	**Marine**
Physical Tests				**Total Metals (cont'd)**			
pH	pH	0.1	0.1	Cesium (Cs)	mg/L	0.000005	0.0005
Alkalinity, Total (as $CaCO_3$)	mg/L	2	2	Chromium (Cr)	mg/L	0.0005	0.001
Hardness (as $CaCO_3$)	mg/L	0.5	0.86 to 4.3	Cobalt (Co)	mg/L	0.00005	0.00005 or 0.0005
Conductivity	µS/cm	2	2	Copper (Cu)	mg/L	0.0005	0.00005 or 0.001
Total Dissolved Solids	mg/L	10	-	Gallium (Ga)	mg/L	0.00005	0.0005
Total Suspended Solids	mg/L	3	3	Iron (Fe)	mg/L	0.03	0.01 to 0.3
Turbidity	NTU	0.1	0.1	Lead (Pb)	mg/L	0.00005	0.00005 or 0.001
Salinity (EC)	g/L	-	1	Lithium (Li)	mg/L	0.0002	0.02
				Magnesium (Mg)	mg/L	0.1	0.2 or 1
Anions				Manganese (Mn)	mg/L	0.0002	0.00005 or 0.0005
Bromide (Br)	mg/L	0.05	2.5 to 25	Mercury (Hg)	mg/L	0.00001	0.00001
Chloride (Cl)	mg/L	0.5	25 to 250	Molybdenum (Mo)	mg/L	0.00005	0.002
Fluoride (F)	mg/L	0.02	0.03 to 1	Nickel (Ni)	mg/L	0.0002	0.00005 or 0.0005
Sulphate (SO_4)	mg/L	0.5	25 to 250	Phosphorus (P)	mg/L	0.30	1 or 3
				Potassium (K)	mg/L	2	4 or 20
Nutrients				Rhenium (Re)	mg/L	0.000005	0.0005
Ammonia (as N)	mg/L	0.005	0.005	Rubidium (Rb)	mg/L	0.00002	0.005
Nitrate (as N)	mg/L	0.005	0.0060 to 2.5	Selenium (Se)	mg/L	0.00020	0.0004 or 0.002
Nitrite (as N)	mg/L	0.001	0.002 to 0.5	Silicon (Si)	mg/L	0.05	0.1 or 0.5
Total Phosphorus (as P)	mg/L	0.002	0.002	Silver (Ag)	mg/L	0.000005	0.0002
				Sodium (Na)	mg/L	2	4 or 20
Cyanides				Strontium (Sr)	mg/L	0.00005	0.00005 or 0.05
Cyanide, Total	mg/L	0.001	0.001 or 0.005	Tellurium (Te)	mg/L	0.00001	0.0005
				Thallium (Tl)	mg/L	0.000002	0.0005
Organic Carbon				Thorium (Th)	mg/L	0.00001	0.0005
Total Organic Carbon	mg/L	0.5	0.5 or 1	Tin (Sn)	mg/L	0.0002	0.001
				Titanium (Ti)	mg/L	0.0002	0.005
Total Metals				Tungsten (W)	mg/L	0.00001	0.001
Aluminum (Al)	mg/L	0.003	0.005 or 0.01	Uranium (U)	mg/L	0.000002	0.00005 or 0.0005
Antimony (Sb)	mg/L	0.00001	0.0005	Vanadium (V)	mg/L	0.00005	0.0005
Arsenic (As)	mg/L	0.00005	0.00040 or 0.0002	Yttrium (Y)	mg/L	0.000005	0.0005
Barium (Ba)	mg/L	0.0001	0.001	Zinc (Zn)	mg/L	0.003	0.0008 to 0.005
Beryllium (Be)	mg/L	0.000005	0.0005	Zirconium (Zr)	mg/L	0.00005	0.0005
Bismuth (Bi)	mg/L	0.00005	0.0005				
Boron (B)	mg/L	0.005	0.1	**Radiochemistry**			
Cadmium (Cd)	mg/L	0.000005	0.00002 or 0.00012	Radium-226	Bq/L	0.005	0.005
Calcium (Ca)	mg/L	0.05	0.1 or 0.5				

Samples were collected once during the ice-covered season (April), and three times during the open water season (July, August, September) between April 18 and September 30, 2010. Water samples from REF-Marine were not collected during the April sampling survey due to melting ice. Within each lake, samples were collected at 1 m depth over the deepest part of the lake. In Reference Lake B, a the first bathymetric survey of this lake was conducted on August 8 and 9, 2010 (Rescan 2011a), so samples collected before this date were collected from a mid-depth site (April and July), and samples collected after this date were collected over the deepest part of the lake (August and September). In the deepest lakes (Doris Lake North and Reference Lake B), samples were collected both at 1 m below the surface and 2 m above the sediment.

In April, the underlying water was accessed through a hole following the temperature, CTD, and dissolved oxygen profiles. An adapted 2.5 L 'skinny' Niskin bottle was used to collect water during winter sampling. This bottle is 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 achieve bottle closure and to ensure the collection of discrete samples. During summer and fall sampling, all water samples were collected using an acid-washed 5 L GO-FLO sampling device. The GO-FLO was configured properly and securely attached to a metred cable line. The GO-FLO was then lowered to the appropriate sampling depth and allowed to equilibrate for one minute, at which time it was triggered closed using a brass messenger. The GO-FLO was then raised and brought into the boat for subsampling. Each GO-FLO cast represented one replicate.

Subsamples for the various water quality components (e.g., physical parameters\major ions, nutrients, and total metals) were drawn from the GO-FLO/Niskin bottles. All sample bottles were rinsed three times prior to filling with care being taken not to bring the bottle or cap into contact with the plastic spigot or other possible sources of contamination. The appropriate preservatives provided by ALS were added in the field after collection.

All samples were kept cold and in the dark while in the field and were refrigerated at camp prior to transport. Samples were transported in coolers with freezer packs to ALS, Burnaby for all analyses as described in for stream water quality samples. The parameters analyzed and applicable detection limits are summarized in Table 2.2-3. Realized detection limits were occasionally higher than the theoretical detection limits in freshwater samples due to interference from other parameters. Marine waters were consistently diluted to reduce matrix effects from the high concentrations of cations (i.e., sodium).

2.2.2.3 Quality Assurance and Quality Control (QA/QC)

A set of travel, field, and equipment blanks (4% of total samples) were processed and submitted with the water samples as part of the QA/QC program. These blanks identified potential sources of contamination to the field samples. Results for all water quality QA/QC blanks are provided in Appendix A.

2.2.3 Sediment Quality

Sediment quality samples were collected at the stream, lake, and marine sites during the open-water season in August, 2010. This sampling coincided with benthic invertebrate sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and the analyzed parameters are summarized in Table 2.2-5. All sampling locations are presented in Figure 2.1-1. Sampling procedures for each aquatic habitat are described below.

Table 2.2-4. AEMP Stream, Lake, and Marine Sediment Quality and Benthic Invertebrate Sampling Dates and Depths, Doris North Project, 2010

Habitat	Site	Sampling Date	Depth (m)
Stream	Doris Outflow	20-Aug-10	NA
	Roberts Outflow	13-Aug-10	NA
	Little Roberts Outflow	12-Aug-10	NA
	Reference B Outflow	09-Aug-10	NA
	Reference D Outflow	13-Aug-10	NA
Lake	Doris Lake North	08-Aug-10	14
	Doris Lake South	09-Aug-10	3.75
	Little Roberts Lake	10-Aug-10	2.75
	Reference Lake B	25-Aug-10	11
	Reference Lake D	11-Aug-10	3
Marine	RBE (Roberts Bay)	15-Aug-10	4.7
	RBW (Roberts Bay)	15-Aug-10	3.9
	REF-Marine (Reference Bay)	19-Aug-10	7

NA – not applicable

2.2.3.1 Streams

Three replicate sediment samples were collected at each stream site. Replicate samples were collected by plunging an Ekman sediment sampler (surface sampling area of 0.023 m^2) into the sediment bed, with each replicate spaced approximately three times the channel width apart. The sample was carefully raised and inspected to ensure the collection of an intact, undisturbed sample.

After the water was allowed to drain slowly, the sediment material was emptied onto a clean, plastic, white tray where a photograph was taken, and a sediment description sheet was completed. The surface 2 to 3 cm was subsequently removed with a clean plastic spoon and homogenized in a plastic bowl. Subsamples of this homogenous surface material were then transferred into separate pre-labelled Whirl-Pak bags: one for grain size analysis, and one for sediment chemistry analysis. Each bag was then placed into another Whirl-Pak bag as a protective measure. All samples were refrigerated (in darkness) until they were shipped to ALS (Burnaby, BC) for analysis on the first available flight out of camp. Table 2.2-5 presents the sediment quality parameters that were analyzed and their corresponding detection limits.

Standard summary statistics (minimum, maximum, median, mean, standard deviation, and standard error) were calculated for all 2010 sediment quality analyses. Results of these summaries are presented in Appendix A.

2.2.3.2 Lakes

Lake sediments were obtained in the deepest section of the lake (except Doris Lake South) using an Ekman sediment sampler with the replicates collected 5 to 20 m apart. Sampling depths are provided in Table 2.2-4. The Ekman was carefully set open, lowered gradually onto soft sediment using a metred cable line, and triggered closed with a messenger. The sample was carefully raised and inspected to ensure the collection of an intact, undisturbed sample. All processing, shipping, and analytical procedures were identical to those completed for stream sediment quality collection. Summary statistics for all lake sediment quality parameters are provided in Appendix A.

Table 2.2-5. AEMP Sediment Quality Parameters and Realized Detection Limits, Doris North Project, August 2010

Parameter	Units	Realized Detection Limit		Parameter	Units	Realized Detection Limit	
		Freshwater	Marine			Freshwater	Marine
Physical Tests				***Metals (cont'd)***			
Moisture	%	0.1	0.1	Bismuth (Bi)	mg/kg	20	20
pH	pH	0.1	0.1	Cadmium (Cd)	mg/kg	0.1	0.1
				Calcium (Ca)	mg/kg	50	50
Particle Size				Chromium (Cr)	mg/kg	2	2
% Gravel (>2 mm)	%	0.1	0.1	Cobalt (Co)	mg/kg	2	2
% Sand (2.0 - 0.063 mm)	%	0.1	0.1	Copper (Cu)	mg/kg	1	1
% Silt (0.063 mm - 4 µm)	%	0.1	0.1	Iron (Fe)	mg/kg	50	50
% Clay (<4 µm)	%	0.1	0.1	Lead (Pb)	mg/kg	2	2
				Lithium (Li)	mg/kg	2	2
Organic / Inorganic Carbon				Magnesium (Mg)	mg/kg	50	50
Total Organic Carbon	%	0.1	0.1	Manganese (Mn)	mg/kg	1	1
				Mercury (Hg)	mg/kg	0.005	0.005
Leachable Nutrients				Molybdenum (Mo)	mg/kg	0.2	0.2
Total Nitrogen	%	0.02	0.02	Nickel (Ni)	mg/kg	5	5
				Phosphorus (P)	mg/kg	50	50
Plant Available Nutrients				Potassium (K)	mg/kg	200	200
Available Ammonium-N	mg/kg	0.8-2.4	0.8-1.2	Selenium (Se)	mg/kg	0.5	0.5
Available Nitrate-N	mg/kg	2-7.5	2	Silver (Ag)	mg/kg	0.1	0.1
Nitrite-N	mg/kg	0.4-1.5	0.4	Sodium (Na)	mg/kg	200	200
Available Phosphate-P	mg/kg	2	2	Strontium (Sr)	mg/kg	0.5	0.5
				Sulphur (S)	mg/kg	100-500	100
Metals				Thallium (Tl)	mg/kg	0.5	0.5
Aluminum (Al)	mg/kg	50	50	Tin (Sn)	mg/kg	5	5
Antimony (Sb)	mg/kg	10	10	Titanium (Ti)	mg/kg	1	1
Arsenic (As)	mg/kg	0.05	0.1	Uranium (U)	mg/kg	0.1	0.1
Barium (Ba)	mg/kg	1	1	Vanadium (V)	mg/kg	2	2
Beryllium (Be)	mg/kg	0.5	0.5	Zinc (Zn)	mg/kg	1	1

2.2.3.3 Marine

Marine sediment quality samples were collected in triplicate using a ponar grab sampler, with replicates spaced 5 to 20 m apart. The sampling depths are provided in Table 2.2-4. Each sediment sample was carefully transferred onto a tray, and the top 2 to 3 cm of sediment was scraped into two Whirl-Pak bags: one for grain size, and one for sediment chemistry. All samples were refrigerated (in darkness) until they were shipped to ALS Yellowknife for analysis on the first available flight out of Doris camp. Summary statistics for marine sediment quality are presented in Appendix A.

2.2.4 Primary Producers

Primary producer biomass (as chlorophyll *a*) samples were collected in streams, lakes, and the marine habitat to assess potential changes in their standing stocks due to eutrophication (i.e., excess

nutrients) or toxicity (i.e., presence of deleterious substances). Periphyton biomass samples were collected in streams during the open-water season in July, August, and September. Phytoplankton biomass samples were collected in lakes and the marine environment under-ice in April, and during the open-water season in July, August, and September.

2.2.4.1 Stream Periphyton

Stream periphyton samples were collected using artificial substrate samplers. These samplers were installed in each study stream a month before their collection and processing, i.e., those plates collected in July, August, and September, were installed in June, July, and August, respectively. The complete installation schedule is outlined in Table 2.2-6.

Table 2.2-6. Periphyton Sampling Dates, Doris North Project, 2010

Stream Site	Installation Date	Retrieval Date
Doris Outflow	20-Jun-10	20-Jul-10
	20-Jul-10	20-Aug-10
	20-Aug-10	20-Sep-10
Roberts Outflow	20-Jun-10	20-Jul-10
	20-Jul-10	19-Aug-10
	19-Aug-10	20-Sep-10
Little Roberts Outflow	20-Jun-10	20-Jul-10
	20-Jul-10	19-Aug-10
	19-Aug-10	20-Sep-10
Reference B Outflow	19-Jun-10	19-Jul-10
	19-Jul-10	19-Aug-10
	19-Aug-10	20-Sep-10
Reference D Outflow	20-Jun-10	19-Jul-10
	19-Jul-10	19-Aug-10
	19-Aug-10	20-Sep-10

The samplers used were 10 cm × 10 cm Plexiglas® plates, which were affixed to rocks with fishing line and placed in the stream such that they remained submerged until retrieval (Plate 2.2-1). Overall, five plates were submerged per site, but only three plates were processed. These extra plates were used to increase the likelihood that at least three plates were available to process after a month's time. The plates were installed a minimum distance of three times the channel width apart from each other.

Upon collection, the sample plates were scrapped with a razor blade, and rinsed into a 250 mL wide-mouth plastic jar. The samples were then filtered at Doris camp onto 47 mm diameter, 0.45 μm pore-size membrane filters, folded carefully in half, and wrapped in aluminum foil. A label was then attached to the foil indicating all sampling information and the volume of water filtered. The filters were kept frozen until they were sent to ALS Burnaby for analysis.

Standard summary statistics, including minimum, maximum, median, mean, standard deviation, and standard error were calculated for 2010 periphyton biomass. Results of these summaries are presented in Appendix A.

Plate 2.2-1. Plexiglas® substrate samplers used for stream periphyton, Doris North Project, 2010

2.2.4.2 *Lake and Marine Phytoplankton*

Lake and marine phytoplankton biomass samples were collected in triplicate at 1 m depth using a 5 L GO-FLO water sampler. In April, a 2.5 L Niskin bottle was used. For each sample, the water sampler was lowered to the appropriate depth using a metred cable line and triggered closed with a messenger. Once in the boat, a subsample was drawn for a chlorophyll *a* sample. The GO-FLO/Niskin was set, lowered, and triggered three times; once for each replicate.

Subsamples for chlorophyll *a* were obtained by rinsing and filling a clean, 1 L bottle. The samples were kept cold and dark and transported to Doris camp, where the samples were filtered in the environmental laboratory using gentle vacuum filtration (hand pump). The samples were filtered onto 47 mm diameter, 0.45 µm pore size membrane filters, folded carefully in half, and wrapped in aluminum foil. A label was then attached to the foil indicating all sampling information and the volume of water filtered. The filters kept frozen until they were sent to ALS Burnaby for analysis.

Chlorophyll *a* samples from REF-Marine were not collected during the April sampling survey due to melting ice (April), which created dangerous conditions.

Like stream periphyton, standard summary statistics were calculated for 2010 lake and marine phytoplankton biomass and the results appear in Appendix A.

2.2.5 Benthos

Benthic invertebrate (benthos) samples were collected at the stream, lake, and marine sites during the open-water season in August, 2010. This coincided with the sediment quality sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and all sampling locations are indicated in Figure 2.1-1.

All field sampling devices and methods for the AEMP benthos sampling were designed to comply with EEM guidance documents (Environment Canada 2002). Sampling procedures for each aquatic habitat are described below.

2.2.5.1 Streams

Benthos samples were collected at all AEMP streams from August 8 to August 25, 2010. To comply with EEM requirements, three separate subsamples were collected and pooled for each replicate sample, and five replicates were collected at each site (Figure 2.1-1). All samples were collected in riffle habitats using a Hess sampler (surface sampling area of 0.096 m^2) fitted with a 500 µm mesh size net and terminal cod-end. Replicate samples were collected a minimum distance of three times the channel width apart from each other.

For each subsample, the bottom of the Hess sampler was placed firmly on the sediment bottom making sure sediment contact was continuous along the bottom rim. The encircled sediment was then swept by hand and all rocks lifted and scrubbed to make sure the entire sediment surface was agitated. After sweeping, the collected debris was transferred from the cod-end into a 500 mL wide-mouthed plastic jar. Three subsamples were combined to make one sample and this was preserved with 10% formalin. All benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification. Benthos counts were normalized to the surface area of the of the Ekman sediment sampler (0.0225 m^2).

Several community descriptors were calculated from the taxonomic results, including benthos density, family richness (S), Simpson's diversity and evenness indices, and the Bray-Curtis Index. Family richness was calculated as the total number of benthic invertebrate families present in each replicate sample, and the Simpson's diversity index was calculated as:

$$\textit{Simpson Diversity Index (D)} = 1 - \sum_{i=1}^{F} p_i^2$$

where F is the number of families present, and p_i is the relative abundance 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 all individuals. Simpson's Evenness Index was calculated as:

$$\textit{Simpson Evenness Index (J)} = 1 / \sum_{i=1}^{F} p_i^2 / F$$

A complete dissimilarity matrix was also generated that included pair-wise comparisons of all samples using the Bray-Curtis dissimilarity index (Environment Canada 2002). This index takes into account the number of families and the total number of individuals within each replicate sample and compares it to a single median reference community composition. This reference composition is generated from the median abundance of each represented family from all of the reference site replicates. Since the median reference composition is generated from the reference site replicates, the comparison of an actual reference site replicate community to the median reference community composition will produce a dissimilarity value (although generally a much lower value than exposure sites). 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. This index is calculated as:

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

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 separate analysis was completed for stream, lake, and marine benthos. For the stream benthos, all replicate data from the two reference locations (Reference B and D outflows) were used to produce a 'mean reference composition' to best summarize the overall variability of the reference condition. Because lakes can have dramatically different physico-chemical and biological function based on their morphologies, median reference compositions were created for each individual reference lake (large lake: Reference Lake B; small lake: Reference Lake D). Bray-Curtis distances were then calculated only by comparing the Reference Lake B median community to the large lake sites, Doris Lake North and South, while the Reference Lake D median community was only compared to the benthos community composition of Little Roberts Lake. For the marine sites, the REF-Marine median community composition was compared to the RBW and RBE benthos communities.

Some benthos groups were not identifiable to the family level, and were only able to be identified to a higher taxomonic level such as order. Within each higher taxonomic grouping, organisms that were not identifiable to the family level were assumed to belong to a single family for the purpose of calculating measures of richness, diversity, and evenness.

Standard summary statistics were calculated for all 2010 benthic invertebrate endpoints described above. These included the minimum, maximum, median, mean, standard deviation, and standard error for specific parameters. Results of these summaries are presented in Appendix A.

2.2.5.2 Lakes

Benthos samples were collected during the summer season at all AEMP lakes from August 8 to August 24, 2010. Like streams, all lake benthos sampling was designed to meet EEM criteria (i.e., three subsamples/replicate; five replicates/site). With the exception of Doris Lake South, lake benthos samples were obtained in the deepest section of the lake using an Ekman sediment sampler, with replicates collected 5 to 20 m apart. The Ekman was carefully set open, lowered gradually onto soft sediment using a metred cable line, and triggered closed with a messenger. All sampling depths are provided in Table 2.2-4.

Once at the surface, each sediment sample was transferred into a 500 µm sieve bucket and rinsed with site-specific water until free of sediments. The material retained within the sieve was then placed into a labelled plastic jar and filled with 10% buffered formalin. All benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification, and community descriptors and summary statistics were calculated as described for stream benthos. Benthos counts were normalized to the surface area of the of the Ekman sediment sampler (0.0225 m^2).

2.2.5.3 Marine

Benthos samples were collected during the summer season at the two sites in Roberts Bay (RBW and RBE; August 15, 2010) and at the reference site in Reference Bay (REF-Marine; August 15, 2010). Samples were collected with a 6 L capacity ponar dredge. Attempts were made to sieve the sediments through a 500 µm sieve; however, given the large amount of sediment per cast and the high proportion of coarse sand at the near-shore marine sites (>90% at RBE), this proved impossible. Thus, the benthos sampling routine was modified from that in the lakes and streams, but strived to follow the recommendations of the EEM. At each site, three casts were collected for each of the five replicate samples. For each replicate, 1 L of sediment was collected from each of the three subsample casts and placed into a plastic bowl. This was homogenized using a plastic spoon and 1 L of sediment was collected in two 500 mL wide-mouth plastic jars. Because of the high sand content at RBE and RBW, these samples were not sieved and the samples were preserved by directly adding 10% buffered

formalin into the jars. The jars were agitated to fully distribute the preservative. Because the sediments at site REF-Marine were finer, samples from this site were sieved, and the retained benthos were transferred into a 500 mL plastic jar and preserved with 10% buffered formalin. All benthos samples were sent to Columbia Science (Courtney, BC) for enumeration and identification, and community descriptors and summary statistics were calculated as described for stream benthos. Benthos density was normalized to the combined surface area of the two jars (0.013 m^2).

2.2.5.4 Sample Processing and Quality Control and Quality Assurance (QA/QC)

All benthic samples were stained with rose Bengal prior to sorting in the laboratory. The benthic samples were sieved into a coarse fraction (> 1 mm) and a fine fraction (0.5 to 1 mm). The coarse fraction was sorted using a whole sort method and the fine fraction using a subsampling method by trained technicians following established protocols (Wrona, Culp, and Davies 1982; Glozier, Culp, and Halliwell 2002).

The whole sort method consisted of completely and systematically sorting organisms from the coarse fraction on a gridded petri dish under a dissecting microscope at 7 to 10× magnification. The subsampling method consisted of the cone subsampler described by Wrona, Culp, and Davies (1982). The fine material was placed into an Imhoff cone and water was added to provide a total volume of 1 L. This mixture was agitated with an air stone for five minutes to ensure thorough mixing. Subsamples of 25 mL were removed from the cone and systematically sorted for organisms on a gridded Petri dish under a dissecting microscope. The number of subsamples taken depended on the number of organisms present in the subsample (as outlined in established protocols such as Wrona, Culp, and Davies (1982) and Glozier, Culp, and Halliwell (2002).

A re-sorting of randomly selected sample residues was conducted on 10% of the samples by a different technician to determine the level of sorting efficiency. The criteria for an acceptable sorting were that more than 90% 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). The 90% minimum efficiency was always attained (Appendix A).

Benthic organisms were identified and counted using dissecting or compound microscopes. Identifications were to the lowest practical taxonomic level (genus, where possible) using current literature and nomenclature. Microscope slide mounts were prepared for taxa, such as chironomids, which required detailed microscopic examination for identification. The most common species were usually distinguishable on the basis of gross morphology, requiring only a few mounts as checks, while mounts were made for all less commonly occurring species. The numbers of each taxon occurring in the total fine fraction were obtained by multiplying the counts of each taxon by the volumetric proportion that the subsamples represented of the total fine fraction. These counts were then added to the counts obtained from the coarse fraction for each taxon. Identified organisms were stored in vials for each sample with 70% isopropyl alcohol for archiving.

2.2.6 Lake Fish Survey

2.2.6.1 Fish Population Sampling

Ninespine stickleback were sampled from July 4 to 14, 2010. Sampling took place in Little Roberts Lake (Figure 2.2-1), Doris Lake North (north basin of Doris Lake, Figure 2.2-2) Doris Lake South (south basin of Doris Lake, Figure 2.2-3), Reference Lake B (Figure 2.2-4) and Reference Lake D (Figure 2.2-5) between the hours of 8:00 and 19:00. Twenty each of male, female, and immature stickleback were targeted for biological sampling at each lake site.

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Minnow Trap Locations in Little Roberts Lake, Doris North Project, 2010

Figure 2.2-1

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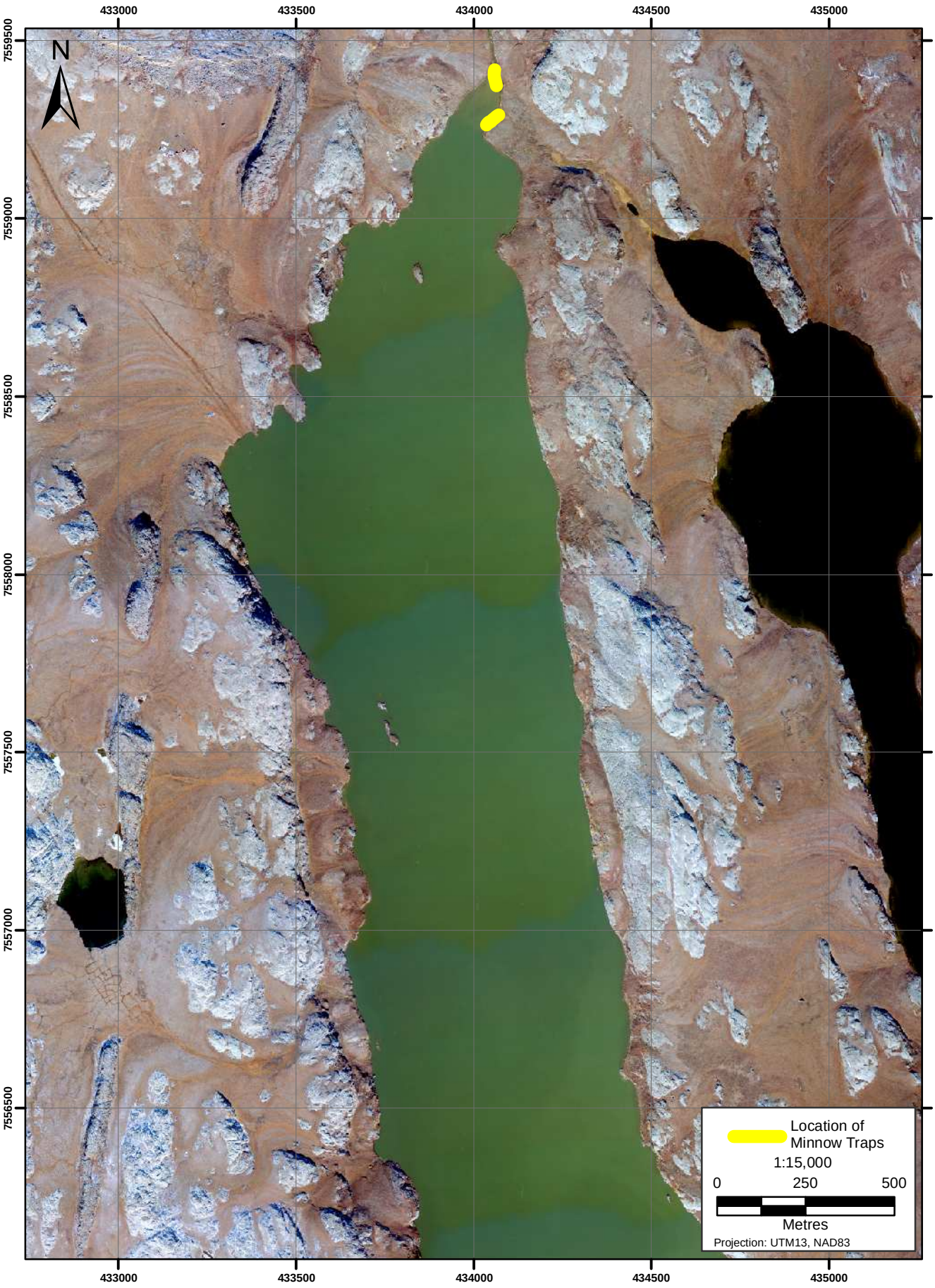

Figure 2.2-2

Minnow Trap Locations in Doris Lake North, Doris North Project, 2010

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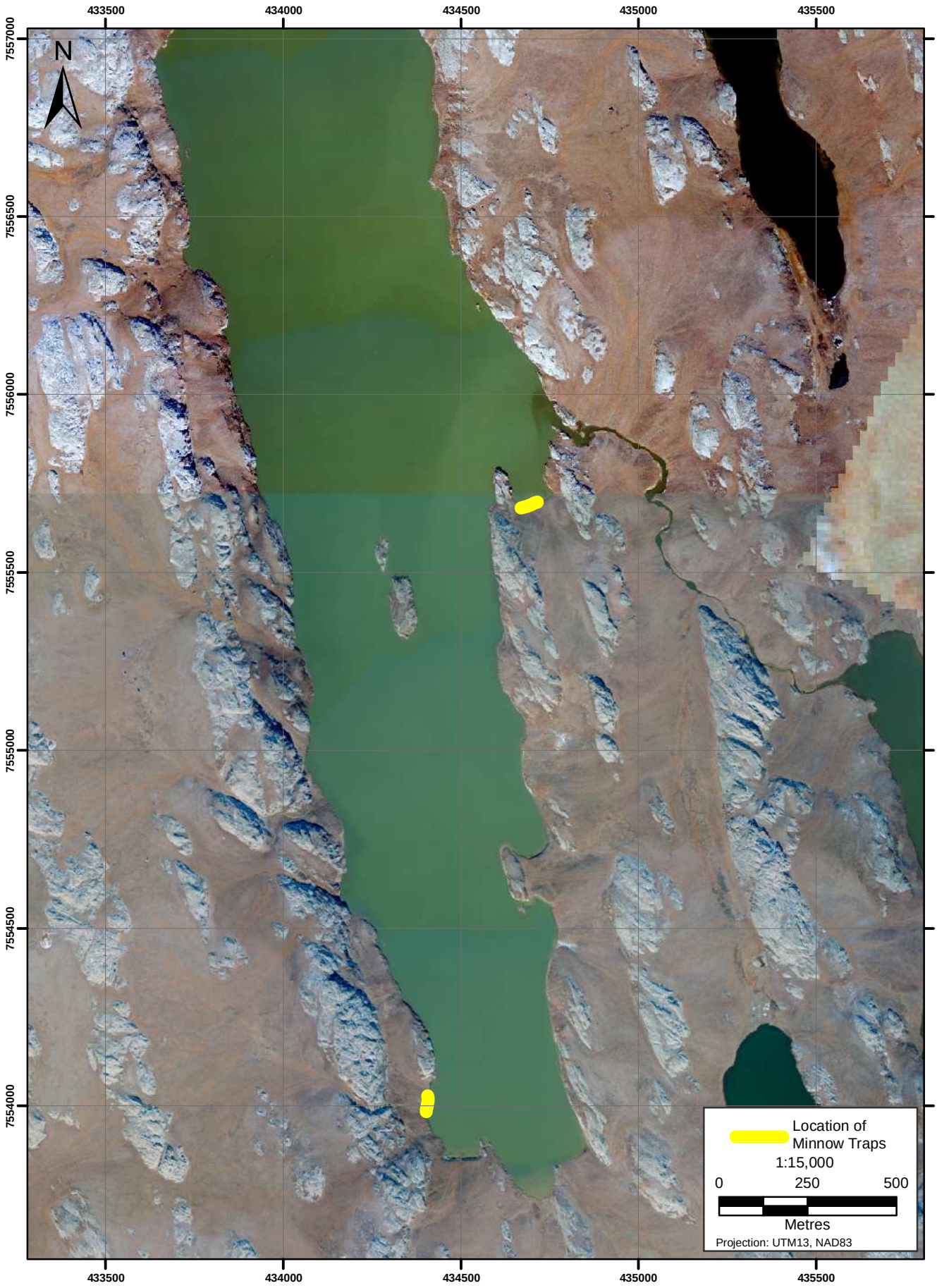

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Minnow Trap Locations in Doris Lake South, Doris North Project, 2010

Figure 2.2-3

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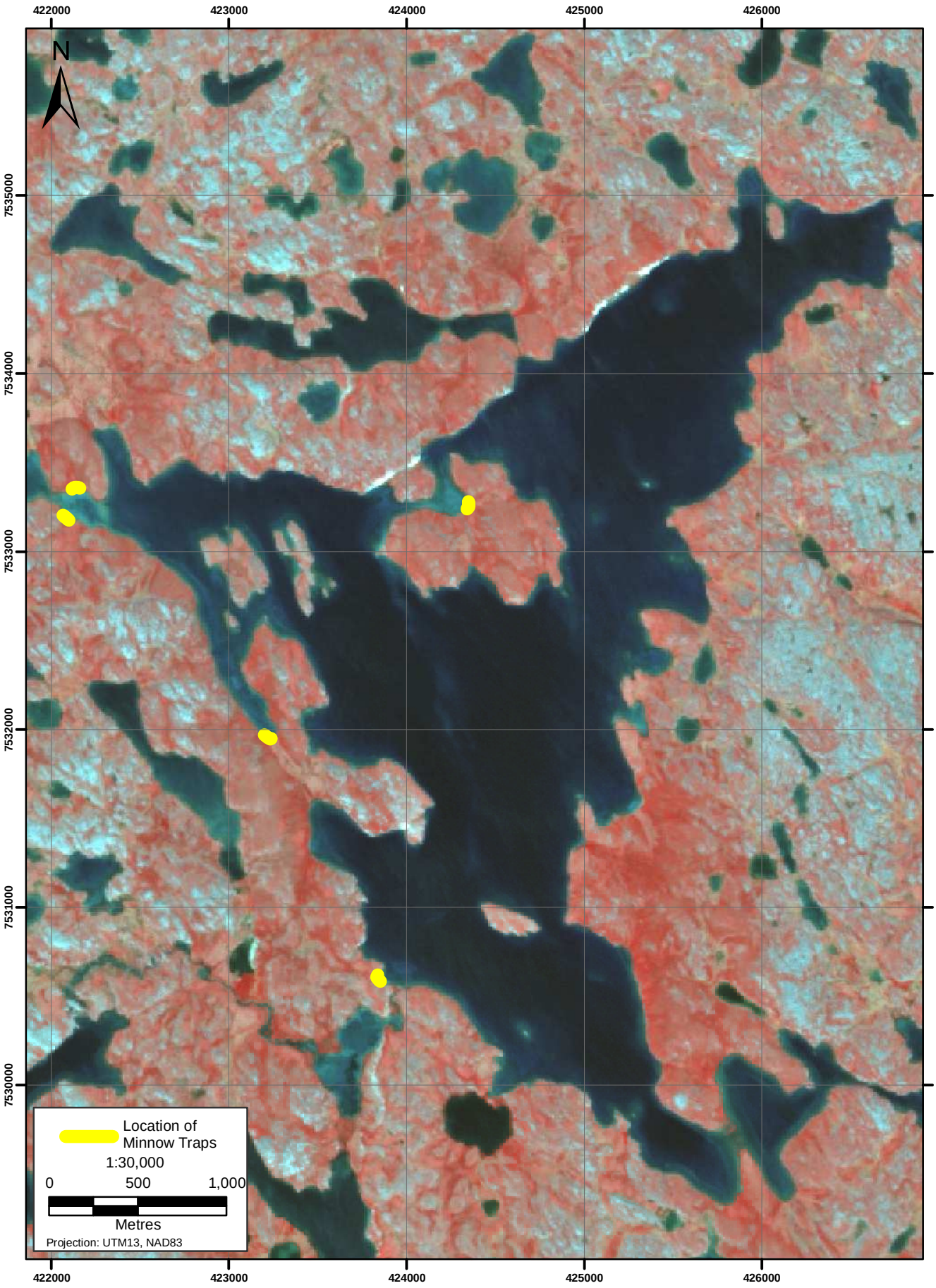

Figure 2.2-4

Minnow Trap Locations in Reference Lake B, Doris North Project, 2010

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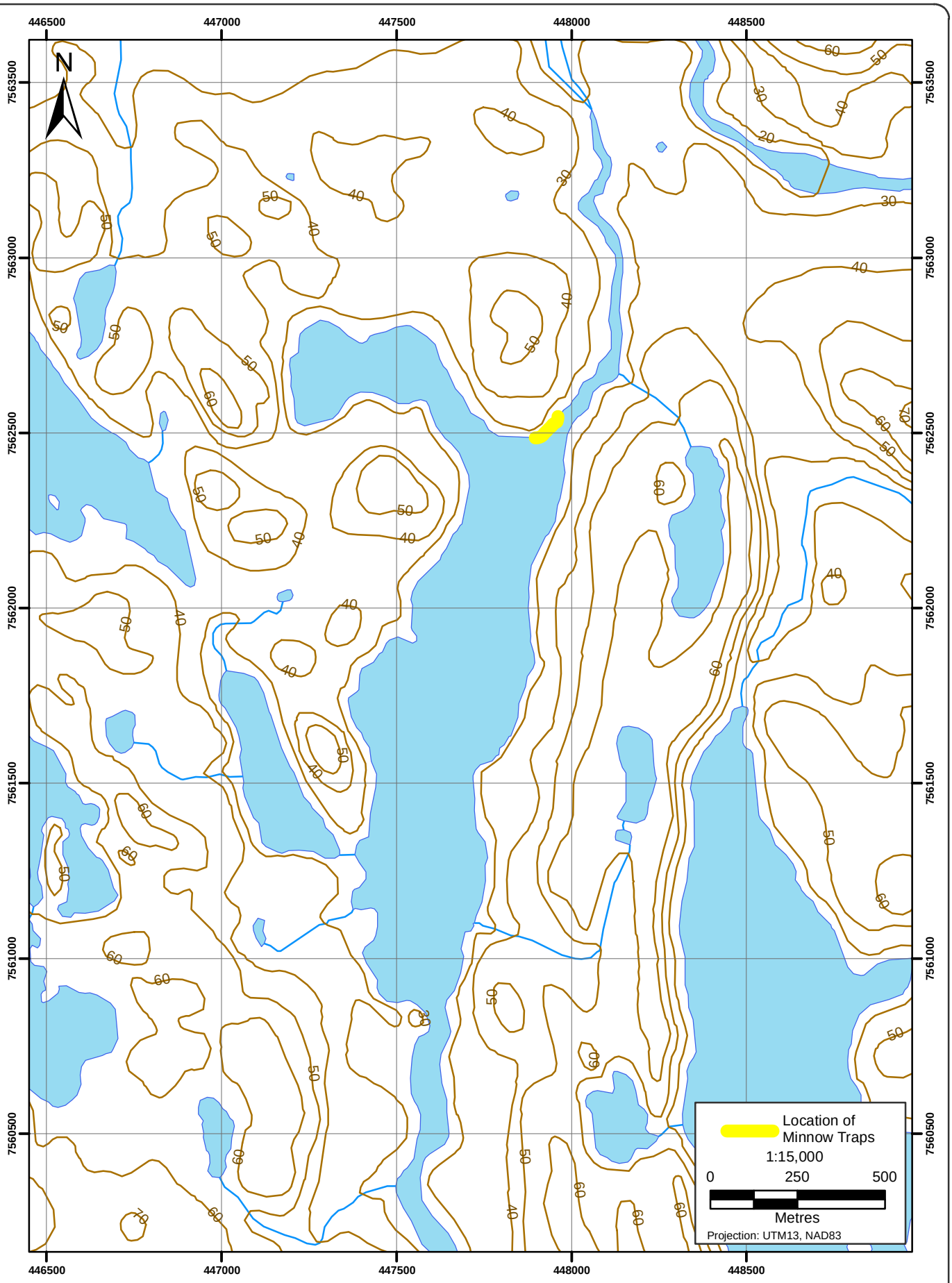

Figure 2.2-5

Minnow Trap Locations in Reference Lake D, Doris North Project, 2010

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Ninespine stickleback (Plate 2.2-2 and 2.2-3) were captured via minnow traps, which consisted of two wire mesh cylinders (mesh size 0.635 cm) that were locked together using a clip attached to a rope and marker buoy. Each minnow trap was baited with a small amount of commercial crab bait pellets (all traps contained the same amount of bait). Minnow traps were then placed along the shore of lakes at approximately 1 m depth. Minnow traps were set for approximately 24 hours.

Plate 2.2-2. Ninespine stickleback, Doris North Project, 2010.

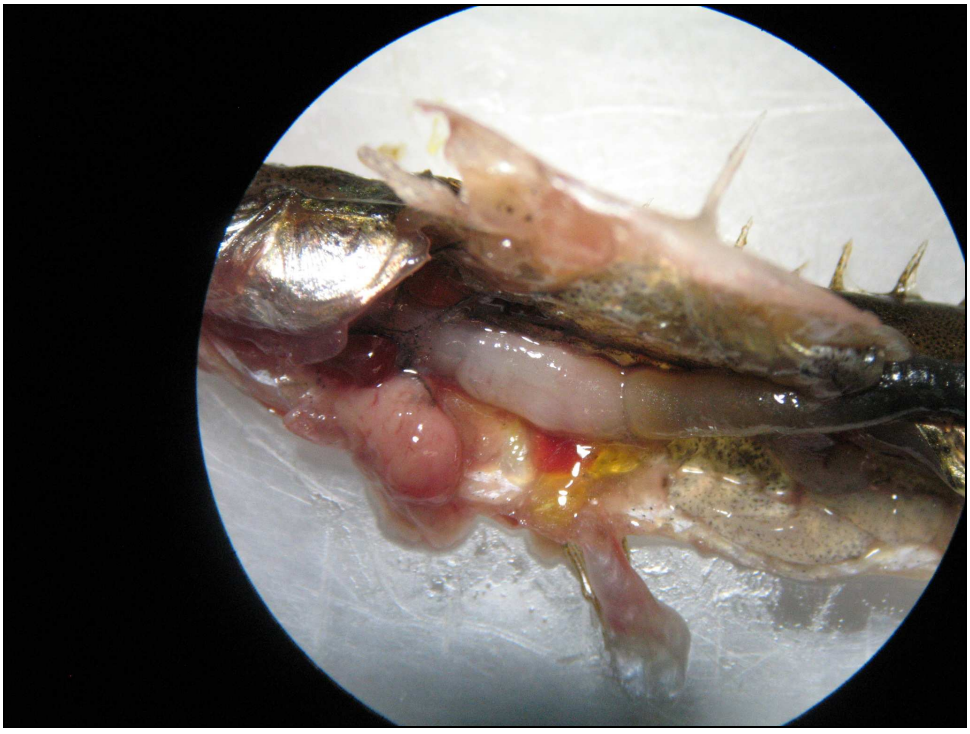

Plate 2.2-3. Photograph of a dissected ninespine stickleback, Doris North Project, 2010

2.2.6.2 Biological Processing

Upon capture, stickleback were identified by sex and 20 males, 20 females, and 20 immature individuals (immatures) were euthanized and placed on ice. No other species were identified. Sacrificed fish were first measured for length and weight. Individuals were then dissected. Livers and gonads were removed and weighed; internal photographs were taken of a subsection of individuals (Plate 2.2-3). All weights (body, liver, gonads) were measured using a suitably sensitive micro-scale. Any external deformities, erosions, lesions and/or tumours (DELT) as well as parasites were noted and photographed.

To age the stickleback, sagittal otoliths and fin clips were taken from 336 ninespine stickleback and sent to Dr. Steve Campana at the Bedford Institute of Oceanography in Dartmouth, Nova Scotia for analysis. Otoliths were individually mounted on standard microscope slides with cyanoacrylate glue, which provided an immediate and permanent clearing effect. Age interpretations were made under a binocular microscope at 16-50× magnification using reflected light. In a subsample of otoliths, the growth increment sequence was digitally photographed at a resolution of 2048× while immersed in ethanol, then digitally enhanced for contrast using Adobe Photoshop CS2. Age interpretations based on the enhanced images were identical to those made microscopically. Similarly, age interpretation did not change after polishing with 3M^{TM} Imperial lapping film (3 µm grit size). No fin clips were used to age fish as otoliths provided reliable ages.

Ovaries were removed from female stickleback and placed individually in labelled vials filled with 10% buffered formalin. Samples were then shipped to Nell Postans at Applied Technical Services, Victoria, BC for egg counts and classification by stage of maturation (immature, 0.5 to 1 mm; immature, 1 to 1.5 mm; mature > 1.5 mm).

2.2.6.3 Tissue Metal Analysis

From each site, eight groups of approximately five female ninespine stickleback (~5 g of stickleback) were weighed, euthanized and placed in individually labelled Whirl-Pak bags. The whole-fish tissue samples were frozen immediately and were kept frozen until they were delivered to ALS Burnaby, BC for analysis of metal concentrations. As a result of an error at ALS, two of the eight samples from both Little Roberts Lake and Doris Lake North were combined. This resulted in only seven samples being analyzed for metals from Little Roberts Lake and Doris Lake North. ALS analyzed the tissue samples for metal concentrations according to procedures adapted from the United States Environmental Protection Agency (US EPA 1995). Samples were divided into two parts: one part for measurement of metal concentrations (on a wet weight basis) and a second part for measurement of percent moisture so that the results could be converted to mg/kg dry weight, if required. All of the 38 samples collected had sufficient volume to allow an accurate measurement of percent moisture.

Each sample was homogenized either mechanically or manually prior to digestion. The hotplate digestion method involved the use of nitric acid followed by repeated additions of hydrogen peroxide. Total concentrations of 39 metals were measured by inductively coupled plasma – mass spectroscopy (ICPMS). The 39 metals and their analytical detection limits are shown in Table 2.2-7.

Tissue metals in which 90% of the all concentrations were below the method detection limit (MDL) were excluded from all analyses. For the included metals, all concentrations listed as below the MDL were assigned values of one-half the MDL in order to use those concentrations in statistical analyses.

Ten of the 39 metals are either subject to EEM Effluent Characterization Study (aluminum, cadmium, iron, mercury and molybdenum) or designated as deleterious effluent substances by the MMER (arsenic, copper, lead, nickel and zinc). These metals were analyzed in more detail than the others listed in Table 2.2-7.

Table 2.2-7. Tissue Metals and Realized Detection Limits for Ninespine Stickleback, Doris North Project, 2010

Total Metal	Detection Limit (mg/kg wet weight)	Total Metal	Detection Limit (mg/kg wet weight)
Percent Moisture	0.1	Mercury	0.001
Aluminum	0.4	Molybdenum	0.004
Antimony	0.002	Nickel	0.01
Arsenic	0.004	Phosphorus	25
Barium	0.01	Potassium	100
Beryllium	0.002	Rhenium	0.002
Bismuth	0.002	Rubidium	0.01
Boron	0.2	Selenium	0.02
Cadmium	0.002	Sodium	100
Calcium	2.5	Strontium	0.01
Cesium	0.001	Tellurium	0.004
Chromium	0.01	Thallium	0.0004
Cobalt	0.004	Thorium	0.002
Copper	0.02	Tin	0.004
Gallium	0.004	Titanium	0.010
Iron	0.2	Uranium	0.0004
Lead	0.004	Vanadium	0.004
Lithium	0.02	Yttrium	0.002
Magnesium	5	Zinc	0.1
Manganese	0.004	Zirconium	0.04

2.2.6.4 Indices Calculated

The parameters used to assess the fish populations and biology included length, weight, condition (body, liver and gonad) and catch-per-unit-effort (CPUE). Data analysis and interpretation of these parameters followed the Metal Mining EEM Guidance Document (Environment Canada 2002).

Populations

The CPUE statistic is used as an estimate of relative abundance of fish (Ricker 1975). Catch is standardized by effort as well as by gear (net type, mesh size, etc.). The same traps were used at all sites allowing comparisons of CPUE data to be made between waterbodies. CPUE is generally used as a measure to estimate proportional abundances of fish or more realistically a measure of the community composition of fishes.

For minnow traps, CPUE was the number of fish caught per trap per 1 hour, and was calculated as:

$$CPUE = number\ of\ fish\ caught\ per\ minnow\ trap * [1/set\ time\ (h)]$$

Biology

Condition, weight-length regressions and the hepatosomatic index (HSI) are indicators of the physical condition of fish. Condition factor was based on the following formula from Ricker (1975):

$$Condition\ (K) = weight\ (g) * 10^5 / length^3\ (mm)$$

Weight was multiplied by 10^5 to avoid fractional values, and a weight-length exponent of exactly 3 was assumed to apply to all species of fish because the condition factor assumes a cubic relationship between weight and length (Ricker 1975).

Weight-length relationships of ninespine stickleback were calculated for each lake. Weight and length data were transformed with natural logarithms to linearize the relationship and homogenize the variances:

$$ln(weight, g) = ln(a) + b[ln(fork\ length, mm)]$$

where *a* is a coefficient and *b* is the slope of the regression.

Since the liver is the site of detoxification within a fish (as with humans), the relative weight of the liver is an index of disease state. The hepatosomatic index was defined as:

$$Hepatosomatic\ Index\ (\%) = liver\ weight\ (g) * 100 / total\ body\ weight\ (g)$$

The mean hepatosomatic index was calculated for male and female ninespine stickleback as well as for immature individuals.

The mean gonadosomatic index (GSI) was assessed for both female and male ninespine stickleback and is defined as:

$$Gonadosomatic\ Index\ (\%) = gonad\ weight\ (g) * 100 / total\ body\ weight\ (g)$$

The gonadosomatic index varies through a year in response to the reproductive cycle; it is at its maximum immediately before spawning and at its minimum immediately after spawning.

2.2.6.5 Data Analysis

Standard summary statistics were calculated for all 2010 ninespine stickleback indices described above, as well as for length, weight and age of the stickleback. These statistics included the minimum, maximum, median, mean, standard deviation, and standard error for specific parameters. Results of these summaries are presented within Appendix B. A principle component analysis (PCA) was used to reduce redundancy in the tissue metals data set and to allow clearer interpretation of trends in the metals data. PCA is a statistical routine that reduces a dataset containing a large number of correlated observations into a smaller number of uncorrelated artificial variables called components. PCA is also called data reduction because there are always fewer components than original variables once the redundant information has been removed. The PCA was applied to a single matrix containing the standardized tissue metal concentrations (in mg/kg ww, where ww is wet weight). The amounts of variance explained by each component and a scree plot (not shown here) were used to determine how many of those components were important and which were trivial. A scree plot is a plot of the variance explained by a component against the order in which the components were extracted. Important components appear as a 'cliff face' and trivial components appear as the 'scree' at the bottom of the cliff.

2.2.6.6 Quality Control and Quality Assurance (QA/QC)

Data Collection and Entry

A quality assurance and quality control program (QA/QC) was included in this study. For all fish community surveys, data sheets were reviewed at the end of each day by an experienced fish biologist to ensure data records were complete and data collected properly. Field notes were transcribed onto electronic spreadsheets and then all transcriptions were checked against the field forms and errors

corrected visually. The visual checks were completed by a Rescan scientist who did not enter the data into the electronic spreadsheet. The data were also plotted (e.g., weight-length plots) to identify any outliers that may have resulted from transcription errors that occurred in the field.

Tissue Metals

To assess the accuracy of the metal analyses on the ninespine stickleback, ALS conducted two measures of quality control: method blanks (MB) and comparison with reference material (CRM). A method blank is a test in which no tissue is added. Three method blanks were run with 39 metals and two were run with six of the 39 metals (calcium, magnesium, mercury, potassium, phosphorus and sodium) resulting in a total of 129 comparisons between measurements and targets.

To further assess the accuracy of the metal analyses, samples of a reference material, VA-NRC-TORT2 or lobster hepatopancreas, certified by the National Research Council of Canada, were subjected to the same analytical procedures as the ninespine stickleback tissue samples. The measured concentrations of each metal were then compared to the known metal concentrations in the certified material to determine if they fell within the 95% confidence limits expected for each metal.

To assess the variability of the fish metal analysis, and hence the homogeneity of the samples, four of the 64 samples (~6% of the total number of samples) were each split into two replicates. The relative percent difference (RPD) between replicate metal concentrations (and percent moisture) was calculated as:

$$RPD = 100 * ((sample - duplicate) / ((sample + duplicate) / 2))$$

2.2.7 Marine Fish Survey

2.2.7.1 Biological Sampling and Processing

Mussels of the species *Mytilus trossulus* (the bay mussel) were collected from RBE, RBW (August 22, 2010), and Reference Bay (August 24, 2010; Figure 2.2-6). Samples were collected via snorkelling (20 mussels were collected from RBE and RBW and 24 mussels were collected from Reference Bay). Upon collection, mussels from RBE and RBW were taken to the laboratory for processing. Measurements taken included: shell length (mm), shell width (mm), shell height (mm), total weight (g), and tissue wet weight (g). The volume of the mussels was defined as:

$$Volume\ (mm^3) = length\ (mm) * width\ (mm) * height\ (mm)$$

Mussels from Reference Bay were frozen upon collection and transported to Rescan's laboratory in Vancouver. Samples were thawed before measurements (as above) were taken.

2.2.7.2 Tissue Metal and Polycyclic Aromatic Hydrocarbon Analysis

After biological measures were taken, eight mussels from each marine site were placed in individually labelled Whirl-Pak bags. The tissue samples were frozen immediately and remained frozen until they were delivered to ALS Burnaby for analysis of metal concentrations. As with the stickleback samples, ALS analyzed the mussel tissue samples for metal concentrations according to procedures adapted from the United States Environmental Protection Agency (US EPA 1995).

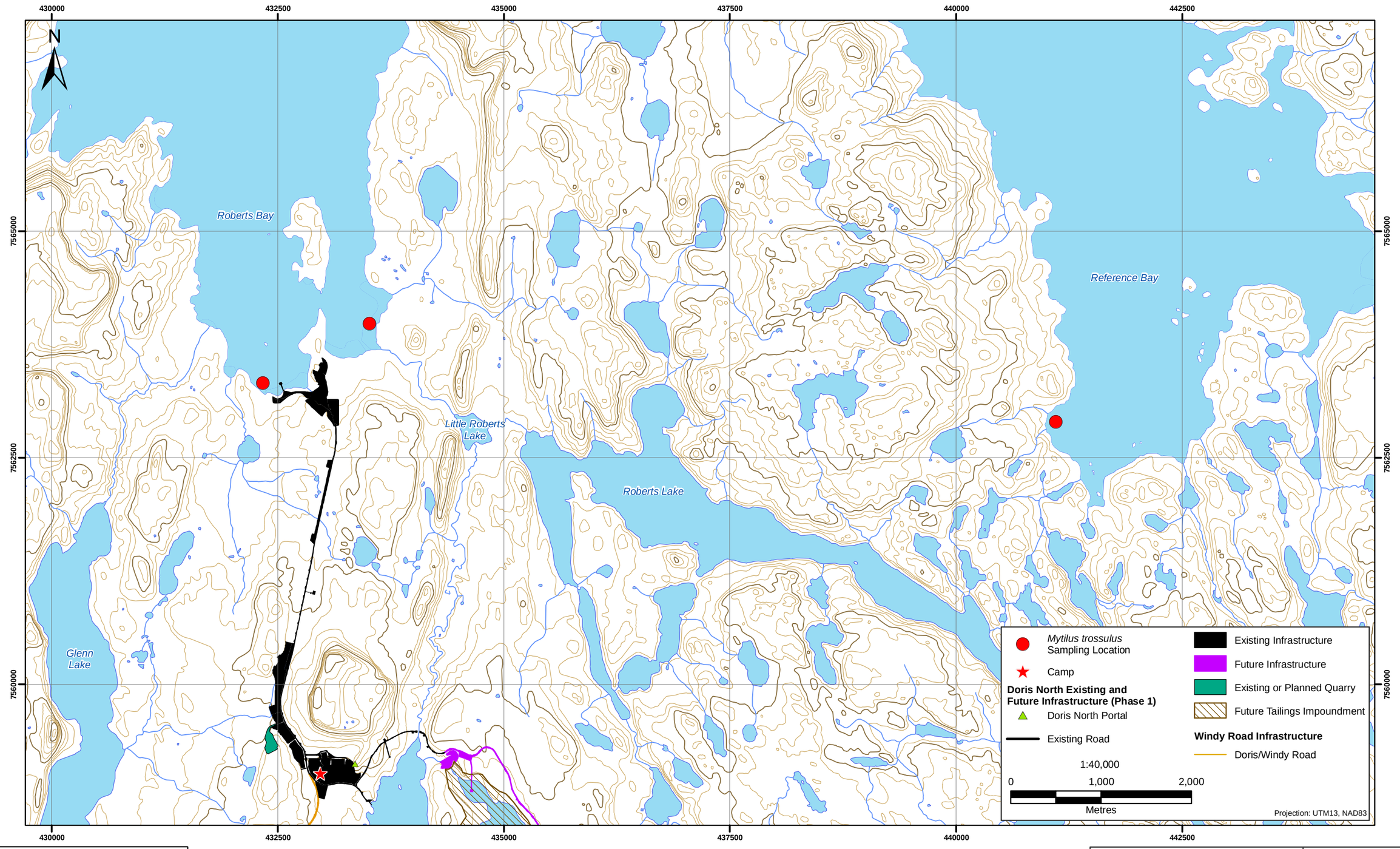

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Figure 2.2-6

Sampling Locations for *Mytilus trossulus*, Doris North Project, 2010

Samples were divided into two parts: one part for measurement of metal concentrations (on a wet weight basis) and a second part for measurement of percent moisture so that the results could be converted to mg/kg dry weight if required. All of the 24 samples collected had sufficient volume to allow an accurate measurement of percent moisture. Each sample was homogenized either mechanically or manually prior to digestion. The hotplate digestion method involved the use of nitric acid followed by repeated additions of hydrogen peroxide. Total concentrations of 39 metals were measured by ICPMS. The 39 metals and their realized analytical detection limits are shown in Table 2.2-8. Three samples from Reference Bay and two from each of RBE and RBW were also analyzed for polycyclic aromatic hydrocarbons (PAHs). The 16 PAHs and the associated detection limits are shown in Table 2.2-9.

Table 2.2-8 Tissue Metals and Realized Detection Limits for *Mytilus trossulus*, Doris North Project, 2010

Total Metal	Detection Limit (mg/kg wet weight)	Total Metal	Detection Limit (mg/kg wet weight)
Percent Moisture	0.1	Mercury	0.001
Aluminum	0.4 to 2.0	Molybdenum	0.004 to 0.012
Antimony	0.002 to 0.01	Nickel	0.01 to 0.03
Arsenic	0.004 to 0.012	Phosphorus	10 to 25
Barium	0.01 to 0.03	Potassium	40 to 100
Beryllium	0.02 to 0.1	Rhenium	0.002 to 0.006
Bismuth	0.002 to 0.03	Rubidium	0.01 to 0.03
Boron	0.2 to 0.6	Selenium	0.02 to 0.2
Cadmium	0.002 to 0.006	Sodium	40 to 100
Calcium	1 to 2.5	Strontium	0.01 to 0.03
Cesium	0.001 to 0.003	Tellurium	0.004 to 0.012
Chromium	0.01 to 0.1	Thallium	0.0004 to 0.01
Cobalt	0.004 to 0.02	Thorium	0.002 to 0.006
Copper	0.01 to 0.03	Tin	0.004 to 0.05
Gallium	0.004 to 0.012	Titanium	0.010 to 0.03
Iron	0.2 to 0.6	Uranium	0.0004 to 0.002
Lead	0.012 to 0.02	Vanadium	0.004 to 0.012
Lithium	0.02 to 0.1	Yttrium	0.002 to 0.006
Magnesium	2 to 5	Zinc	0.1 to 0.3
Manganese	0.004 to 0.012	Zirconium	0.04 to 0.12

2.2.7.3 Data Analysis

Standard summary statistics were calculated for all 2010 mussel biological measures, including length, weight (both total and tissue), height, and volume of the mussels. The summary statistics included the minimum, maximum, median, mean, standard deviation, and standard error for specific parameters. Results of these summaries are presented within Appendix B. A principle component analysis (PCA) was used to reduce redundancy in the tissue metals data set and to allow clearer interpretation of trends in the metals data. The PCA was applied to a single matrix containing the standardized tissue metal concentrations (in mg/kg dw, where dw is dry weight). The amounts of variance explained by each component and a scree plot (not shown here) were used to determine how many of those components were important and which were trivial.

Table 2.2-9. Polycyclic Aromatic Hydrocarbons and Realized Detection Limits for *Mytilus trossulus*, Doris North Project, 2010

PAH	Detection Limit (mg/kg wet weight)	PAH	Detection Limit (mg/kg wet weight)
Acenaphtene	0.01 to 0.025	Chrysene	0.01 to 0.015
Acenaphtylene	0.01 to 0.015	Dibenz(a, h)anthracene	0.01
Anthracene	0.01 to 0.025	Fluoranthene	0.01
Benz(a)anthracene	0.01	Fluorene	0.01 to 0.03
Benzo(a)pyrene	0.01	Indeno(1, 2, 3-c, d)pyrene	0.01
Benzo(b)fluoranthene	0.01	Naphthalene	0.01 to 0.015
Benzo(g, h, i)perylene	0.01	Phenanthrene	0.01 to 0.015
Benzo(k)fluoranthene	0.01	Pyrene	0.01 to 0.015

2.2.7.4 Quality Control and Quality Assurance (QA/QC)

Tissue Metals

Two method blanks were run, the first with 14 metals (arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium and zinc) and the second with 8 metals (arsenic, cadmium, cobalt, lead, mercury, nickel, selenium and zinc) resulting in a total of 24 comparisons between measurements and targets.

As with the quality control protocol of the ninespine stickleback, to further assess the accuracy of the metal analyses in the mussel tissue samples, samples of a reference material (VA-NRC-TORT2 or lobster hepatopancreas) certified by the National Research Council of Canada were subjected to the same analytical procedures. The measured concentrations of each metal were then compared to the known metal concentrations in the certified material to determine if they fell within the 95% confidence limits expected for each metal.

To assess the variability of the mussel tissue metal analysis, and hence the homogeneity of the samples, two of the 23 samples (~9% of the total number of samples) were each split into two replicates and the RPD between metal concentration and percent moisture was calculated.

2.3 EVALUATION OF EFFECTS

Select data collected since 1995 in the Doris North Project area were compared against 2010 data to determine whether there were changes to the aquatic environment as a result of Project activities. The goal of this effects assessment was to determine whether adverse changes occurred in the aquatic environment that could be directly attributed to the Doris North Project 2010 activities.

Since the fish program carried out in 2010 was intended to fulfill Year 1 of fish data collection, data from this component of the AEMP were not subjected to an evaluation of effects. The next scheduled fish sampling is in 2013, at which time data will be subjected to a full evaluation. Stream, lake, and marine benthos also were not evaluated for effects since 2010 samples were collected using a different methodology than historical samples. Stream periphyton biomass was not subjected to an effects evaluation because of the limited historical data for this parameter. Benthos and stream periphyton biomass will be evaluated for effects in 2011. Summary statistics for all 2010 fish, benthos, and stream periphyton endpoints are presented in Appendix A.

2.3.1 Parameters Subjected to Evaluation

Table 2.3-1 presents the physical, chemical, and biological parameters that were evaluated for 2010. All water quality parameters associated with the various components of the MMER (e.g., Schedule 4 Deleterious Substances, Effluent Monitoring Conditions (Division 2), EEM's Effluent Characterization) were assessed for potential effects. Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life exist for most of the assessed parameters. As per the MMER and EEM requirements, sediment particle size and total organic carbon content were assessed, as were sediment parameters for which there are CCME sediment quality guidelines for the protection of aquatic life. Biological components that met methodological criteria (described below) were also assessed for effects (phytoplankton).

Table 2.3-1. Parameters Subjected to Effects Analysis, Doris North Project, 2010

Water Quality		Physical Limnology		
Deleterious Substances[a]	**Effluent Characterization and Water Quality Parameters[b]**	**Effluent Characterization and Water Quality Parameters[b]**	**Sediment Quality**	**Biology**
Total Suspended Solids[d]	pH[d]	Dissolved Oxygen[d]	Particle Size[c]	Phytoplankton Biomass
Cyanide, Total[d]	Alkalinity, Total		Total Organic Carbon[c]	
Arsenic, Total[d]	Hardness		Arsenic[d]	
Copper, Total[d]	Ammonia (as N) [d]		Cadmium[d]	
Lead, Total[d]	Nitrate (as N) [d]		Chromium[d]	
Nickel, Total[d]	Aluminum, Total[d]		Copper[d]	
Zinc, Total[d]	Cadmium, Total[d]		Lead[d]	
Radium-226	Iron, Total[d]		Mercury[d]	
	Mercury, Total[d]		Zinc[d]	
	Molybdenum, Total[d]			

Notes:
[a] Parameters regulated as deleterious substances as per Schedule 4 of the MMER
[b] Parameters required for effluent characterization and water quality monitoring as per Schedule 5 of the MMER
[c] Parameters required as part of the benthic invertebrate surveys under the EEM
[d] Parameters that have CCME water or sediment quality guidelines for the protection of aquatic life
2010 was Year 1 of fish data collection. The next scheduled sampling is in 2013, at which time fish parameters will be included in the evaluation.
2010 was Year 1 of MMER-level periphyton biomass and benthos and data collection. Periphyton and benthos and parameters will be included in the 2011 evaluation.

2.3.2 Baseline Data and Effects Analysis

Baseline physical, chemical, and biological data have been collected in the Doris North Project area since 1995. Historical samples have been collected from a variety of locations and depths within each of the AEMP stream, lake, and marine environments. 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 for meaningful comparisons with the 2010 data.

The approaches used to assemble the appropriate baseline datasets and to determine whether effects on evaluated parameters were observed in 2010 are discussed below. Key determining factors for the inclusion of baseline data included the proximity of historical sampling sites to 2010 sampling sites, the depth of sampling (for sediment quality), and sampling methodology (for benthos). Historical data used

for the effects analyses were from the following reports: Klohn-Crippen Consultants Ltd. (1995), Rescan (1997, 1998, 2001, 2010a, 2010b), RL&L Environmental Services Ltd. and Golder Associates Ltd. (2003a, 2003b), and Golder Associates Ltd. (2005, 2006, 2007, 2008, 2009).

2.3.2.1 Physical Limnology and Oceanography

Data Selection

Potential effects on physical limnology and oceanography were evaluated using April under-ice dissolved oxygen since concentrations are lowest during this period, and therefore pose the greatest concern for aquatic life. Although temperature and salinity (marine) were also measured, they were not evaluated for effects since they are largely determined by climatic variability, and no effluent was discharged into the aquatic environment in 2010.

Under-ice dissolved oxygen measurements have been collected intermittently at the AEMP sites since 2004. Doris Lake North and Little Roberts Lake have the best temporal coverage, with under-ice profiles collected several times since 2004. Under-ice dissolved oxygen data for Doris Lake South and Reference Lake B are available only from 2009 and 2010. Reference Lake D was profiled for the first time in 2010 and therefore could not be used for comparison with temporal dissolved oxygen trends in Little Roberts Lake.

In the marine environment, under-ice dissolved oxygen profiles were collected at RBE in May 2006 and at RBW in April 2009. 2010 dissolved oxygen profiles were taken in April at RBE and RBW, but not at REF-Marine for safety reasons. No historical under-ice data exit for REF-Marine.

Effects Analysis

The potential for effects was judged by graphical analysis since the dissolved oxygen profiles were not replicated and were not amenable to statistical analysis. For winter dissolved oxygen to warrant concern and be considered an effect, concentrations from 2010 had to be noticeably different from all available baseline years (pre-2010). For example, if 2010 dissolved oxygen levels were different from 2005, but not 2007, it was concluded that there were no construction effects at that exposure site. Dissolved oxygen concentrations were also compared against CCME guidelines for the protection of aquatic life (CCME 2011b) to determine if historical or 2010 concentrations dropped below recommended levels.

Ice cover usually forms in October and November in the Doris North region, and under-ice oxygen profiles were collected in April 2010. The formation of the ice cover in November 2009 isolated lakes, streams, and Roberts Bay from any atmospheric sources of Project activities like dust between November 2009 and June/July 2010. The water-column that was profiled in April 2010 therefore reflects activities from 2009 rather than 2010.

2.3.2.2 Water Quality

Data Selection

Water quality samples have been collected in the Doris North Project area since 1995 (Figure 2.3-1). The selection of historical data to include in the 2010 evaluation was based on similarity of historical sampling locations to 2010 sampling locations, methodology (e.g., shoreline grabs were excluded from dataset), sampling depth (e.g., for marine data, historical samples collected from just above the sediment were excluded because all 2010 samples were collected from the surface zone), and professional judgment. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix C.

PROJECT #**1009-002-28** GIS # **HB-01-038** March 2, 2011

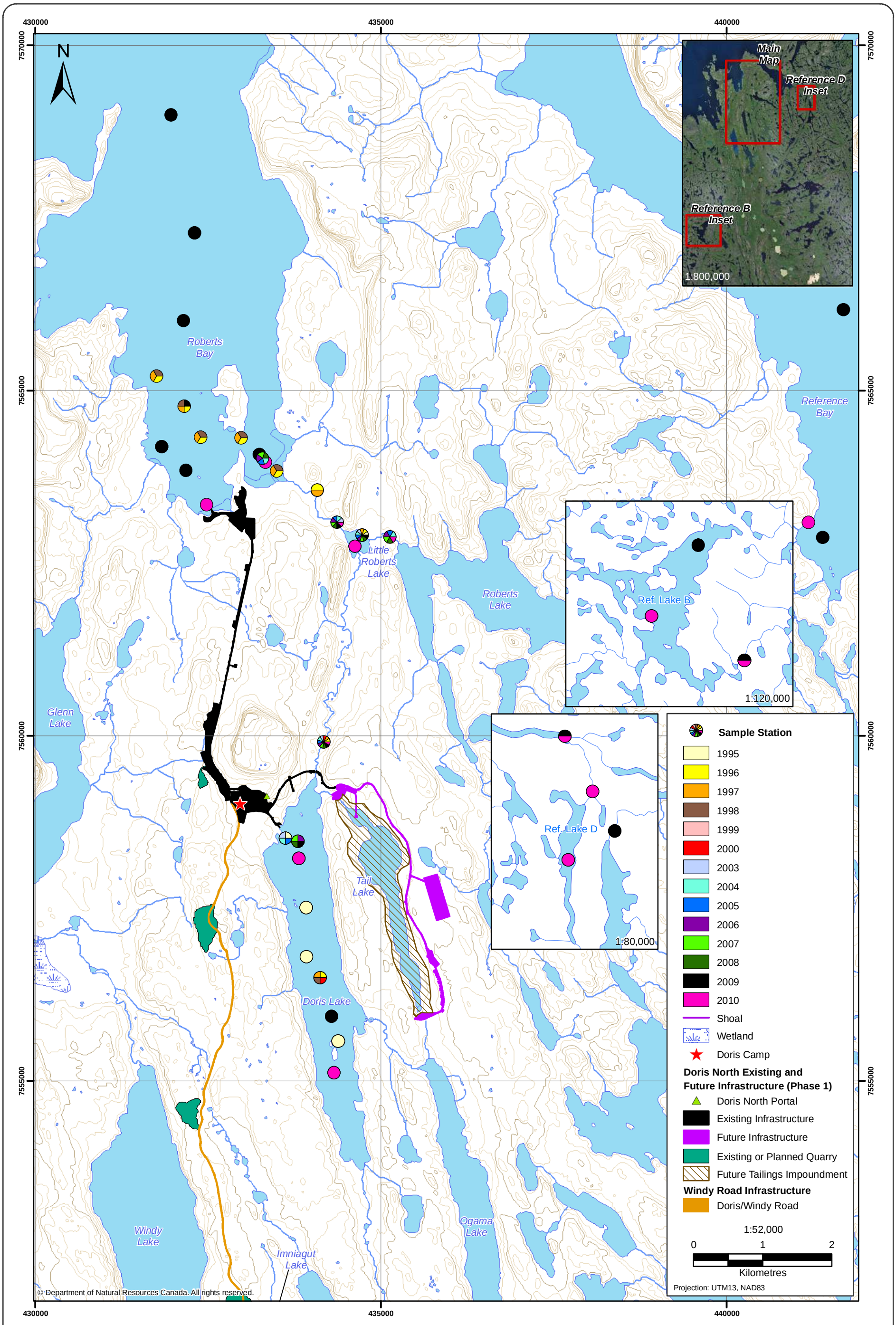

Figure 2.3-1

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Historical Water Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1995-2010

Figure 2.3-1

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Effects Analysis

All 18 evaluated water quality parameters presented in Table 2.3-1 were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2011b). For each parameter, a graph showing annual mean parameter concentrations for all available years is presented alongside a graph comparing before-after trends at the exposure sites to before-after trends at the reference sites. This graphical analysis was used to identify trends and to supplement the results of the statistical analyses. Relevant CCME guidelines are included on these graphs, as well as in Appendix A.

For each waterbody, a before-after comparison between the historical mean and the 2010 mean was conducted for each of the 18 evaluated parameters (provided that historical data were available). A mixed model ANOVA using the Proc Mixed procedure in SAS 9.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season* (early vs. late), and random effect of *year* to account for variability in water quality data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1995 to 2009) or *after* the start of construction (2010). For the *season* effect, samples were grouped into one of two seasons depending on the timing of sampling: *early* (i.e., June or earlier, which included all freshet or under-ice sampling) or *late* (i.e., July or later, which included all open-water season sampling). To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. If the results of the before-after analysis indicated that a parameter mean was not significantly different in 2010 compared to the historical mean, no further statistical analysis results are discussed, and it was concluded that there was no effect of construction activities on this parameter.

If the before-after comparison revealed that a 2010 parameter mean was different from the historical mean, the next step of the analysis was to conduct a before-after-control-impact (BACI) analysis, which is a standard method used to assess an environmental impact. The BACI analysis compares a before-after trend apparent at the exposure site with that at the reference site, to see if it is attributable to a natural process. A BACI analysis could only be performed if both historical and 2010 data were available for both the exposure site and the reference site. This analysis introduces a *class* effect to the mixed model ANOVA, which is the classification of the waterbody as an exposure or a reference site. The interaction between the *period* and *class* effects reveals whether any change in the mean of the water quality parameter that occurred in the exposure site also occurred in the reference site. To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. If a change in the mean was detected by the ANOVA, but the BACI analysis revealed that this change also occurred at the reference site, it is reasonable to assume that this change was likely a natural phenomenon and was unrelated to the commencement of construction activities. Note that BACI results are only discussed in the text if a difference is detected by the ANOVA analysis, but all BACI results are included in Appendix C. In every instance that no statistical difference was found by the ANOVA before-after comparison, the BACI analysis also found no statistical difference between the trends at the exposure and reference site (provided that both historical and 2010 data were available for the reference site).

All sample replicates within the historical and 2010 water quality dataset were treated as pseudo-replicates and were averaged prior to graphical and statistical analysis. In some large lake sites, the dataset included samples that were collected from multiple depths within the water column. Because there was little evidence of vertical chemical stratification, the data were pooled regardless of sampling depth. For all effects analyses, statistical results were considered unreliable if > 70% of the values in the dataset for a parameter were below analytical detection limits (i.e., censored data). These statistical results are not presented in this report (though statistical results for these data do appear in the raw outputs provided in Appendix C).

Half the detection limit was substituted for censored data that were included in the analyses. In general, similar results were obtained regardless of whether half the detection limit or the full detection limit was substituted for these censored values. Values determined to be outliers were excluded from the statistical analyses. In most cases, outliers were historical values that were below very high detection limits. These and other anomalous historical values were removed to reduce artificial inflation of the variance, which would lead to reduced power to detect effects. The only 2010 data treated as outliers were censored values that were below relatively high detection limits (i.e., mercury concentrations of < 0.00005 mg/L measured in June stream samples from Roberts Outflow, Reference B Outflow, and Reference D Outflow; and a single nitrate concentration of < 2.5 mg/L measured in July at REF-Marine).

A complete description of the statistical analyses used to assess the construction effects on water quality, including all assumptions, lists of outliers, and detailed methodology and results, is included in Appendix C.

2.3.2.3 Sediment Quality

Data Selection

Sediment quality sampling has been conducted five times in the AEMP freshwater and marine habitats since 1996 (Figure 2.3-2). The most important criterion in the historical sediment quality selection process was that pre-2010 samples had to be collected from the same depth strata as the 2010 samples, since higher metal concentrations are often associated with higher silt content, and this in turn is affected by the depth of sampling (i.e., deeper samples tend to contain higher proportions of fine sediments). The selection of historical data was also based on the proximity of baseline sampling sites to the 2010 sites, the requirement that at least three replicates were collected to allow proper statistical analysis, and the similarity of sampling techniques. Data from 1996 and 1997 were excluded because they did not meet all of these criteria, since multiple sediment layers were collected in 1996 (0–1 cm and 1-3 cm horizons) and single un-replicated samples were collected in 1997. 2009 samples from Doris Lake North and Reference Lake B were not considered as they were from different depth strata than 2010 samples. 2009 data from Doris Lake South also was not suitable for effects comparisons as it was taken near a stream inflow where the sediments were dominated by sand, a substrate generally associated with low metal content. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix C.

Effects Analysis

The nine sediment quality parameters presented in Table 2.3-1 were evaluated in 2010 using graphical analysis, before-after comparisons, and BACI analysis. All evaluated sediment quality parameters were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2011a). Relevant CCME guidelines are included on effects analysis graphs, as well as in Appendix A.

Before-after comparisons were used for those sites that had historical data to determine if 2010 concentrations of sediment quality parameters differed from historical means. All analyses were completed using the Proc Mixed procedure in SAS 9.2. Because all selected *before* data was represented by a single year (Appendix C), the before-after model was the equivalent of a two-sample Student's t-test. The potential for false positives (Type I errors) due to the large number of tested parameters was reduced by lowering the level of significance to 0.01. Each waterbody was treated independently and each parameter was treated separately. If the results of the before-after analysis indicated that a parameter mean was not significantly different in 2010 compared to the historical mean, no further statistical analysis results are discussed, and it was concluded that there was no effect of construction activities on this parameter.

PROJECT #**1009-002-28** GIS # **HB-01-039** March 4, 2011

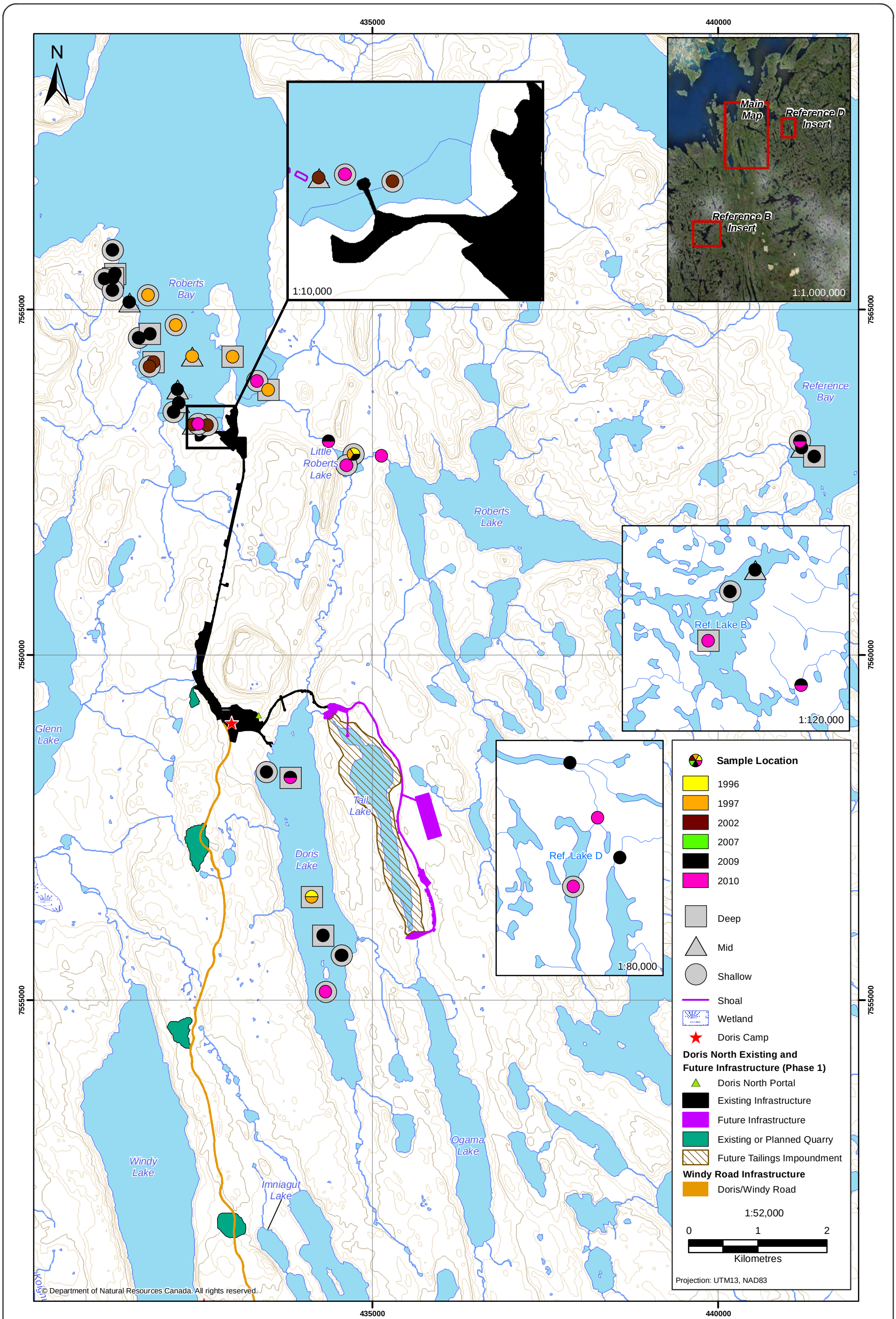

Figure 2.3-2

NEWMONT NORTH AMERICA

Historical Sediment Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2010

Figure 2.3-2

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If before-after comparisons were statistically different, a BACI analysis was performed where historical reference data existed (i.e., streams and marine sites) to determine if exposure sites were increasing relative to reference sites. To test this, a mixed-model ANOVA was run where *period* was the effect of before or after construction, *class* was the effect of a Project or reference waterbody, and the interaction of *period* and *class* revealed whether any change in the mean of the sediment quality parameter that occurred in an exposure site also occurred in the reference site. For lakes sites, there was no relevant historical sediment data for the reference lakes; therefore, only before-after comparisons (t-test) could be run for these waterbodies.

The key effect of interest in this BACI design is the interaction effect. If exposure site parameters increased over time relative to reference sites (i.e., a significant interaction effect), this may suggest that the Project is having an effect on the surrounding sediments (i.e., a non-parallel effect). However, the change over time at exposure sites could also be due to episodic events (e.g., the 1-in-100 peak flow year in 2010; Rescan 2011b) or slight differences in sampling locations (leading to differences in grain size composition). Thus, professional judgment was used to determine if a statistically significant interaction effect was likely attributable to Project activities. For the marine environment, the historical data used for before-after comparisons of exposure and reference sites were from different years (2002 data were used for the exposure site, RBW, and 2009 data were used for the reference site, REF-Marine). Therefore, caution must be exercised when interpreting comparisons between these sites. All other BACI comparisons were between 2009 and 2010.

Like water quality, highly censored parameters (i.e., > 70% of data below detection limit) were deemed unreliable and were not subjected to effects analysis. Censored data that was considered for analysis was substituted with one half the detection limit concentration. A complete description of the statistical effects analysis on the Project sediment quality is presented in Appendix C. This includes all assumptions, methodologies, and results.

2.3.2.4 Primary Producers

Historical primary producer biomass (phytoplankton and periphyton) sampling has been conducted in the Doris North Project area since 1996 (Figure 2.3-3). However, effects were only evaluated for phytoplankton since little historical periphyton data exist for the Doris North Project area. Historical periphyton data were collected in 1997 (in Doris and Little Roberts outflows) and 2009 (in Doris, Little Roberts, Reference Lake B) during August only, while data were collected over three separate months in 2010.

Data Selection

The main criteria for selection of relevant historical phytoplankton biomass data were the proximity of historical sampling sites to 2010 AEMP sampling sites, and that data for a given year be collected over three months in July, August, and September to account for open-water season variability in biomass levels. Phytoplankton biomass samples have been collected in the Doris North region since 1996, including three years of comparable historical data at the freshwater exposure AEMP sites, Doris Lake North and Little Roberts Lake (2003, 2007, and 2008). Biomass samples were collected at most AEMP lakes in 2009, but these data were not included in the effects analysis because samples were only collected during August. Under-ice samples were collected in April 2010 at the AEMP sites, but were not included in the 2010 evaluation to facilitate comparison with the pre-2010 data.

At the marine sites, historical phytoplankton biomass data has been collected in Roberts Bay since 2006; however, relevant pre-2010 data for the before-after comparisons only exist for RBE in 2007 and 2008. Data from these years were collected near the present 2010 RBE location, and were collected in July, August, and September. Although chlorophyll a samples were collected in April (under-ice) from

the AEMP marine sites in 2010, these data were not used in the analysis to facilitate comparisons with 2007 and 2008 data. There are no pre-2010 data that were collected in July, August, and September near the other two AEMP marine sites, RBW and REF-Marine

Effects Analysis

A graphical analysis combined with professional judgment was employed for the evaluation of effects on phytoplankton biomass levels. A before-after comparative approach was taken for the exposure sites, Doris Lake North, Little Roberts, and RBE, but a BACI analysis could not be employed since no historical data was available for any reference site.

2.3.2.5 Benthos

Benthic invertebrates were not evaluated for effects because of the different sampling methodologies used during the first year of AEMP/EEM sampling compared to previous sampling efforts. Prior to 2010, historical benthos sampling consisted of collecting one to five replicates per site with no composite sampling. In 2010, this technique was changed to accommodate the EEM methodologies as required under the Type A Water Licence for the Doris North Project. The 2010 sampling procedure required the pooling of three subsamples per replicate, and the collection of five total replicates to reduce sampling variability. Because this affects sample variability, as well as various diversity components (e.g., richness and evenness), several diversity and community composition measures were not comparable between the before and after construction period. Effects evaluations for benthos will become possible after 2011 sampling, as 2011 sampling techniques will be comparable to those employed in 2010.

PROJECT #**1009-002-28** GIS # **HB-01-040** March 4, 2011

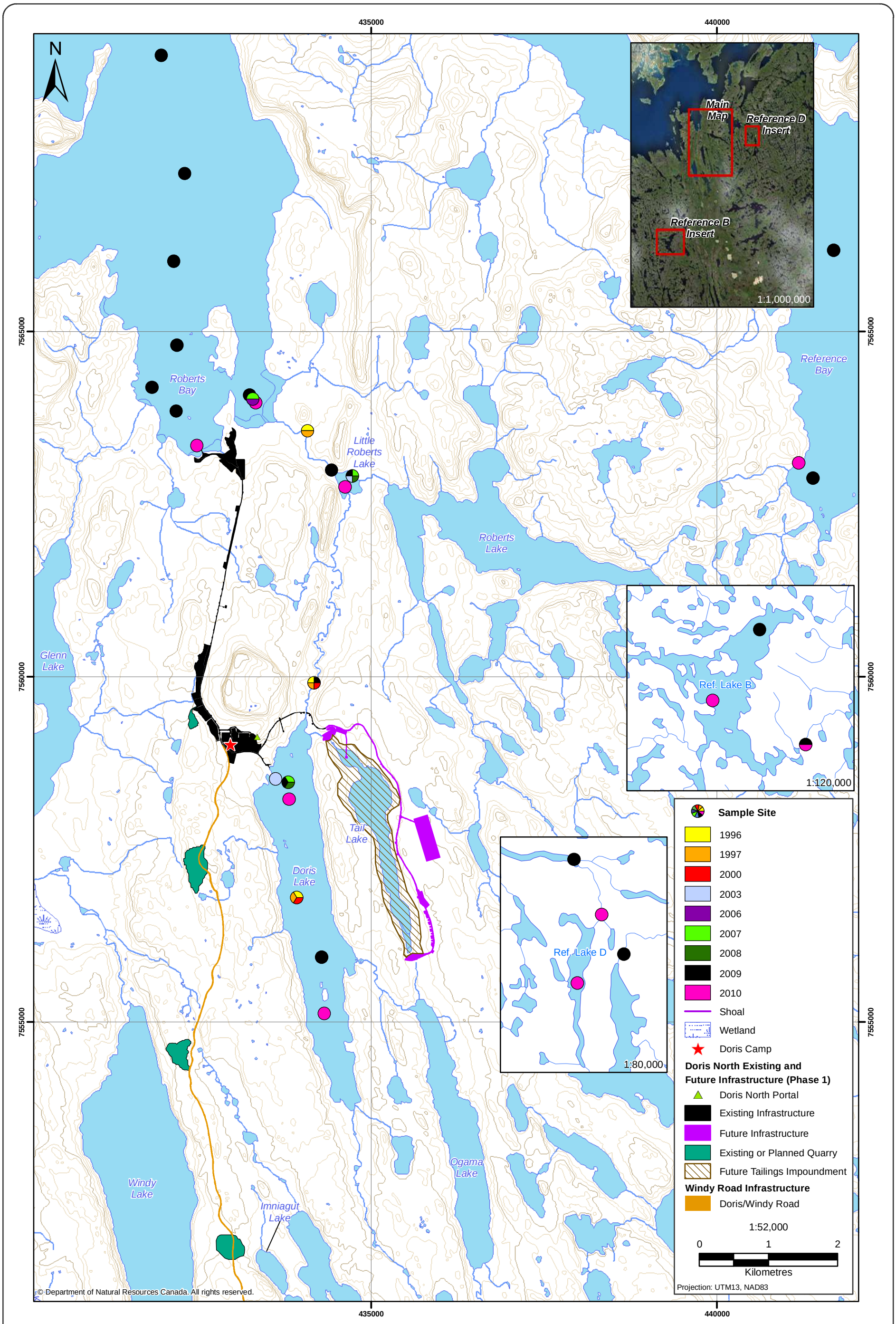

Figure 2.3-3

NEWMONT NORTH AMERICA

Historical Phytoplankton and Periphyton Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2010

Figure 2.3-3

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3. Evaluation of Effects

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3. Evaluation of Effects

3.1 UNDER-ICE DISSOLVED OXYGEN

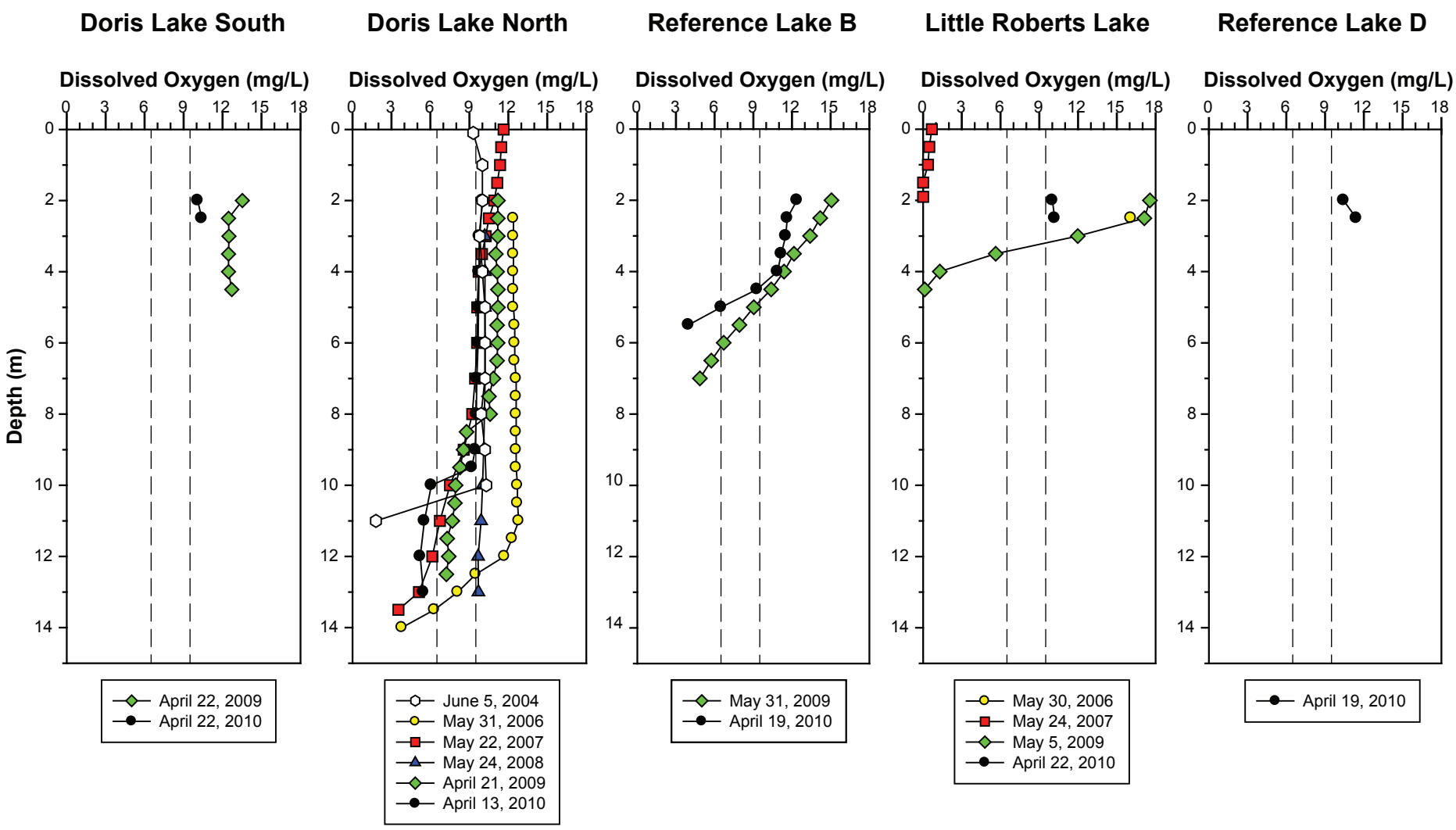
Potential effects on lake and ocean dissolved oxygen concentrations were evaluated using under-ice dissolved oxygen concentrations, since concentrations are lowest during this period and pose the greatest concern for aquatic life. Minimum oxygen levels are required for critical life stages of fish and other freshwater and marine organisms (CCME 2011b). Ice cover usually forms in October and November, and under-ice oxygen profiles were collected in April 2010. The formation of the ice cover in November 2009 isolated lakes, streams, and Roberts Bay from any atmospheric sources of Project activities (e.g., dust) between November 2009 and June/July 2010. The water-column that was profiled in April 2010 therefore reflects activities from 2009 rather than 2010.

Figures 3.1-1 and 3.1-2 present the historical under-ice dissolved oxygen profiles for the lake and marine AEMP sites. Historical under-ice profiles were collected between April and June.

3.1.1 Lakes

There was limited historical winter dissolved oxygen data available for most lake sites, with the exception of Doris Lake North. At this site, profiles were largely consistent from 2004 to 2010, with uniform concentrations in the upper waters and decreasing concentrations below 10 m. Decreasing concentrations were also observed in the deeper waters of Reference Lake B. This dissolved oxygen decrease at depth is a common phenomenon in seasonally stratified lakes. The upper layer dissolved oxygen concentrations were usually near the upper CCME guideline for cold-water, non-early life stages (9.5 mg/L), and approached the guideline for cold-water, early life stages (6.5 mg/L) in the bottom waters. The 2010 profile fell within historical ranges. Although there is only one year of historical data available for Doris Lake South, no definitive changes were apparent at this site, and all concentrations were above the CCME guideline for cold-water, non-early life stages (9.5 mg/L). Winter dissolved concentrations would not be expected to decline unless there was nutrient input to the lake. There were no known sources of nutrient input to Doris Lake in 2009 or 2010. April 2010 dissolved oxygen concentrations were within the expected range of natural variability; hence, no adverse changes were detected.

Winter dissolved oxygen concentrations varied widely in the shallow exposure site, Little Roberts Lake, between 2006 and 2010. The 2010 concentrations (range: 10.0-10.2 mg/L) were higher than the upper CCME guideline limit. Winter 2010 values were within the wide range of historical measurements (May 2007: <1 mg/L, May 2009: 17.6 mg/L). Ice-covered shallow lakes are prone to widely fluctuating oxygen concentrations, particularly late in the ice-covered season, because of increases in epontic and benthic photosynthesis, and the respiratory consumption of organic material in the sediments. April 2010 dissolved oxygen concentrations in Little Roberts Lake were above the most protective CCME guideline and were within the expected range of natural variability; therefore, no adverse changes were detected.



Note: Vertical dashed lines represent CCME 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.
Little Roberts Lake on June 6, 2004 was ice to the bottom.

Figure 3.1-1

NEWMONT NORTH AMERICA

Winter Dissolved Oxygen Concentrations at AEMP Lake Sites, Doris North Project, 2004-2010

Figure 3.1-1

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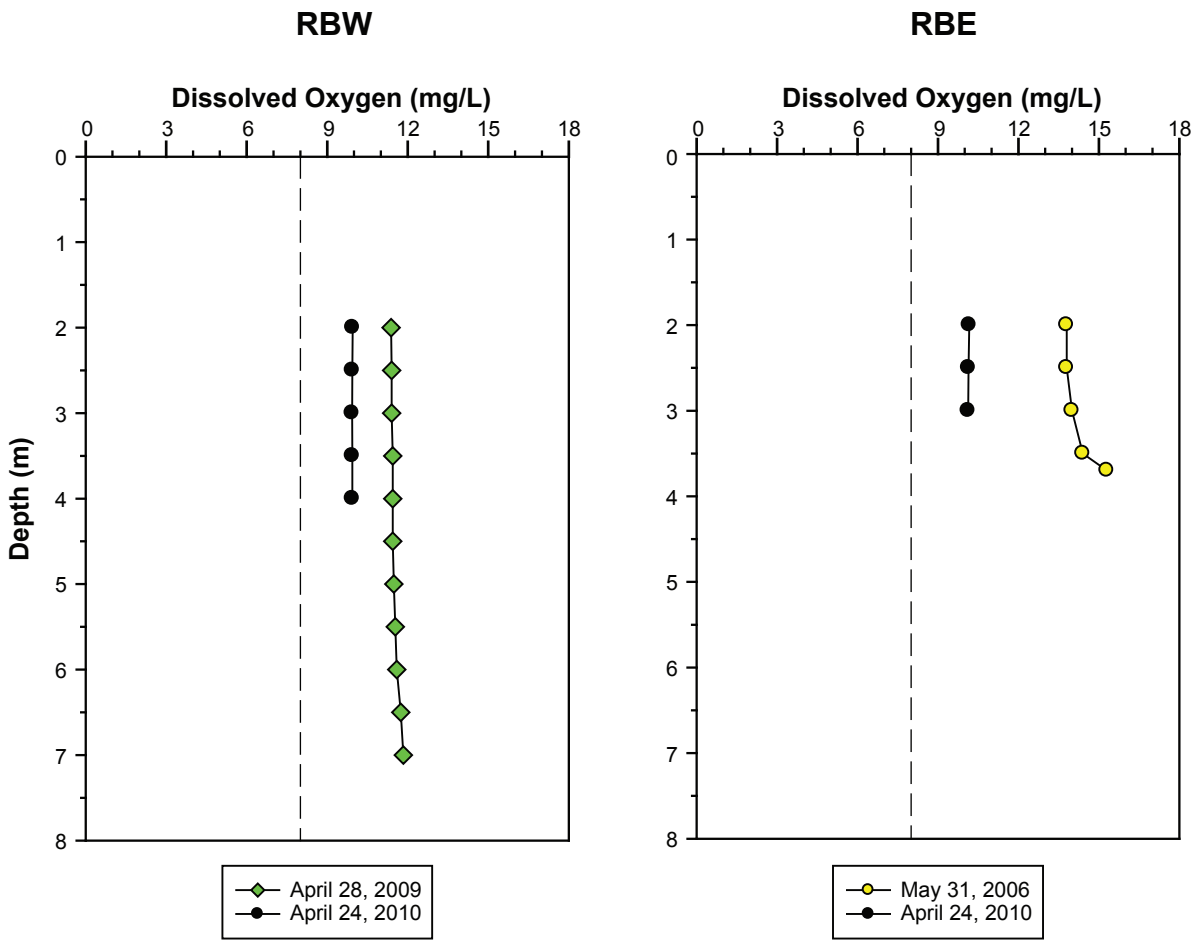

Note: The dashed line shows the recommended minimum concentration of dissolved oxygen in estuarine waters (8.0 mg/L). No 2010 winter dissolved oxygen profiles were collected at REF-Marine due to safety concerns.

Figure 3.1-2

NEWMONT NORTH AMERICA

Winter Dissolved Oxygen Concentrations at AEMP Marine Sites, Doris North Project, 2006-2010

Figure 3.1-2

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3.1.2 Marine

In the marine sites, 2010 dissolved oxygen concentrations were near 10 mg/L. These levels were slightly lower than concentrations recorded in 2006 and 2009, but were higher than the CCME recommended level of 8 mg/L for marine and estuarine systems. There is little reason to suspect that the lower 2010 concentrations were due to the limited Project activity that occurred in 2009. The 2006 profile at RBE was taken in late May, a month later than in 2010. The photoperiod is longer in May than in April, and under-ice photosynthesis is typically higher; therefore, the rate of oxygen evolution is likely higher in May than in April. At RBW, 2009 and 2010 oxygen levels varied by less than 2 mg/L. This is well within the expected annual variation (see Doris Lake North; Figure 3.1-2). As well, instrument variation can result in differences of 1 to 2 mg/L. The marine reference site was not sampled in April 2010 due to safety concerns (helicopter could not safely land on the ice because of melting ice near the shore). Future monitoring will hopefully include the reference site. For April 2010, it is concluded that dissolved oxygen concentrations in Roberts Bay were higher than CCME guidelines and did not pose a concern for resident marine life.

3.2 WATER QUALITY

A specific set of water quality parameters (see Table 2.3-1) was evaluated in order to determine whether 2010 Project activities resulted in adverse changes to water quality. Historical data collected from 1995 to 2009 were included in the effects analysis. For each site, historical data were only included if sampling sites corresponded closely with the locations of sampling sites in 2010.

Graphical analyses, before-after comparisons, and BACI analyses (where possible) were all used to determine if there were changes in water quality parameters in the Doris North Project area. For all graphical and statistical analyses, replicate samples collected on the same date and from the same depth were averaged prior to analysis. In addition, half the detection limit was substituted for water quality parameters that were below analytical detection limits. The complete results of all statistical methods and analyses are provided in Appendix C.

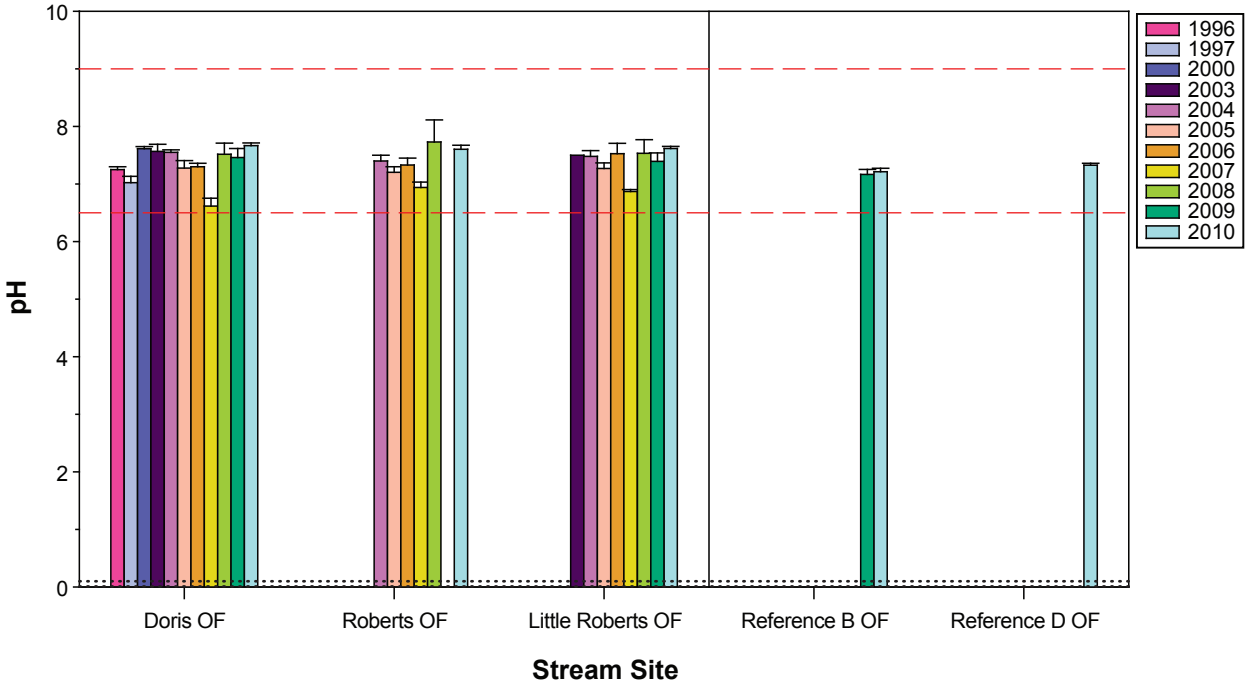
Water quality parameters were compared to CCME water quality guidelines for the protection of aquatic life (CCME 2011b) in order to determine whether concentrations posed a concern for freshwater and marine aquatic life. Site-specific baseline conditions were considered in addition to CCME guidelines to determine whether any detected changes would result in a potential adverse effect to freshwater and marine life.

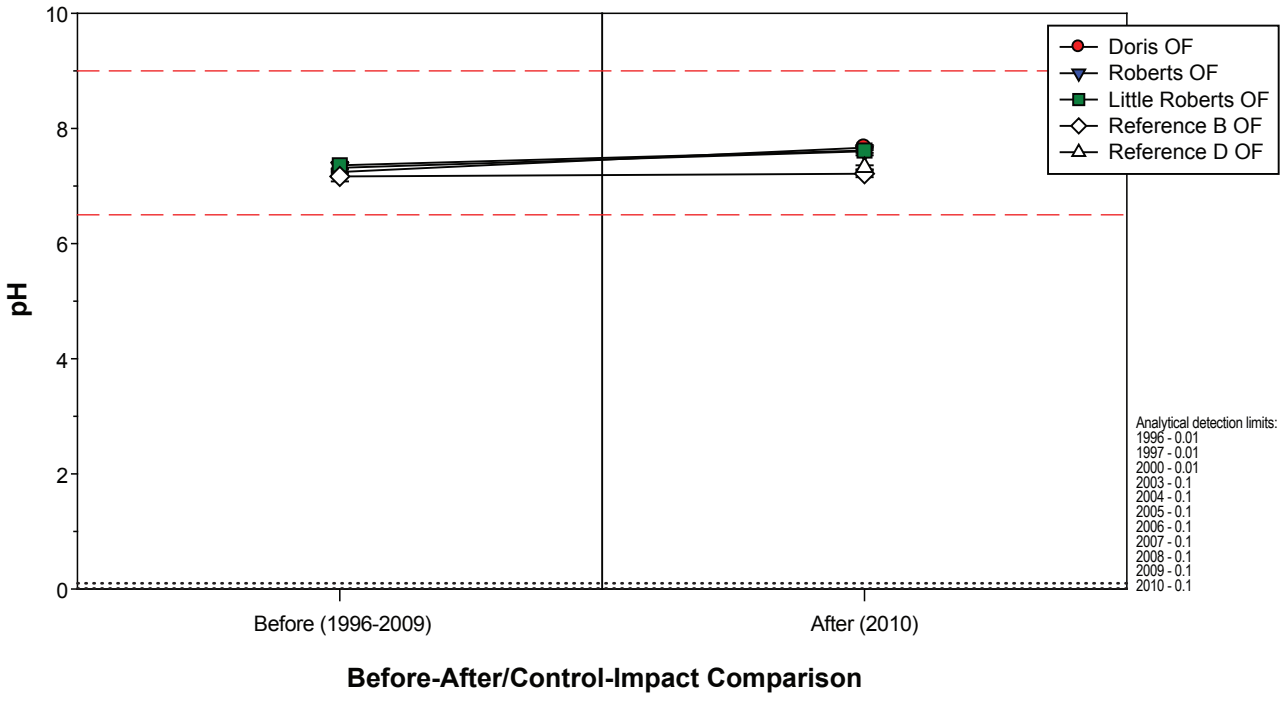
3.2.1 Streams

Water quality samples from streams were collected from three exposure streams (Doris Outflow, Roberts Outflow, and Little Roberts Outflow) and two reference streams (Reference B Outflow and Reference D Outflow) in 2010. For the exposure streams, relevant historical data were available from 1996, 1997, 2000, and 2003 to 2009 (though all streams were not sampled each year). For Reference B Outflow, the only available historical data were from 2009, and no historical data are available for Reference D Outflow. The graphical effects analyses for stream water quality are shown in Figures 3.2-1 to 3.2-18. All statistical results are presented in Appendix C.

3.2.1.1 pH

pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. Mean 2010 stream pH was slightly higher in exposure streams (ranging from 7.6 to 7.7) than reference streams (7.2 to 7.3). However, exposure stream pH levels measured in 2010 were within the range of historical levels measured within each exposure stream (Figure 3.2-1). The before-after comparison confirms that the historical mean pH was not distinguishable from the 2010 mean pH in any exposure stream ($p = 0.32$ for Doris Outflow, $p = 0.31$ for Roberts Outflow, and $p = 0.21$ for Little Roberts Outflow). There was therefore no apparent effect of 2010 Project activities on the pH of streams.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.

NEWMONT NORTH AMERICA

pH in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-1

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Mean 2010 pH levels in exposure and reference streams were always within the recommended CCME guideline range of 6.5 to 9.0 (Figure 3.2-1).

3.2.1.2 Total Alkalinity

Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Total alkalinity (as $CaCO_3$) varied among streams, but was remarkably consistent within each stream over time (Figure 3.2-2). Total alkalinity levels in exposure streams in 2010 were within historical ranges. The before-after comparison confirms that the mean historical alkalinity was not statistically different from the mean 2010 alkalinity in any exposure stream ($p = 0.33$ for Doris Outflow, $p = 0.86$ for Roberts Outflow, and $p = 0.090$ for Little Roberts Outflow); therefore, there was no detectable effect of 2010 Project activities on stream alkalinity.

3.2.1.3 Hardness

Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Similar to total alkalinity, hardness (as $CaCO_3$) varied among streams, but was relatively consistent within each stream over time (Figure 3.2-3). 2010 hardness levels in exposure streams were within historical ranges, and the before-after comparison confirms that 2010 means were not distinguishable from historical means ($p = 1.0$ for Doris Outflow, $p = 0.47$ for Roberts Outflow, and $p = 0.86$ for Little Roberts Outflow). There was no apparent effect of 2010 Project activities on stream hardness.

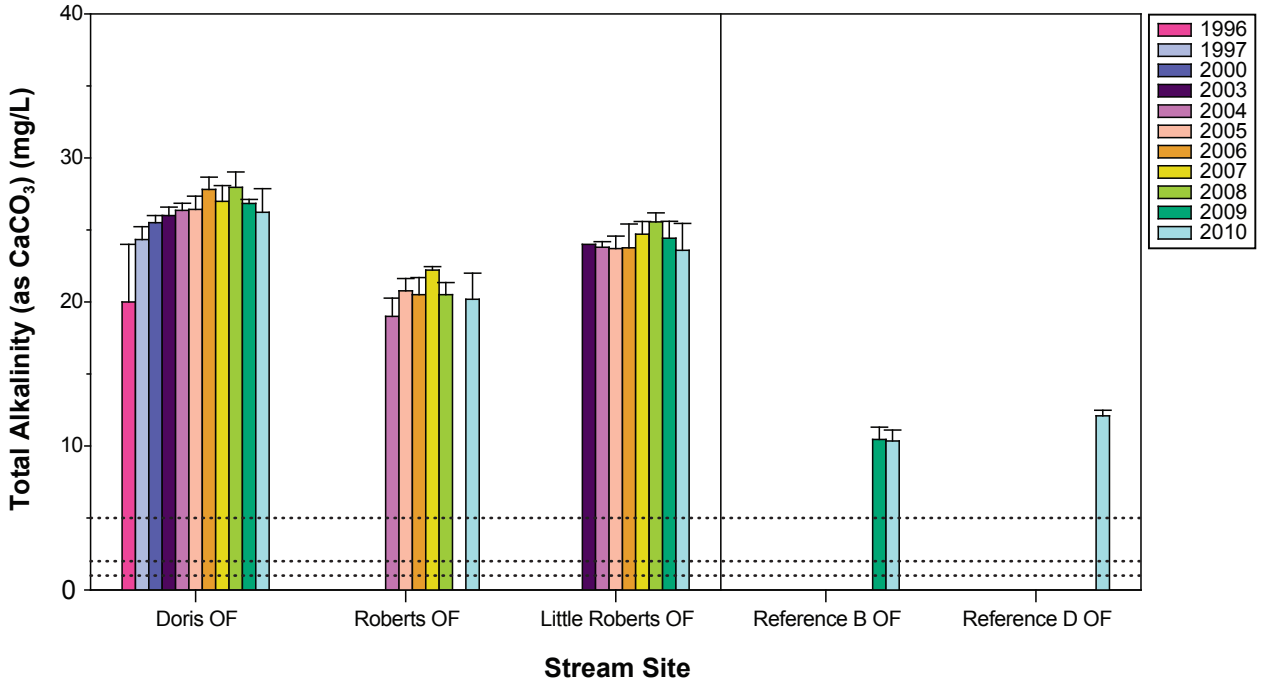
3.2.1.4 Total Suspended Solids

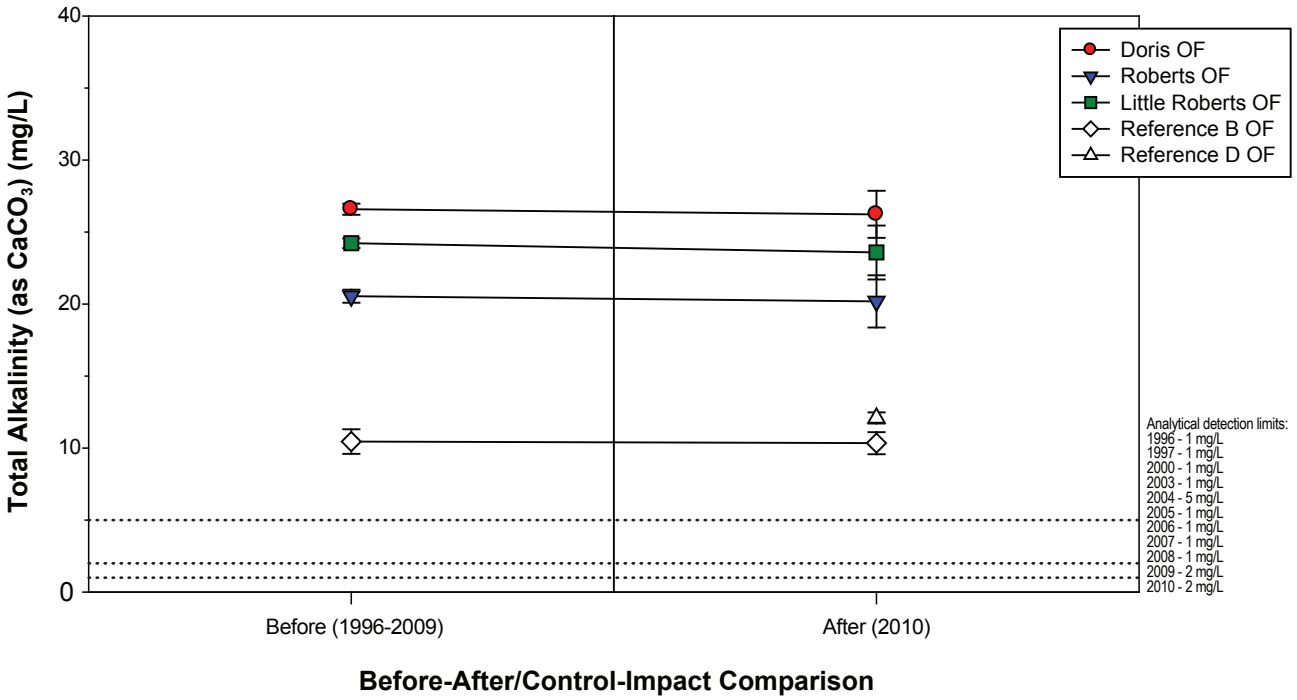
Total suspended solids (TSS) are regulated as deleterious substances in effluents as per Schedule 4 of the MMER. Mean TSS concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual and within-year variability (Figure 3.2-4). It is therefore difficult to distinguish natural variability from potential effects resulting from Project activities.

The mean 2010 TSS concentration in Little Roberts Outflow was within range of historical means, so there was no evidence of an increase in TSS at this site due to 2010 activities (Figure 3.2-4). This is supported by the before-after analysis, which reveals that the mean 2010 TSS level was not distinguishable from the historical mean for Little Roberts Outflow ($p = 0.57$).

The before-after plot shows that mean TSS concentrations increased in 2010 in both Doris and Roberts outflows (Figure 3.2-4). 2010 was a hydrologically “wet” year, and peak flows in both Doris and Roberts outflows were associated with a 1-in-100 year recurrence interval (i.e., peak flow rates as high as those seen in 2010 would only be expected to occur once every 100 years) (Rescan 2011b). High stream flows could increase the amount of sediment re-suspension and consequently the TSS concentration in streams. This suggests that higher TSS levels in 2010 may have resulted from natural factors. Nevertheless, the before-after statistical analysis indicates that these increases were not statistically significant compared to the historical means ($p = 0.17$ for Doris Outflow and $p = 0.087$ for Roberts Outflow). It is therefore concluded that 2010 TSS levels reflected natural variability and were likely not influenced by Project activities.

The CCME guideline for TSS is dependent upon background levels (for clear-flow waters with background TSS levels below 25 mg/L, a maximum increase of 25 mg/L is allowable for any short-term exposure or 5 mg/L for longer term exposure; CCME 2011b). Because there was no increase in TSS concentrations from background levels, 2010 TSS concentrations in exposure streams were below the CCME guideline.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Total Alkalinity in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-2

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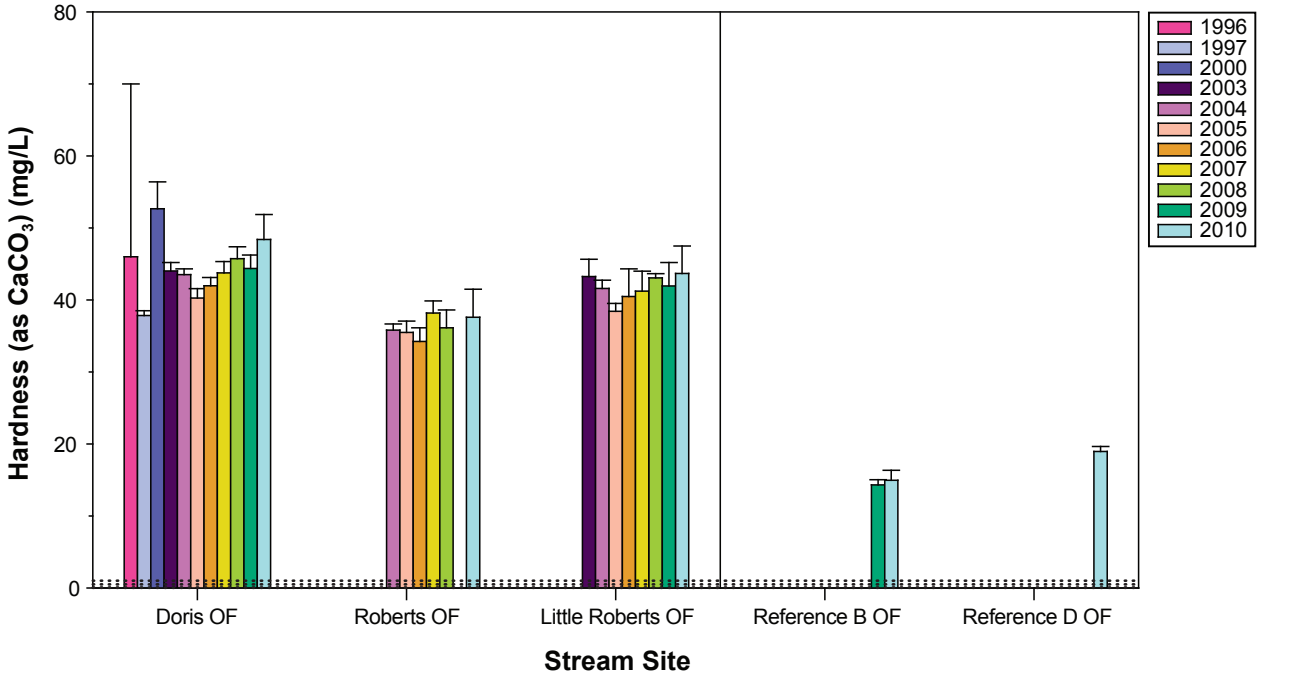

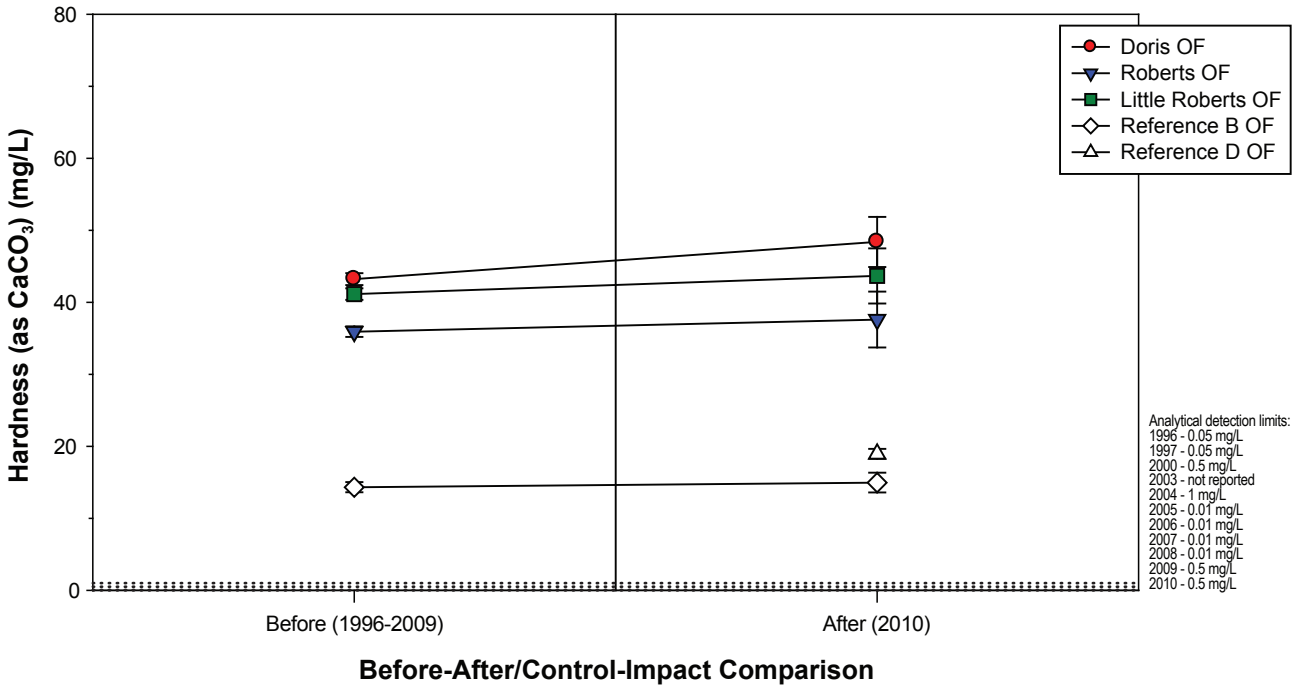

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

NEWMONT NORTH AMERICA

Hardness in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-3

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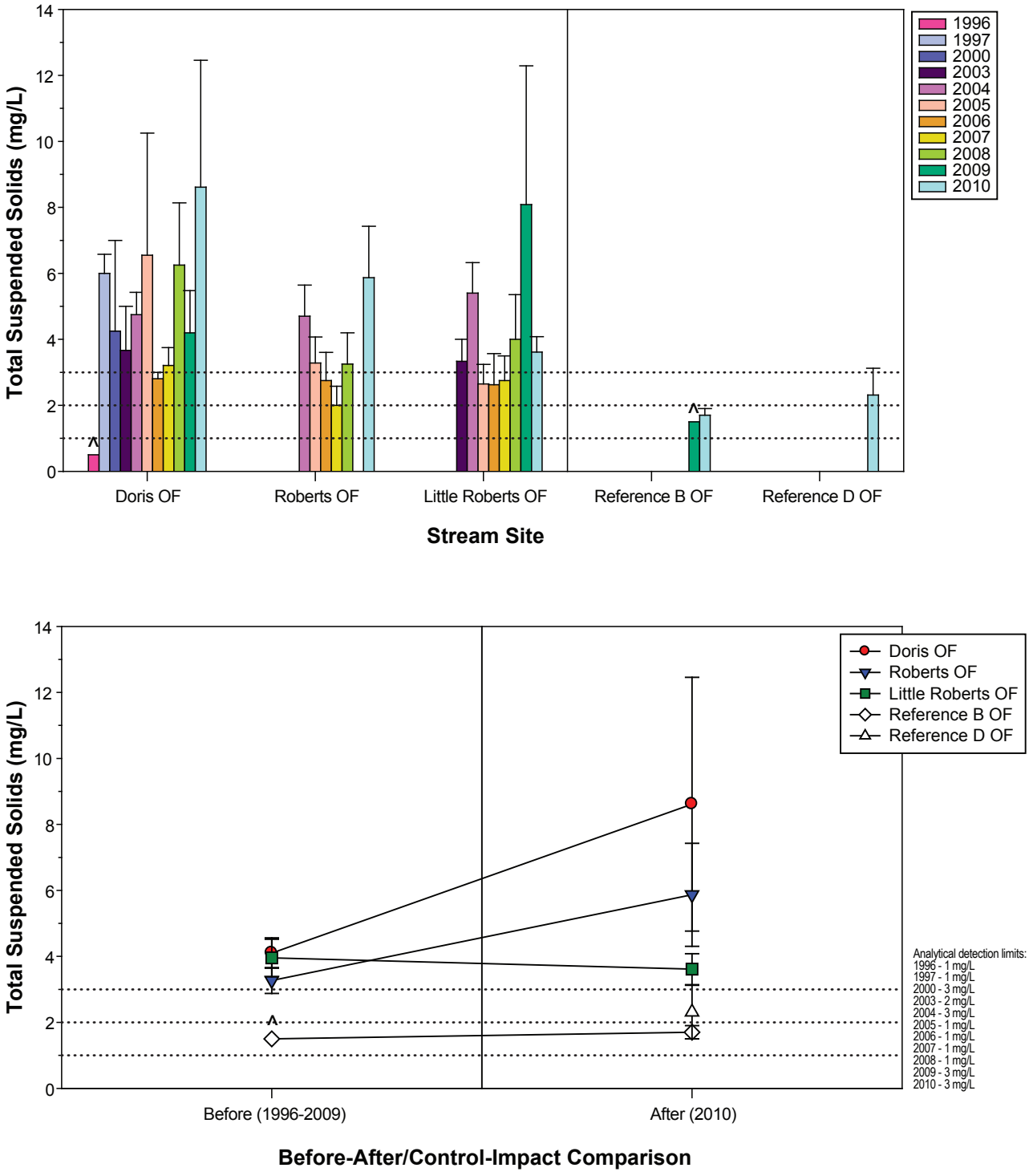

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME guideline for total suspended solids is dependent upon background levels.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Suspended Solids in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-4

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3.2.1.5 Total Ammonia

Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Concentrations of total ammonia were highly variable within each stream over time. Mean 2010 concentrations of total ammonia in exposure and reference streams were always well below the pH- and temperature-dependent CCME guideline (Figure 3.2-5).

In each exposure stream, mean 2010 total ammonia concentrations were within the range of historical means (Figure 3.2-5), suggesting that there was no effect of Project activities on ammonia concentrations. The before-after analysis confirms that there was no difference between 2010 and historical means in any exposure stream ($p = 0.081$ for Doris Outflow, $p = 0.96$ for Roberts Outflow, and $p = 0.38$ for Little Roberts Outflow).

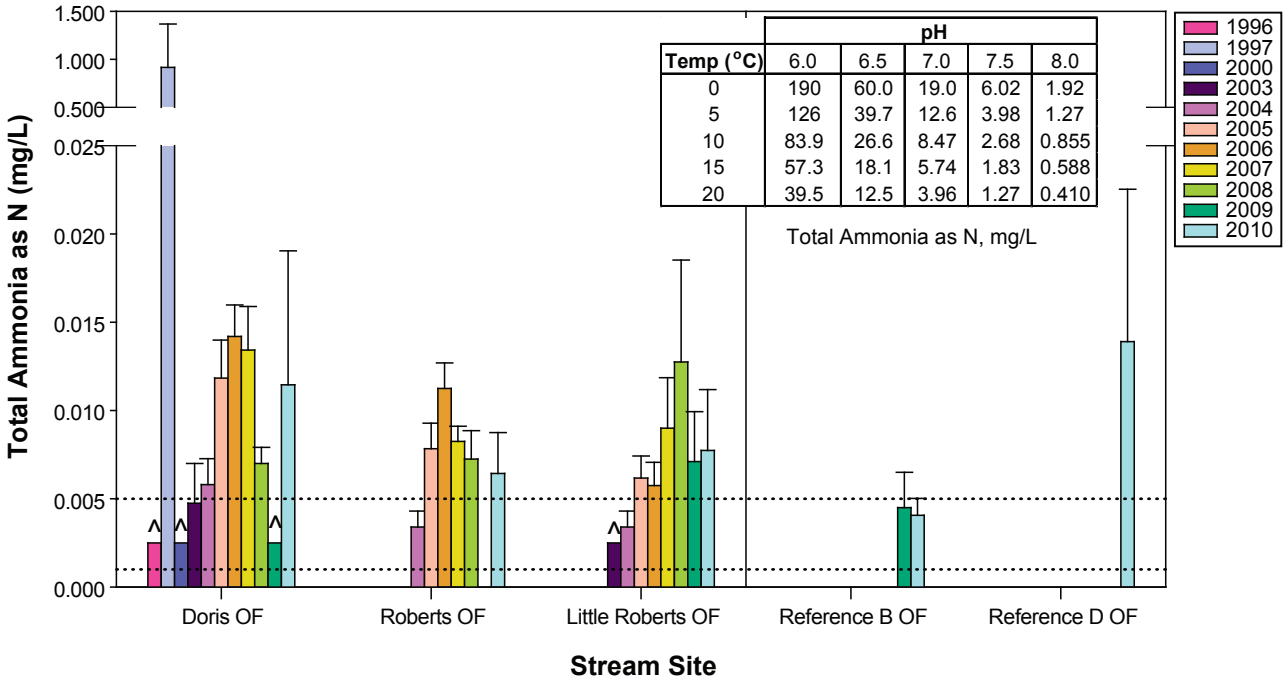
3.2.1.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All nitrate concentrations measured in exposure streams during 2010 were below the analytical detection limit of 0.005 mg nitrate-N/L, and well below the interim CCME guideline of 2.935 mg nitrate-N/L (Figure 3.2-6). Historical measurements of nitrate were typically below detection limits, except for a few sporadically elevated readings (Figure 3.2-6). Detection limits in 2010 were generally comparable to detection limits achieved between 1996 and 2009. Therefore, there was no evidence of an increase in nitrate in exposure streams in 2010. Results from 2010 indicate that on-site management of surface waters and quarry rock were successful in keeping ammonium nitrate salt and residues out of surface waters.

3.2.1.7 Total Cyanide

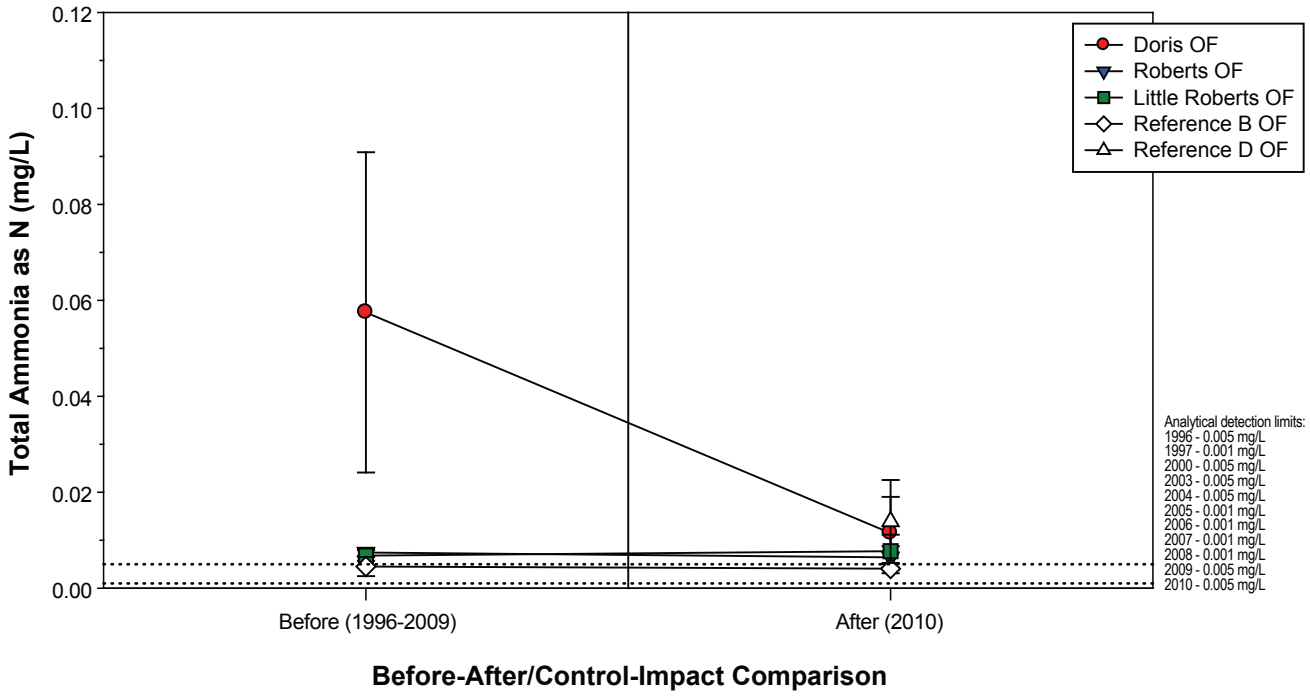
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2010 cyanide concentrations in all exposure (0.0043 mg/L in Doris and Little Roberts outflows and 0.0039 mg/L in Roberts Outflow) and reference streams (0.0028 mg/L in Reference B Outflow and 0.0033 mg/L in Reference D Outflow) were higher than historical annual means in exposure streams, which generally did not exceed 0.001 mg/L (with one exception: the total cyanide concentration was 0.005 mg/L in a single sample collected at Doris Outflow in 1996; Figure 3.2-7). At all sites, 2010 total cyanide concentrations were highest in June (Appendix A). Average June 2010 concentrations of total cyanide in the exposure streams (but not the reference streams) were slightly higher than the CCME guideline; however, the CCME guideline of 0.005 mg/L as free cyanide (cyanide existing in the form of HCN and CN^-) is not directly comparable to total cyanide, which includes all forms of cyanide (free cyanides, metallocyanides, organocyanides, etc. (Singleton 1986)). Mean 2010 concentrations of total cyanide in the exposure streams did not exceed this guideline, nor did mean 2010 concentrations in the reference streams.

The before-after comparison shows that total cyanide concentrations in all three exposure streams were higher in 2010 compared to historical concentrations ($p < 0.001$ for all three streams). Based on the criteria set out in the effects analysis methodology for water quality, statistical analysis would not be recommended for Doris Outflow cyanide concentrations because 75% of data are below detection limits. However, statistical results are presented for this site because all 2010 data were above detection limits, and even if the historical values that are below detection are substituted with the highest possible concentrations (i.e., the value of the detection limit), differences between historical and 2010 means are still significantly different ($p < 0.001$).



Temp (°C)	pH 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

Total Ammonia as N, mg/L



Notes: Y-axis scales differ between graphs.
Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Inset table shows the pH- and temperature-dependent CCME guideline for total ammonia.
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Ammonia Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-5

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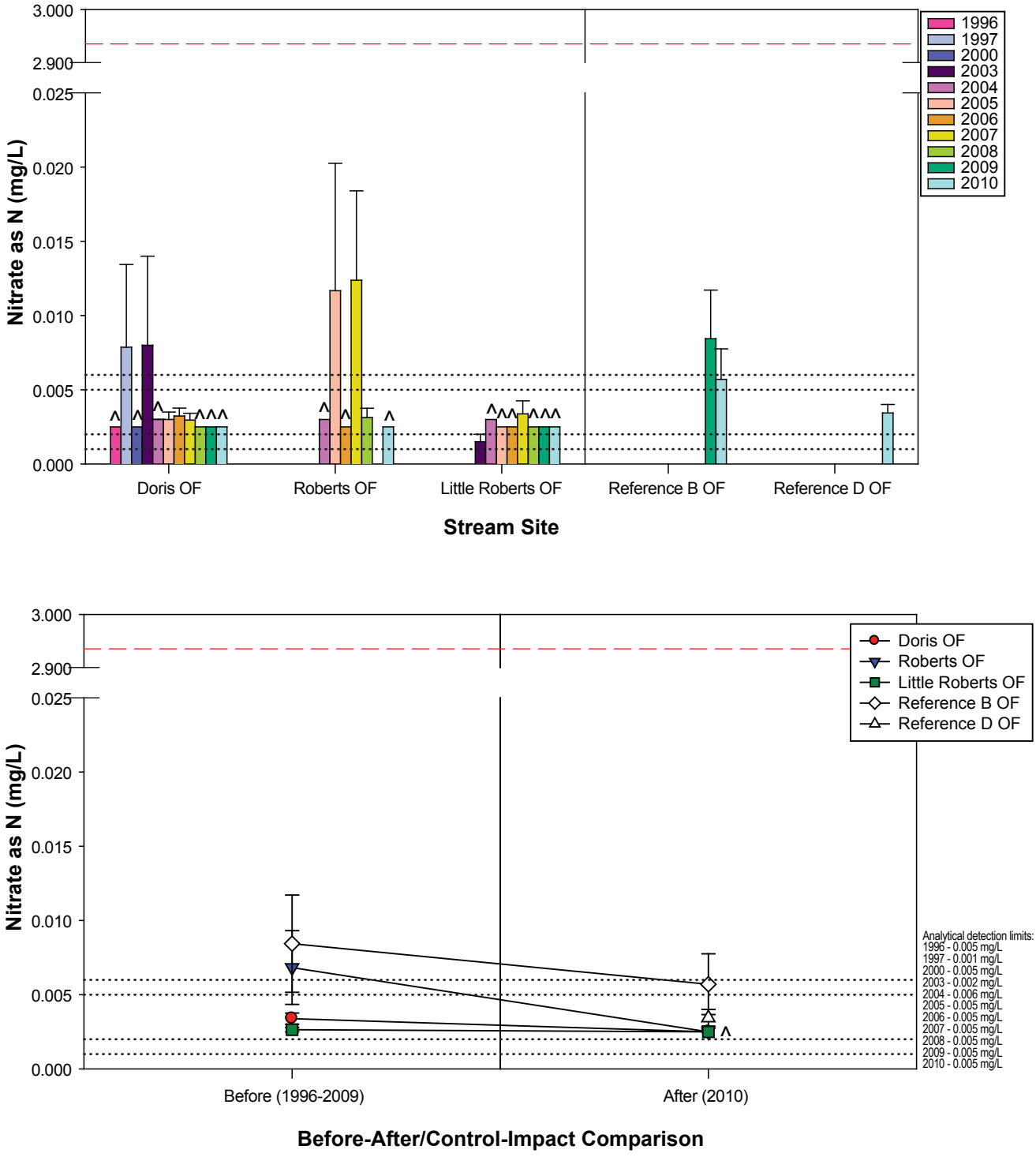

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME guideline for nitrate as N (2.935 mg/L).
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Nitrate Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-6

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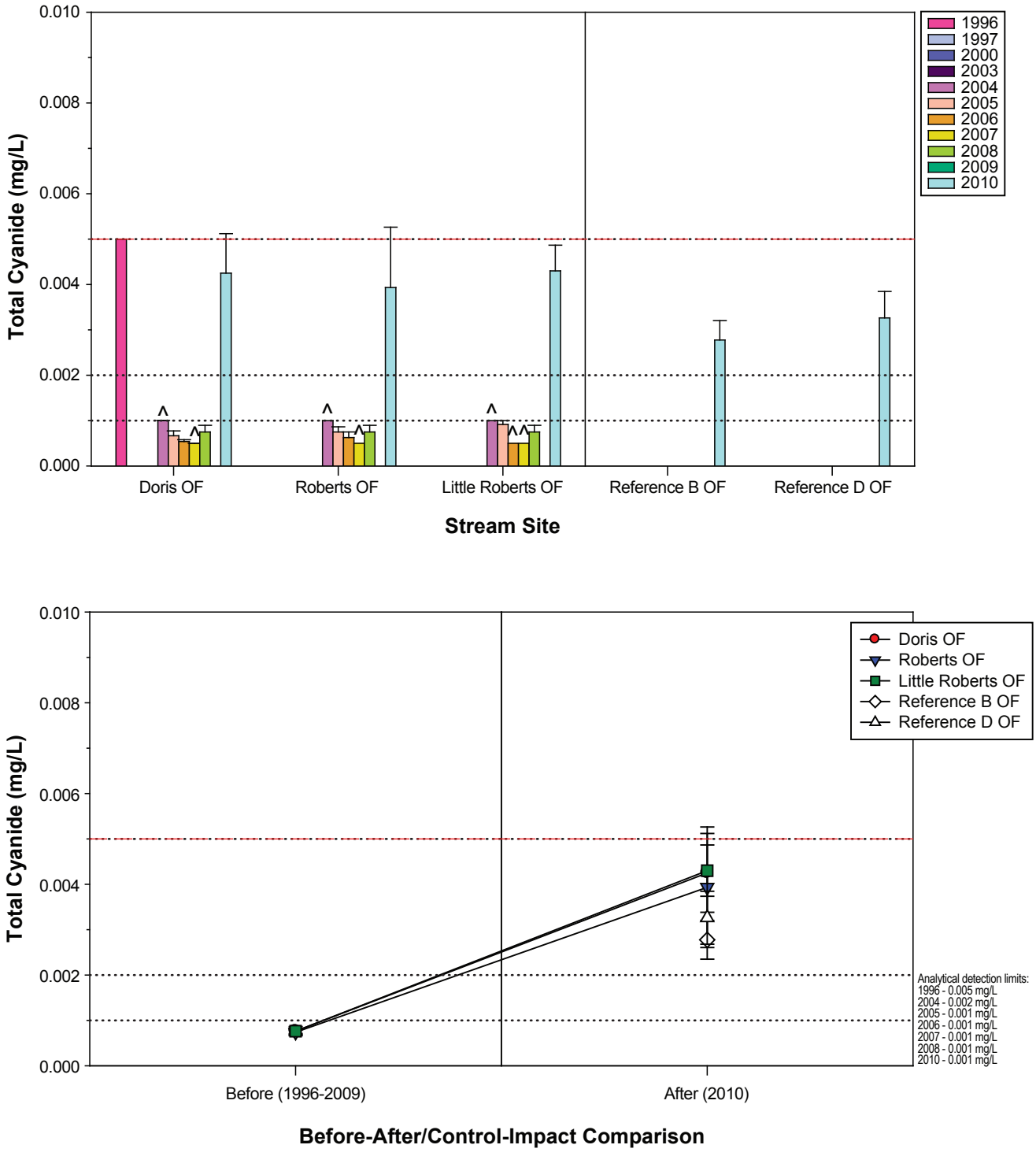

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for cyanide (0.005 mg/L as free cyanide).
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Cyanide Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-7

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Because there is no historical cyanide data for the reference streams, a BACI analysis cannot be performed to determine whether this increase in cyanide is a natural phenomenon that also occurred in reference streams outside of the Project area. The mean cyanide concentrations in reference streams in 2010 were relatively similar to the concentrations in the exposure streams in 2010, and higher than historical concentrations in exposure streams (Figure 3.2-7), suggesting that this 2010 increase in cyanide is an analytical anomaly, a result of inadvertent contamination, or a natural phenomenon that also occurred in streams outside of the Project area. Cyanide is naturally produced by a wide variety of plants and microorganisms (Knowles 1979; Singleton 1986). It is highly unlikely that there was an anthropogenic cause for this increase in cyanide, as cyanide was not brought to the Project site in 2010. The possibility that elevated cyanide concentrations measured in reference and exposure streams were due to an analytical error or contamination is unlikely, because concentrations of cyanide in all equipment, travel, and field blanks analyzed as part of the 2010 sampling program were below the detection limit of 0.001 mg/L (Appendix A). Therefore, the increase in cyanide observed in reference and exposure sites in 2010 likely resulted from a natural process. Cyanide concentrations will continue to be closely monitored in both reference and exposure streams in the future.

3.2.1.8 Radium-226

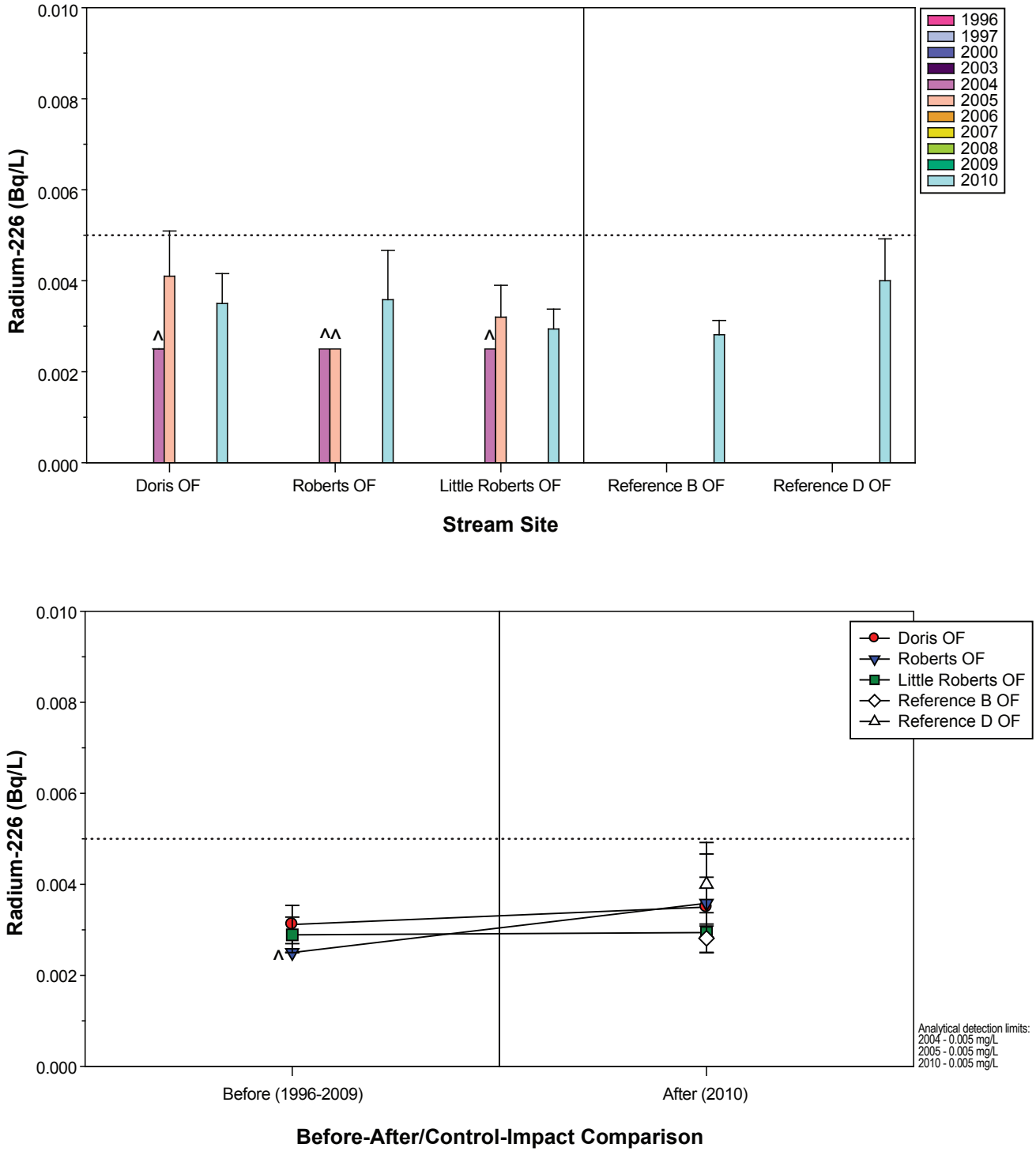
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In both exposure and reference streams, more than 80% of radium-226 concentrations measured during 2010 were below the analytical detection limit of 0.005 mg/L, and the remaining concentrations were barely above this detection limit (Figure 3.2-8). Historical concentrations were similarly near or below the detection limit of 0.005 mg/L. Therefore, 2010 activities were concluded to have no effect on radium-226 concentrations. Statistical analysis is not recommended for total radium, because > 70% of historical and 2010 concentrations were below analytical detection limits.

3.2.1.9 Total Aluminum

Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total aluminum concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual and seasonal variability. At all streams sites except Reference B Outflow, mean 2010 concentrations of total aluminum were higher than the pH-dependent CCME guideline of 0.1 mg/L. However, the historical data show that this guideline was frequently exceeded in all exposure streams, particularly in Roberts and Little Roberts outflows where nearly all historical mean concentrations exceeded this CCME guideline (Figure 3.2-9).

The before-after plot shows that mean 2010 total aluminum concentrations in all streams were higher than historical means (Figure 3.2-9). However, there was a large overlap between total aluminum concentrations measured in 2010 and concentrations measured in previous years (e.g., Doris Outflow in 2005, Roberts Outflow in 2005 and 2008, and Little Roberts Outflow in 2008 and 2009; Figure 3.2-9).

The before-after statistical analysis indicates that the mean total aluminum concentration increased in Doris Outflow in 2010 compared to the historical mean ($p = 0.006$), while total aluminum levels in Roberts and Little Roberts outflows were similar before and after the start of 2010 Project activities ($p = 0.25$ for Roberts Outflow, $p = 0.46$ for Little Roberts Outflow).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Radium-226 Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-8

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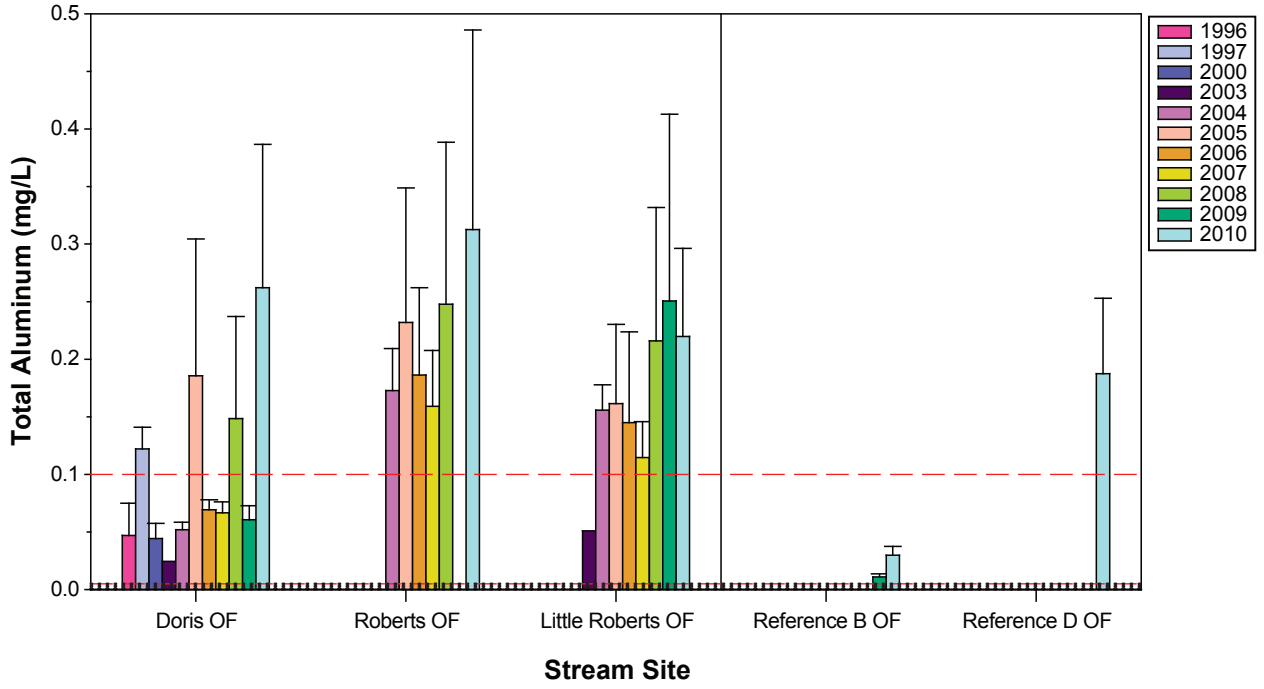

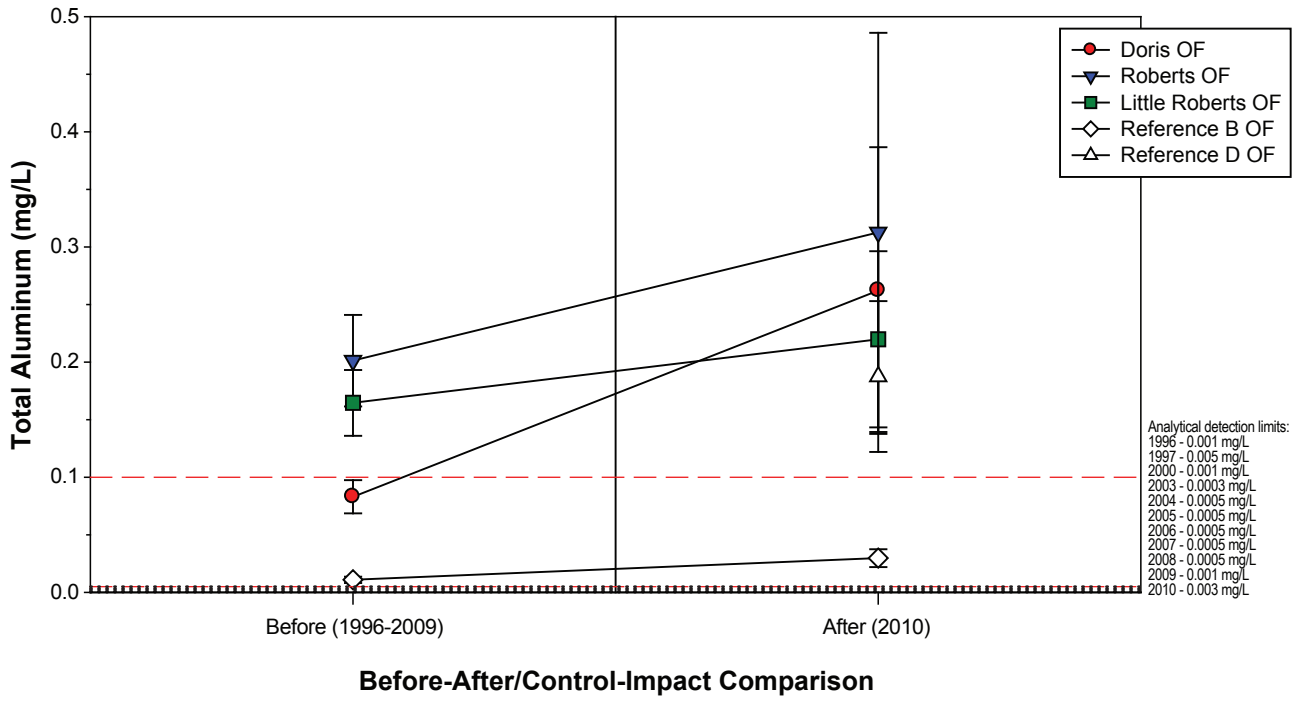

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5).
Mean annual pH levels in all exposure and reference streams were ≥ 6.5.
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Aluminum Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-9

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A BACI analysis was performed for total aluminum concentrations in Doris Outflow to determine whether a parallel increase occurred in the reference stream. The result of this analysis shows that the before-after change seen for Doris Outflow was not distinguishable from the before-after change that occurred in the reference stream ($p = 0.26$). This indicates that the increase in total aluminum in Doris Outflow in 2010 was a natural phenomenon, and was not related to Project activities. Peak stream flows were particularly high in 2010 compared to previous years (Rescan 2011b), and high stream flows could result in the re-suspension of sediments and metals typically associated with sediment, such as aluminum (e.g., Milburn and Prowse 1996).

3.2.1.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010, mean concentrations of total arsenic were similar among exposure streams, but were generally higher in exposure than in reference streams (Figure 3.2-10). Mean total arsenic concentrations in all stream samples were more than an order of magnitude lower than the CCME guideline of 0.005 mg/L. Historical arsenic concentrations in exposure streams were generally similar to or slightly higher than 2010 concentrations (Figure 3.2-10), indicating that there was no Project-related increase in arsenic concentrations. The before-after comparison confirms that there was no change in arsenic concentrations in streams in 2010 ($p = 0.39$ for Doris Outflow, $p = 0.092$ for Roberts Outflow, and $p = 0.28$ for Little Roberts Outflow).

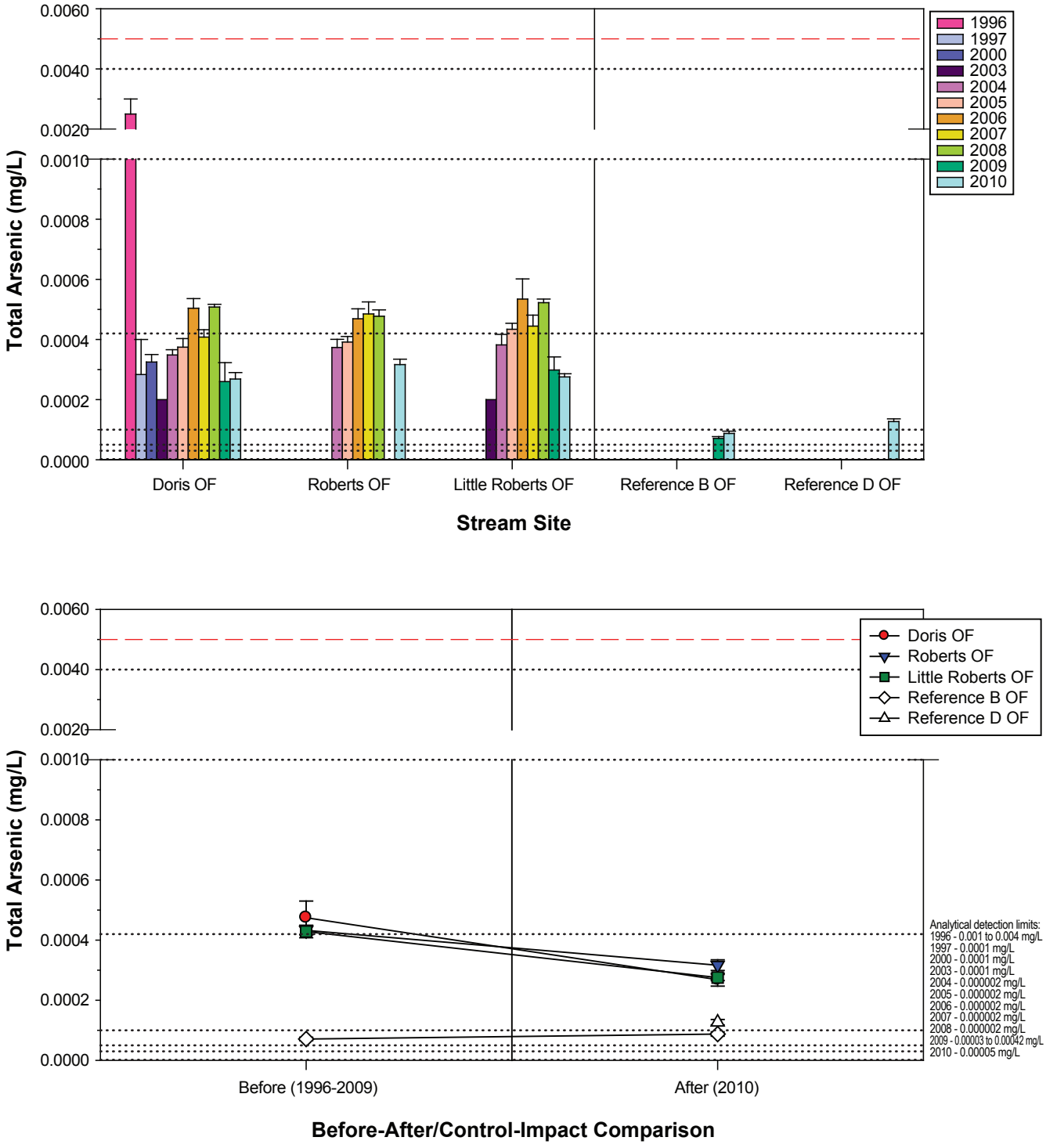
3.2.1.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All total cadmium concentrations measured in exposure streams during 2010 were below the analytical detection limit of 0.000005 mg/L and the hardness-dependent CCME guideline for cadmium (Figure 3.2-11). Historical concentrations were usually near or below comparable detection limits, with a few exceptions. There was therefore no evidence of an increase in cadmium concentrations in 2010 (Figure 3.2-11). For Doris Outflow, statistical analysis is not recommended for total cadmium, because > 70% of historical and 2010 concentrations were below analytical detection limits. For Little Roberts and Roberts outflows, the proportion of censored data was high (69% for both streams), but did not exceed 70%. The before-after analysis shows that there was no change in the mean cadmium concentration in 2010 compared to the historical mean for these streams ($p = 0.74$ for Roberts Outflow, $p = 0.74$ for Little Roberts Outflow), but these results should be interpreted cautiously because of the high level of censorship in the data.

3.2.1.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In Roberts Outflow, the mean 2010 copper concentration was similar to historical concentrations. In both Doris Outflow and Little Roberts Outflow, the before-after plot suggests that copper concentrations may have increased slightly in 2010 compared to historical concentrations (Figure 3.2-12). Mean 2010 concentrations in both Roberts and Little Roberts outflows were equal to or below the hardness-dependent CCME guideline, while the mean 2010 concentration in Doris Outflow slightly exceeded this guideline (Figure 3.2-12).

Any slight increase in copper levels may be related to the higher than average stream flows (Rescan 2011b) because copper is generally associated with suspended sediments (e.g., Milburn and Prowse 1996). However, the before-after analysis shows that this slight increase in copper was not statistically significant ($p = 0.090$ for Doris Outflow, $p = 0.41$ for Roberts Outflow, and $p = 0.13$ for Little Roberts Outflow). There was therefore no effect of 2010 Project activities on total copper concentrations.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME guideline for arsenic (0.005 mg/L).
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Arsenic Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-10

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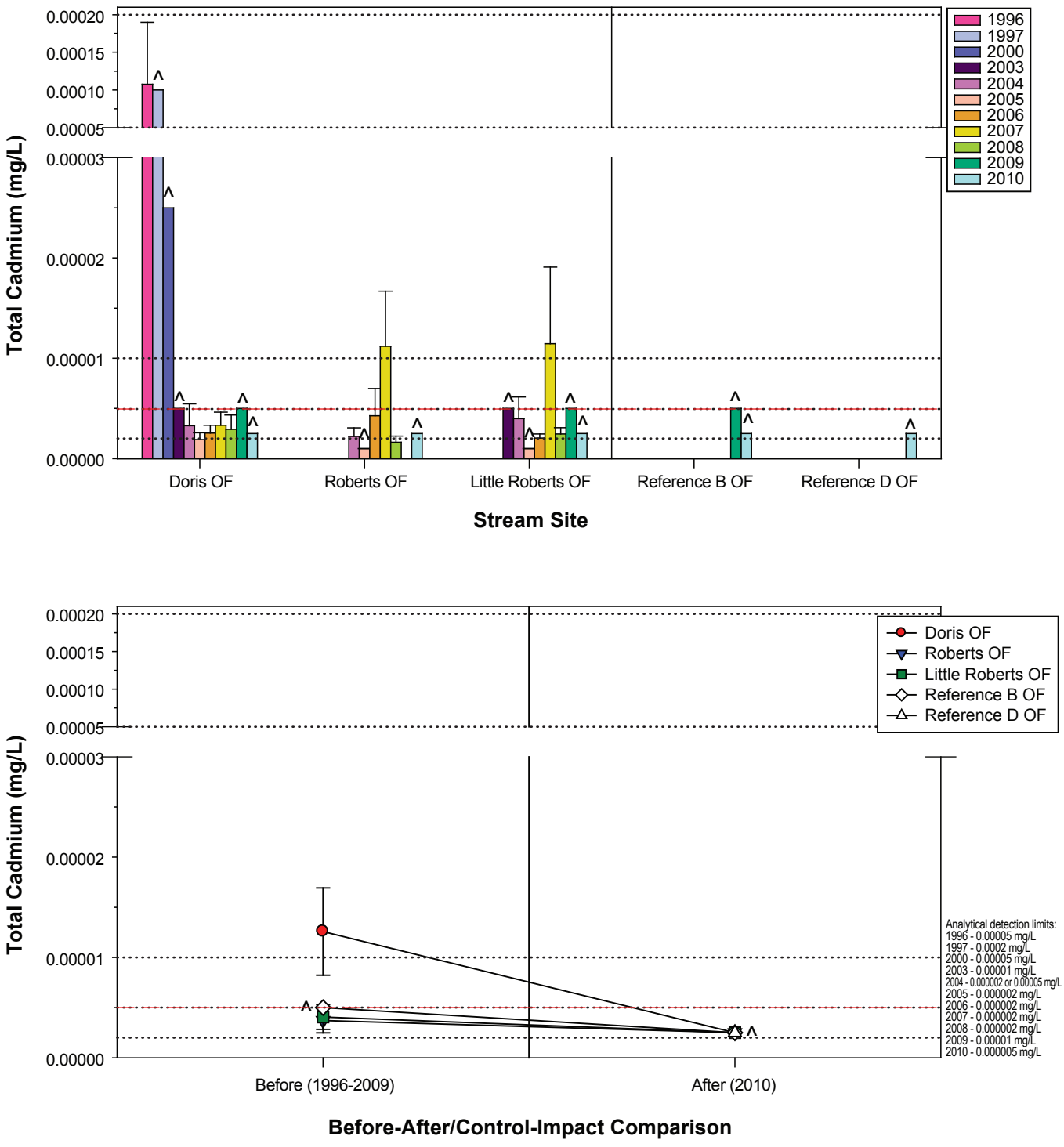

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME guideline for cadmium based on the minimum hardness measured in exposure and reference streams between 1996 and 2010 (hardness: 12 mg/L; CCME guideline: 0.000005 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Cadmium Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-11

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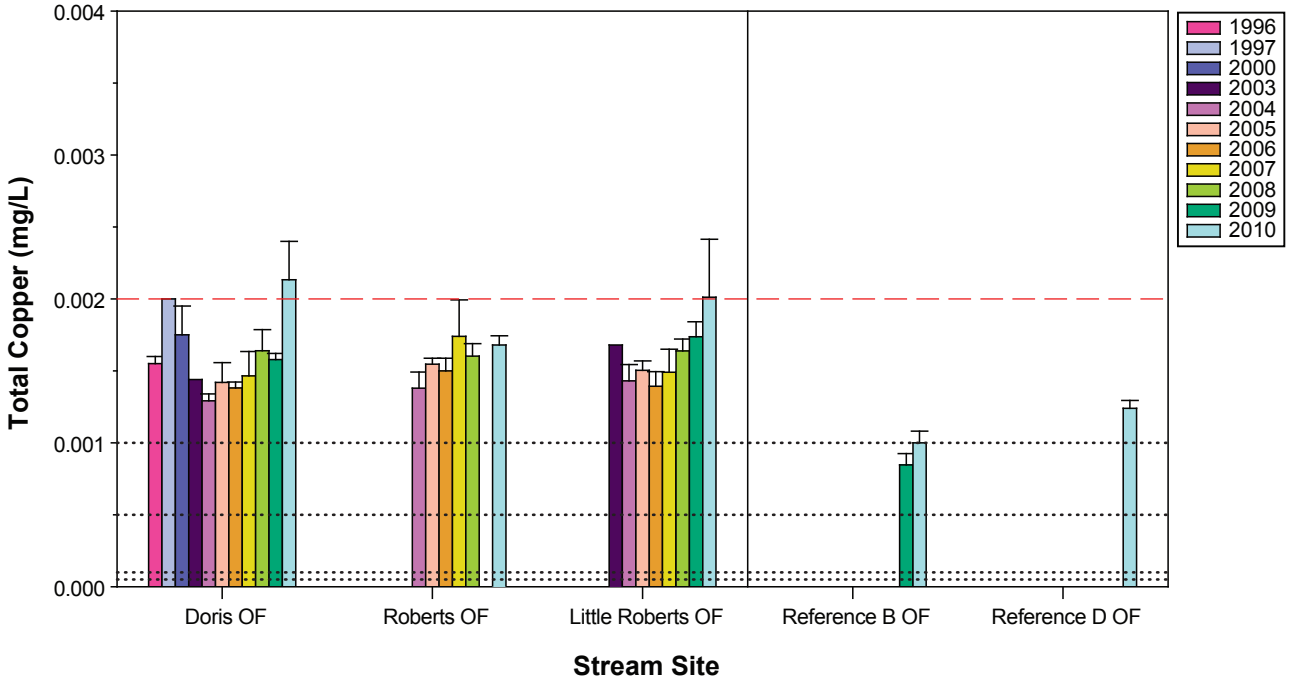

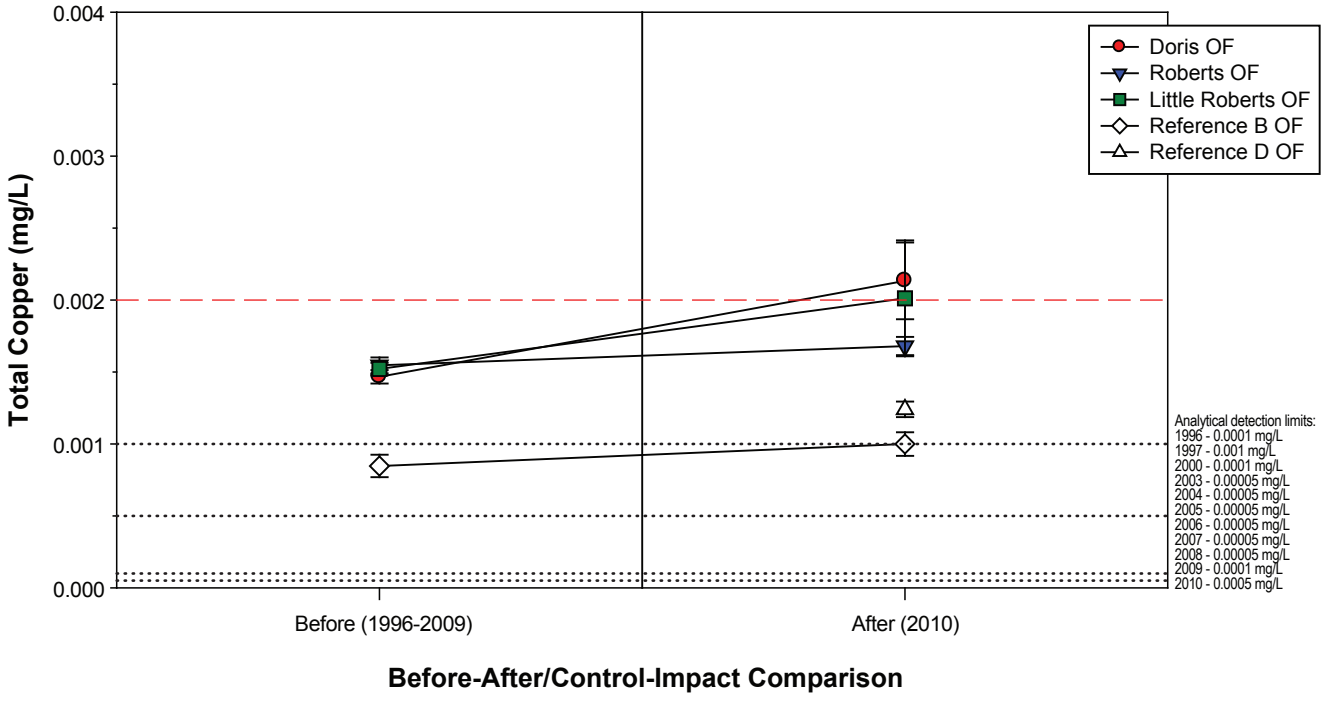

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The CCME guideline for copper is hardness dependent.
Red dashed lines represent the minimum CCME guideline for copper regardless of water hardness (0.002 mg/L).
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Copper Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-12

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3.2.1.13 Total Iron

Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total iron concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual and seasonal variability (Figure 3.2-13). It may therefore be difficult to distinguish natural variability from effects resulting from Project activities.

Although there was a large overlap between total iron concentrations measured in 2010 and concentrations measured in previous years, the before-after plot indicates that mean iron concentrations increased slightly in 2010 in all exposure streams, particularly in Doris and Roberts outflows (Figure 3.2-13). Mean 2010 total iron concentrations in all three exposure streams were slightly higher than the CCME guideline of 0.3 mg/L. In the historical dataset, the only time a mean iron concentration exceeded the CCME guideline was in Little Roberts Outflow in 2009; however, individual replicates collected before 2010 sometimes surpassed this guideline (Figure 3.2-13).

Iron is often closely associated with suspended sediments (e.g., Milburn and Prowse 1996), so the higher than average stream flows in 2010 (Rescan 2011b) could have contributed to increased total iron concentrations. The before-after statistical analysis shows that the 2010 mean total iron concentration in Roberts Outflow was higher than the historical mean ($p = 0.003$), while there was no change in iron concentrations in either Doris ($p = 0.030$) or Little Roberts ($p = 0.17$) outflows.

Although the before-after comparison suggests that the total iron concentration increased in Roberts Outflow in 2010 compared to previous years, the BACI analysis reveals that a parallel increase occurred in the reference stream ($p = 0.35$). Therefore, any increase in total iron that occurred in Roberts Outflow was likely the result of a natural phenomenon, and there was no evidence of an effect of 2010 Project activities on the total iron concentration in any exposure stream. The particularly high stream flows observed in 2010 (Rescan 2011b) could have resulted in the re-suspension of sediments and sediment-associated metals such as iron (e.g., Milburn and Prowse 1996).

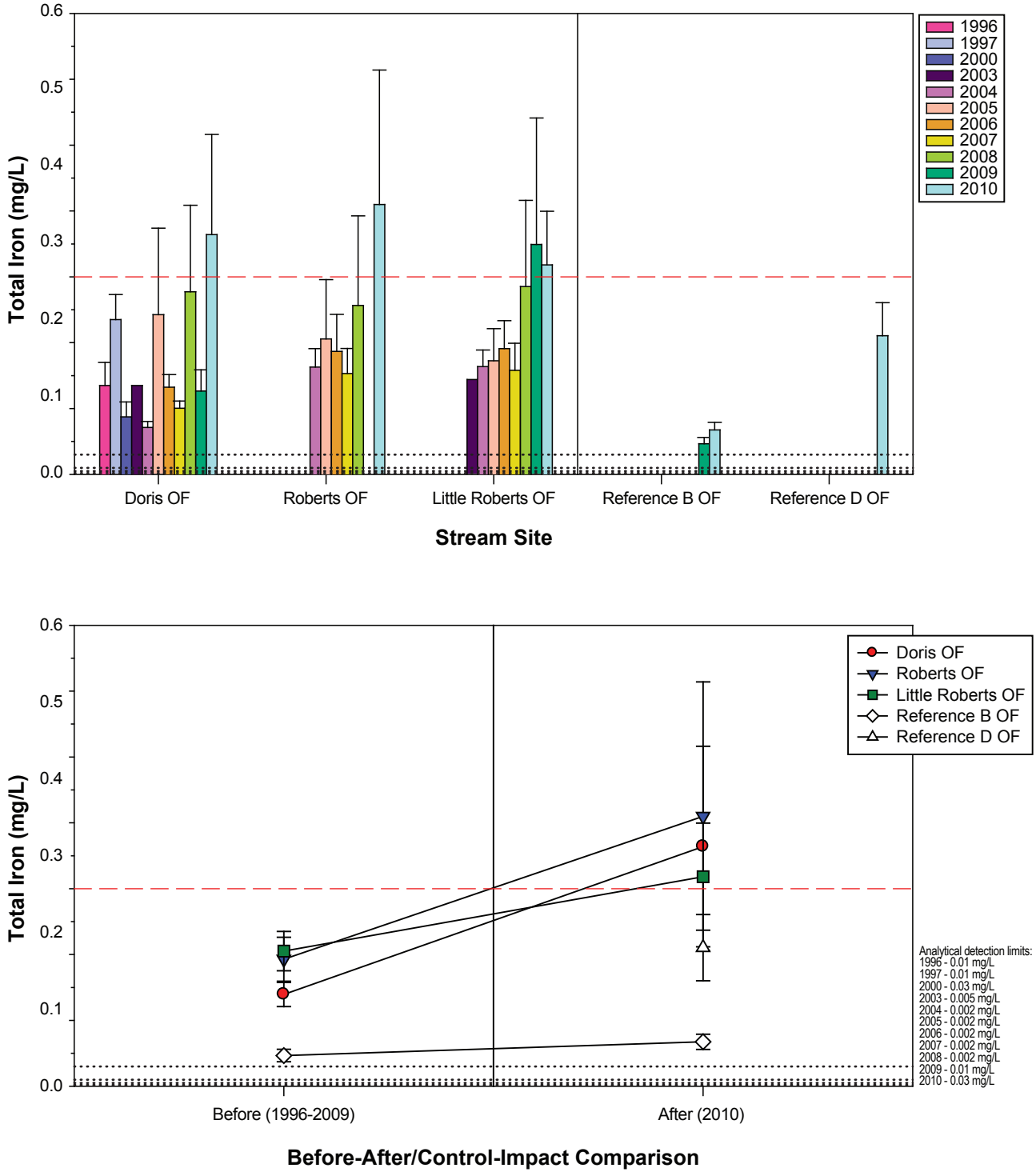
3.2.1.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Inter-annual mean concentrations of total lead were somewhat variable. However, 2010 mean concentrations in exposure streams were always within range of historical means, and were well below the hardness-dependent CCME guideline (Figure 3.2-14). The before-after comparison confirms that there was no effect of 2010 Project activities on total lead in exposure streams ($p = 0.30$ for Doris Outflow, $p = 0.66$ for Roberts Outflow, and $p = 0.96$ for Little Roberts Outflow).

3.2.1.15 Total Mercury

Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All total mercury concentrations measured in exposure and reference streams in 2010 were below the analytical detection limit of 0.00001 or 0.00005 mg/L (Figure 3.2-15). Concentrations below the detection limit of 0.00005 mg/L cannot be directly compared to the CCME guideline for inorganic mercury of 0.000026 mg/L because the detection limit is higher than the CCME guideline. In the remaining samples, total mercury concentrations were always below the CCME guideline for inorganic mercury.

Historical total mercury concentrations were frequently below detection limits, which ranged widely from 0.0000006 mg/L (low-level analysis) to 0.00005 mg/L. There was no evidence of an increase in mercury concentrations in 2010; however, patterns are difficult to interpret because of widely variable detection limits.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME guideline for iron (0.3 mg/L).
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Iron Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-13

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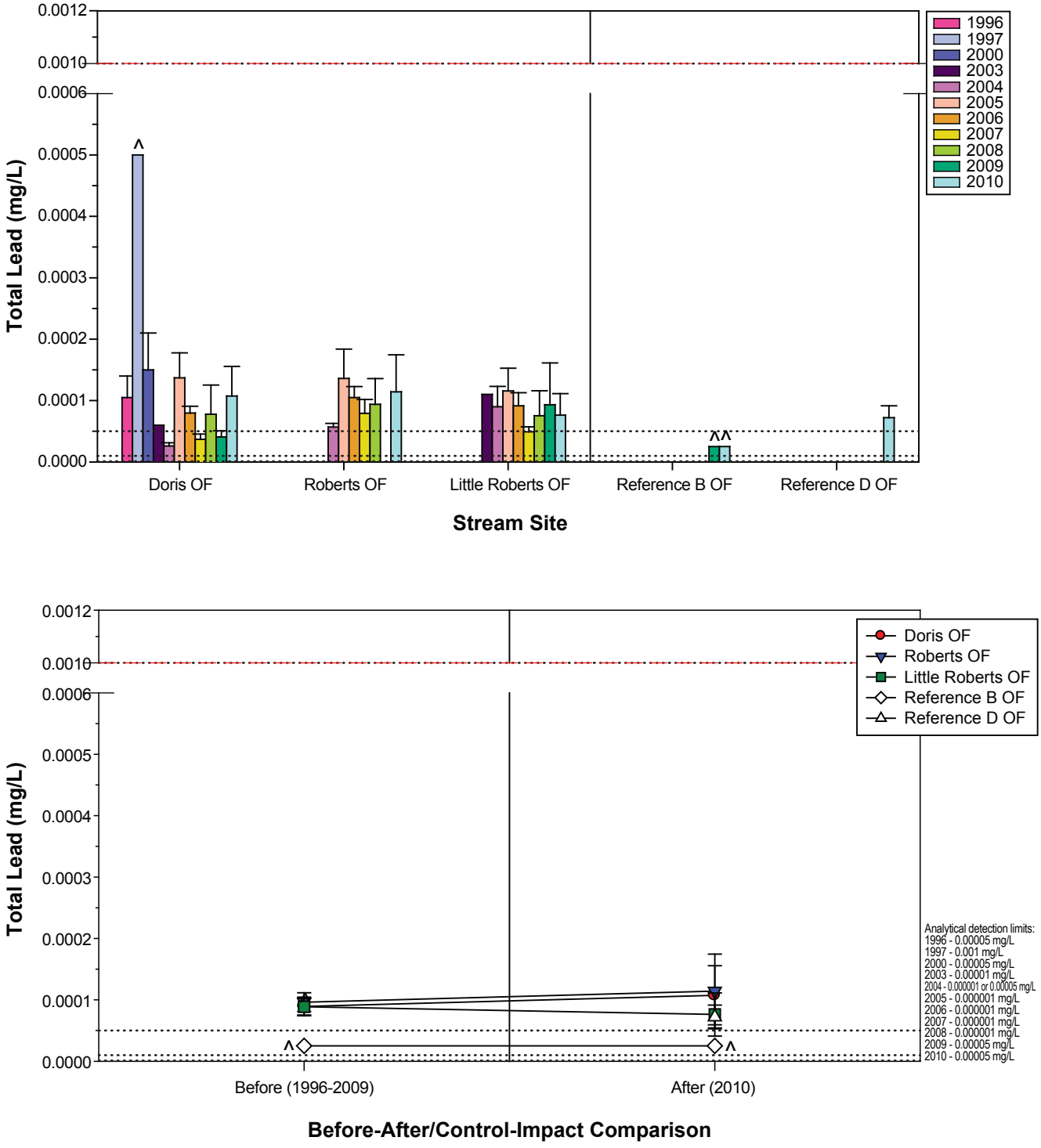


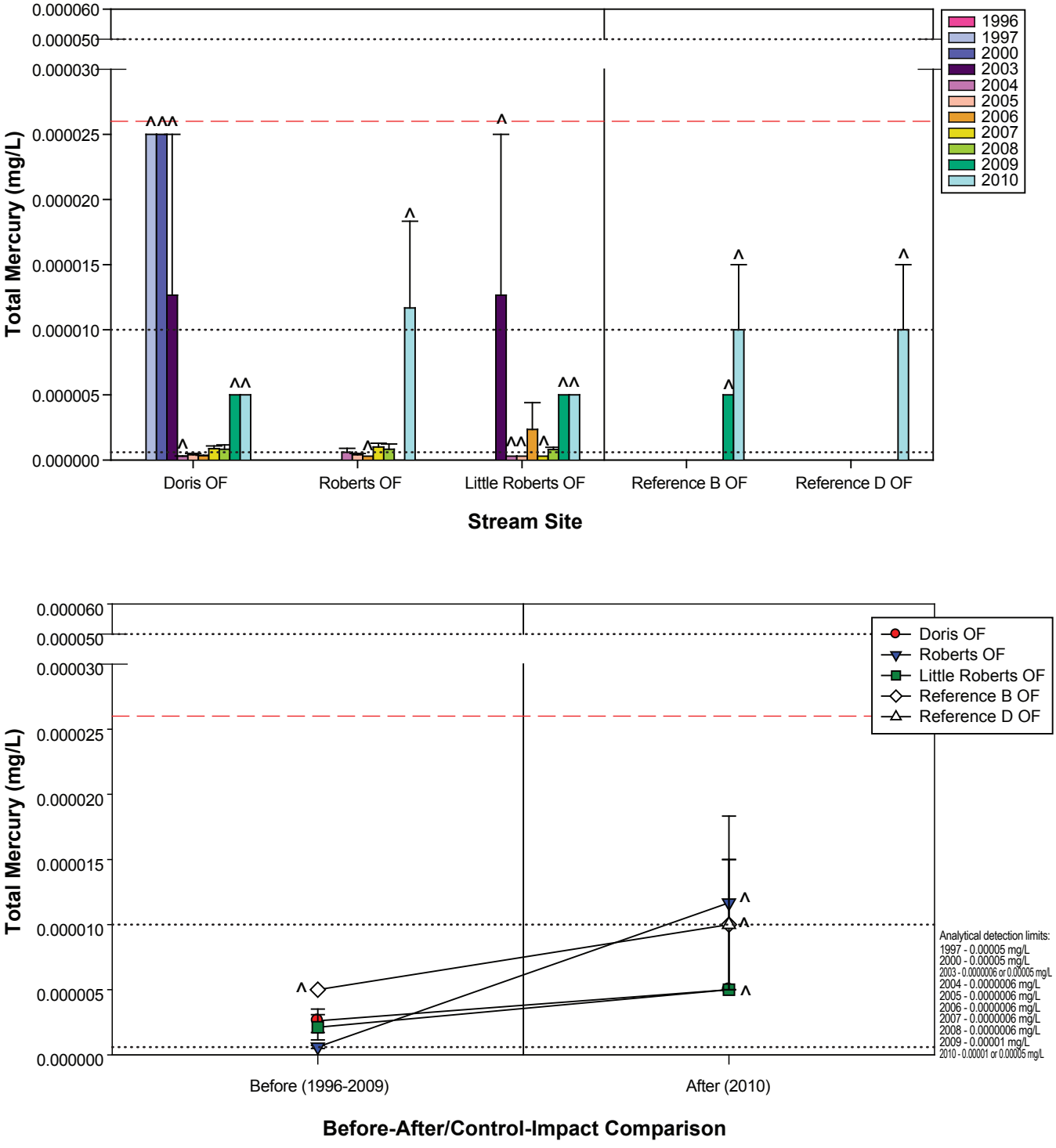
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME guideline for lead is hardness dependent.
Red dashed lines represent the minimum CCME guideline for lead regardless of water hardness (0.001 mg/L).
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Lead Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-14

Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for inorganic mercury (0.000026 mg/L).
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Mercury Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-15

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3.2.1.16 Total Molybdenum

Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean total molybdenum concentrations within each exposure stream were remarkably consistent from year to year, and 2010 concentrations were similar to historical concentrations (Figure 3.2-16). The before-after comparison confirms that there was no effect of 2010 Project activities on total molybdenum in streams ($p = 0.92$ for Doris Outflow, $p = 0.81$ for Roberts Outflow, and $p = 0.69$ for Little Roberts Outflow). Total molybdenum concentrations in all 2010 samples were more than two orders of magnitude lower than the interim CCME guideline of 0.073 mg/L (Figure 3.2-16).

3.2.1.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2010 nickel concentrations in all streams were well below the hardness-dependent CCME guideline. In all three exposure streams, the before-after plot suggests that concentrations increased slightly in 2010 compared to historical concentrations (Figure 3.2-17). High stream flows could have contributed to slightly elevated concentrations of nickel in 2010 because nickel can be associated with suspended sediments (e.g., Bourrin and Durrieu de Madron 2006). However, the before-after analysis reveals that these increases were not statistically significant ($p = 0.30$ for Doris Outflow, $p = 0.054$ for Roberts Outflow, and $p = 0.32$ for Little Roberts Outflow). There was therefore no effect of 2010 Project activities on total nickel concentrations in streams.

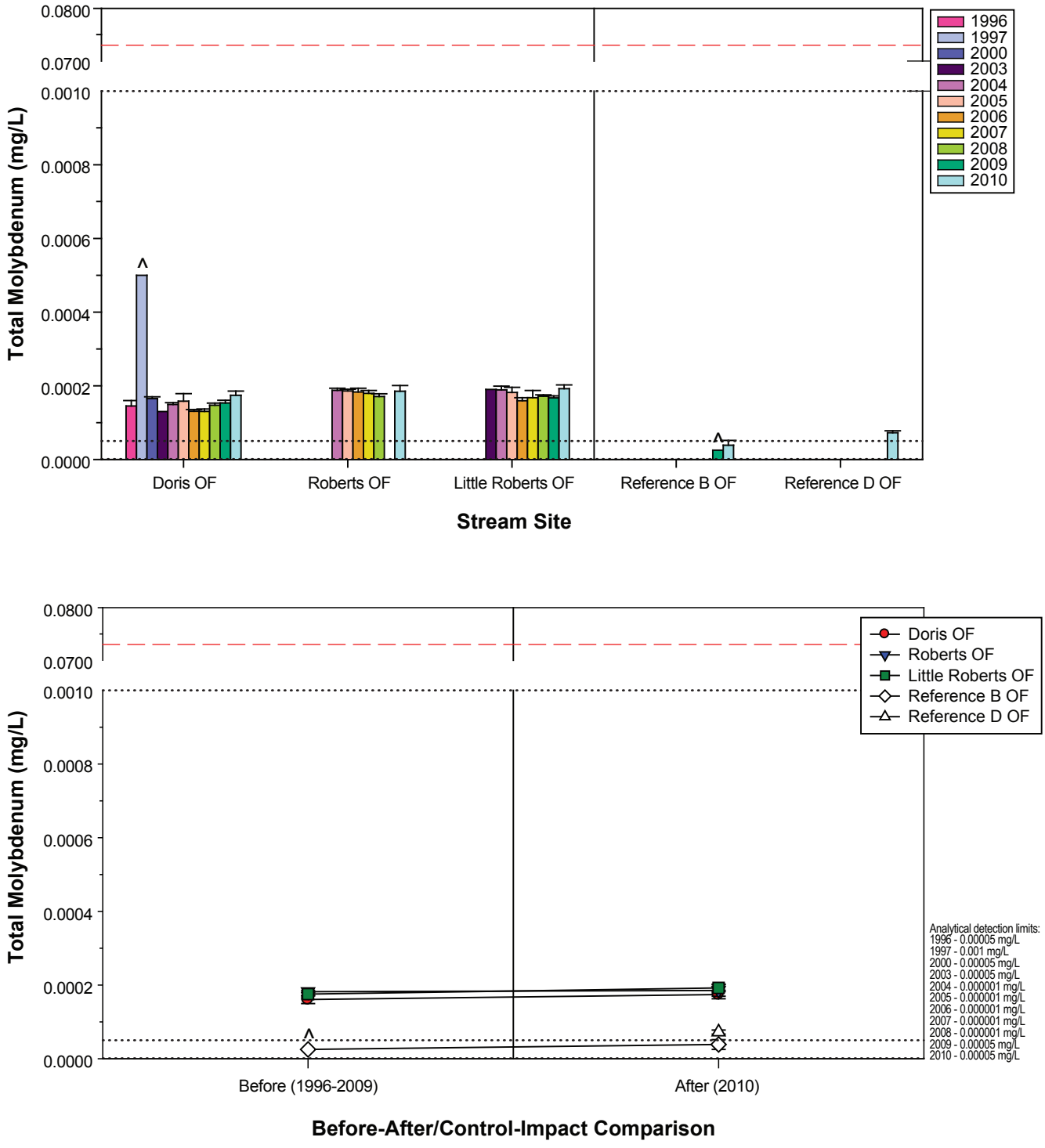
3.2.1.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010, total zinc concentrations were below the analytical detection limit of 0.003 mg/L in all samples collected from exposure and reference streams, with the exception of a single replicate collected at Roberts Outflow in June (which had a total zinc concentration of 0.004 mg/L). All 2010 total zinc concentrations were well below the CCME guideline of 0.03 mg/L. Since nearly all 2010 values were below analytical detection limits, there were no apparent Project-related effects on total zinc (Figure 3.2-18).

3.2.2 Lakes

Water quality samples from lakes were collected from three exposure sites (Doris Lake South, Doris Lake North, and Little Roberts Lake) and two reference lakes (Reference Lake B and Reference Lake D) in 2010. For the exposure lakes, relevant historical data were available from 1995 to 1997 and from 2003 to 2010 (though all lake sites were not sampled each year). The only available historical data for Reference Lake B were from 2009, and no historical data are available for Reference Lake D.

Because of comparability in lake sizes, Reference Lake B was used as a reference site for Doris Lake (these larger lakes are both > 3 km^2 in surface area) and Reference Lake D was used as a reference site for Little Roberts Lake (these smaller lakes are both < 0.1 km^2 in surface area). There was little evidence of vertical chemical stratification in any lake, so all samples were included in graphical and statistical analyses regardless of depth of sampling, and no depth effect was introduced into statistical models. Because no historical data are available for Reference Lake D, no statistical analyses were possible for this lake, and no BACI analysis was possible for Little Roberts Lake. The graphical effects analyses for lake water quality are shown in Figures 3.2-19 to 3.2-36. All statistical results appear in Appendix C.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME guideline for molybdenum (0.073 mg/L).
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Molybdenum Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-16

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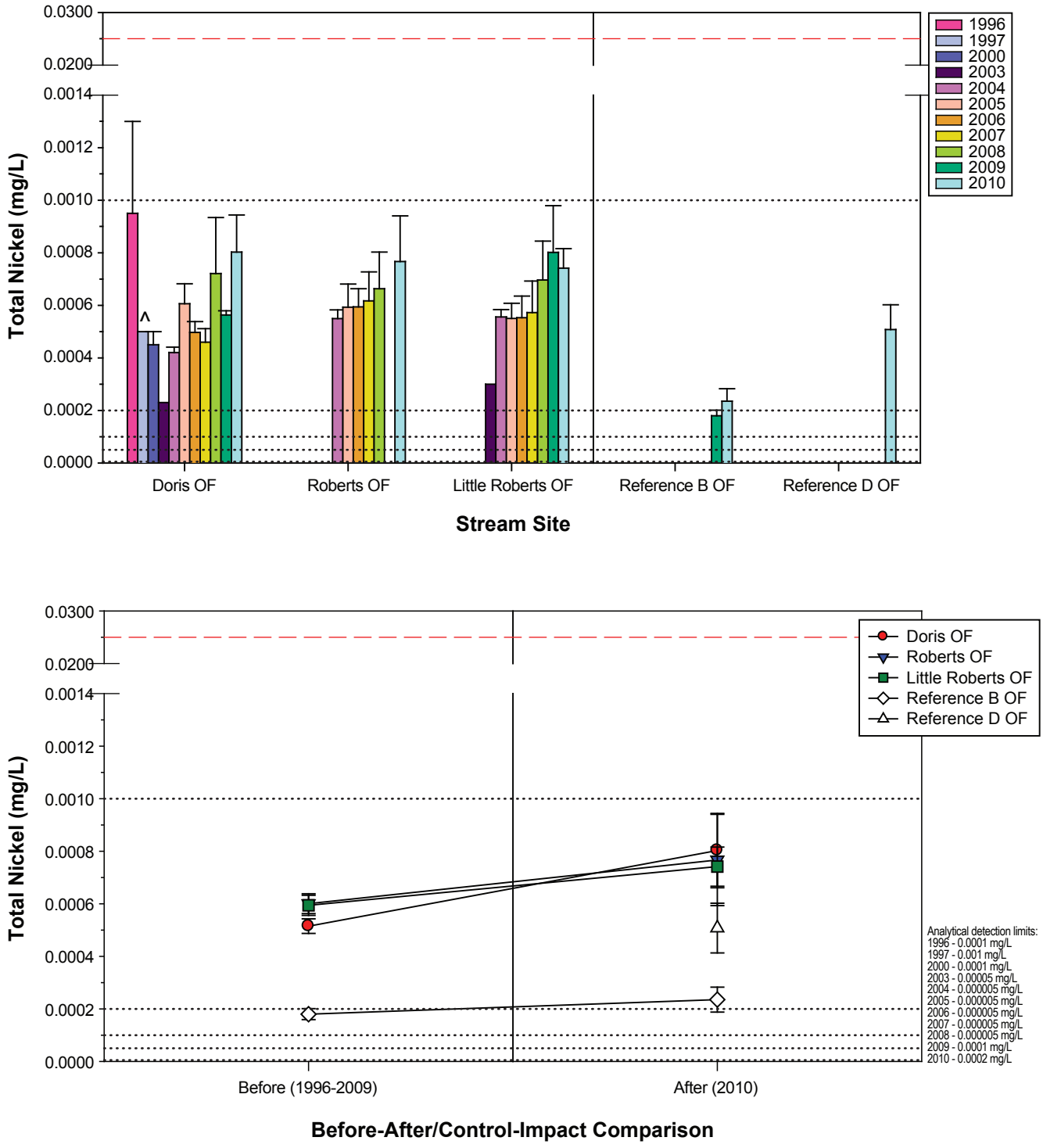

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the minimum CCME guideline for nickel regardless of water hardness (0.025 mg/L).
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Nickel Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-17

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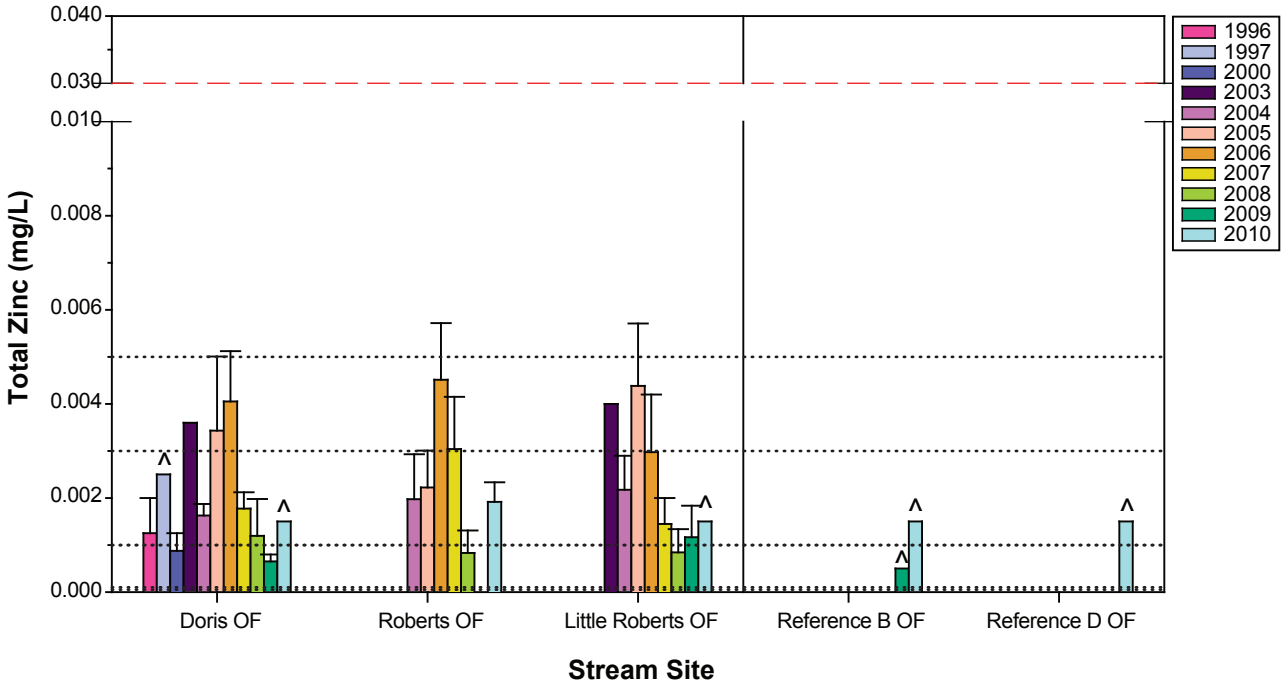

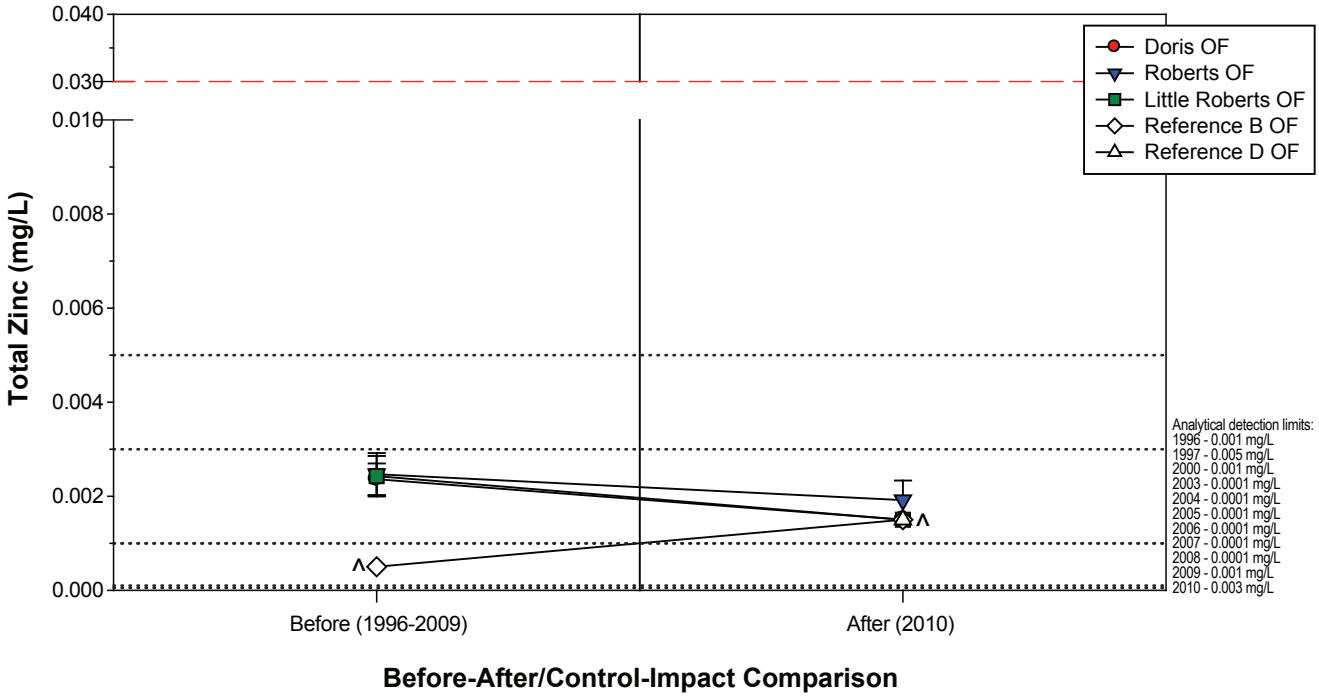

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for zinc (0.03 mg/L).
Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Zinc Concentration in AEMP Stream Sites, Doris North Project, 1996–2010

Figure 3.2-18

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3.2.2.1 pH

pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. pH levels measured in exposure lakes in 2010 were similar to levels in reference lakes and to historical ranges (Figure 3.2-19). Thus, there was no apparent effect of 2010 activities on pH in large and small lakes. The before-after analysis confirms that the mean historical pH was not distinguishable from the mean 2010 pH in any exposure lake ($p = 0.58$ for Doris Lake South, $p = 0.24$ for Doris Lake North, and $p = 0.012$ for Little Roberts Lake).

Mean 2010 pH levels in exposure and reference lakes were always within the recommended CCME guideline range of 6.5 to 9.0 (Figure 3.2-19).

3.2.2.2 Total Alkalinity

Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Total alkalinity (as $CaCO_3$) was higher in exposure lakes than reference lakes in 2010. However, within each lake, 2010 alkalinity was within range of historical alkalinity levels (Figure 3.2-20), and there was no evidence of any Project-related effects. The before-after analysis confirms that there was no change in alkalinity in any exposure lake in 2010 ($p = 0.50$ for Doris Lake South, $p = 0.52$ for Doris Lake North, and $p = 0.89$ for Little Roberts Lake).

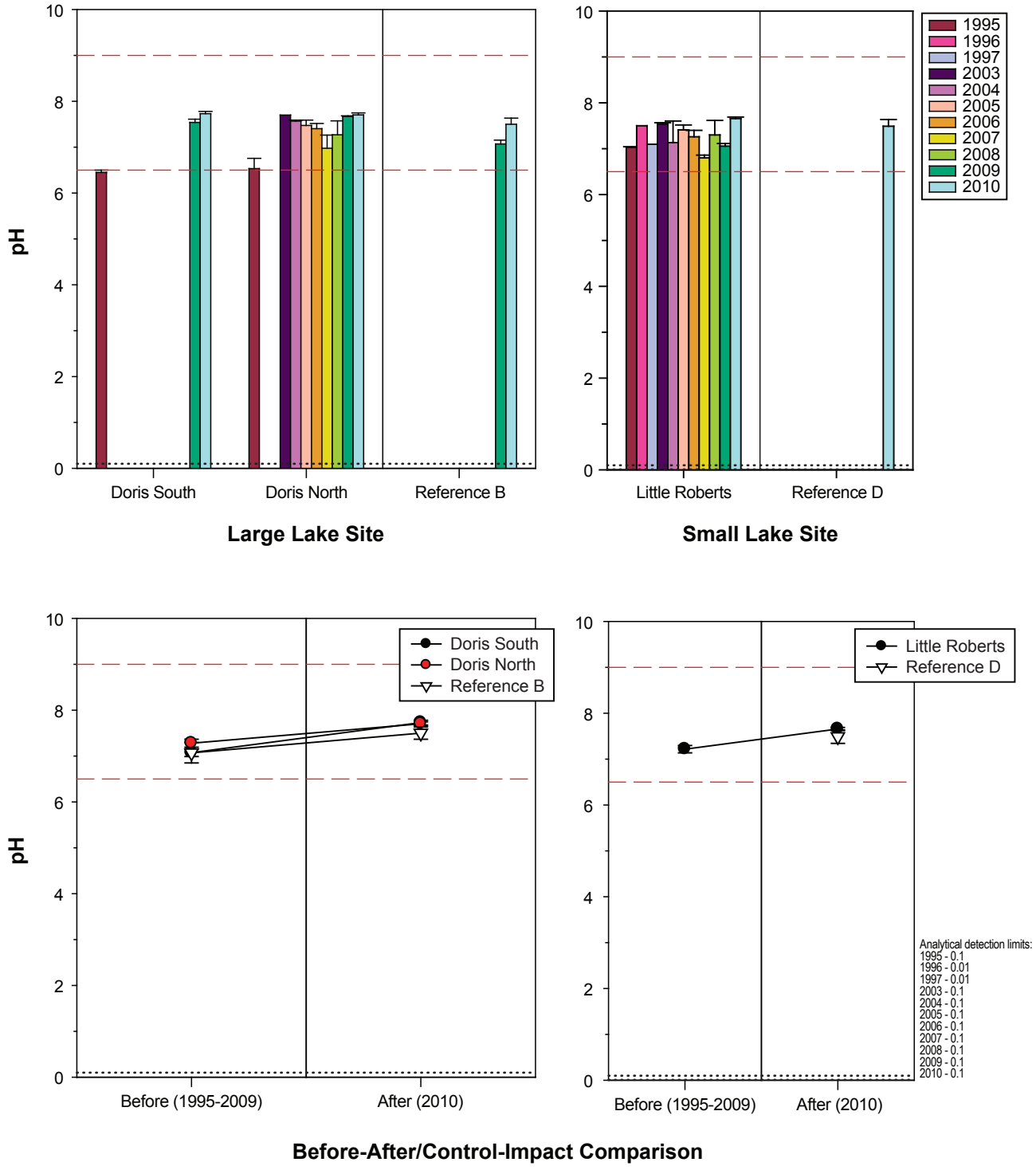
3.2.2.3 Hardness

Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. The spatial and temporal patterns apparent for water hardness (as $CaCO_3$) were similar to those seen for total alkalinity. Hardness varied among lakes, but within each lake, 2010 hardness levels were generally within range of historical levels (Figure 3.2-21). The before-after analysis shows that there was no statistically significant change in hardness in any exposure lake in 2010 ($p = 0.52$ for Doris Lake South, $p = 0.22$ for Doris Lake North, and $p = 0.82$ for Little Roberts Lake). Therefore, 2010 activities had no effect on lake hardness.

3.2.2.4 Total Suspended Solids

Total suspended solids (TSS) are regulated as deleterious substances in effluents as per Schedule 4 of the MMER. Mean TSS concentrations were inter-annually variable, particularly in Little Roberts Lake (Figure 3.2-22). Mean 2010 TSS concentrations in Doris Lake North and Little Roberts Lake were well within range of historical means; therefore, there was no apparent effect of 2010 activities on TSS levels in these lakes. In Doris Lake South, the mean 2010 TSS was slightly higher than the historical mean (Figure 3.2-22). However, the before-after analysis shows that 2010 means were not statistically different from historical means in any of the exposure lakes ($p = 0.53$ for Doris Lake South, $p = 0.64$ for Doris Lake North, and $p = 0.17$ for Little Roberts Lake).

The CCME guideline for TSS is dependent upon background levels (for clear-flow waters with background TSS levels below 25 mg/L, a maximum increase of 25 mg/L is allowable for any short-term exposure or 5 mg/L for longer term exposure; CCME 2011b). Because there was no increase in TSS concentrations from background levels, 2010 TSS concentrations in exposure lakes were below the CCME guideline.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.

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pH in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-19

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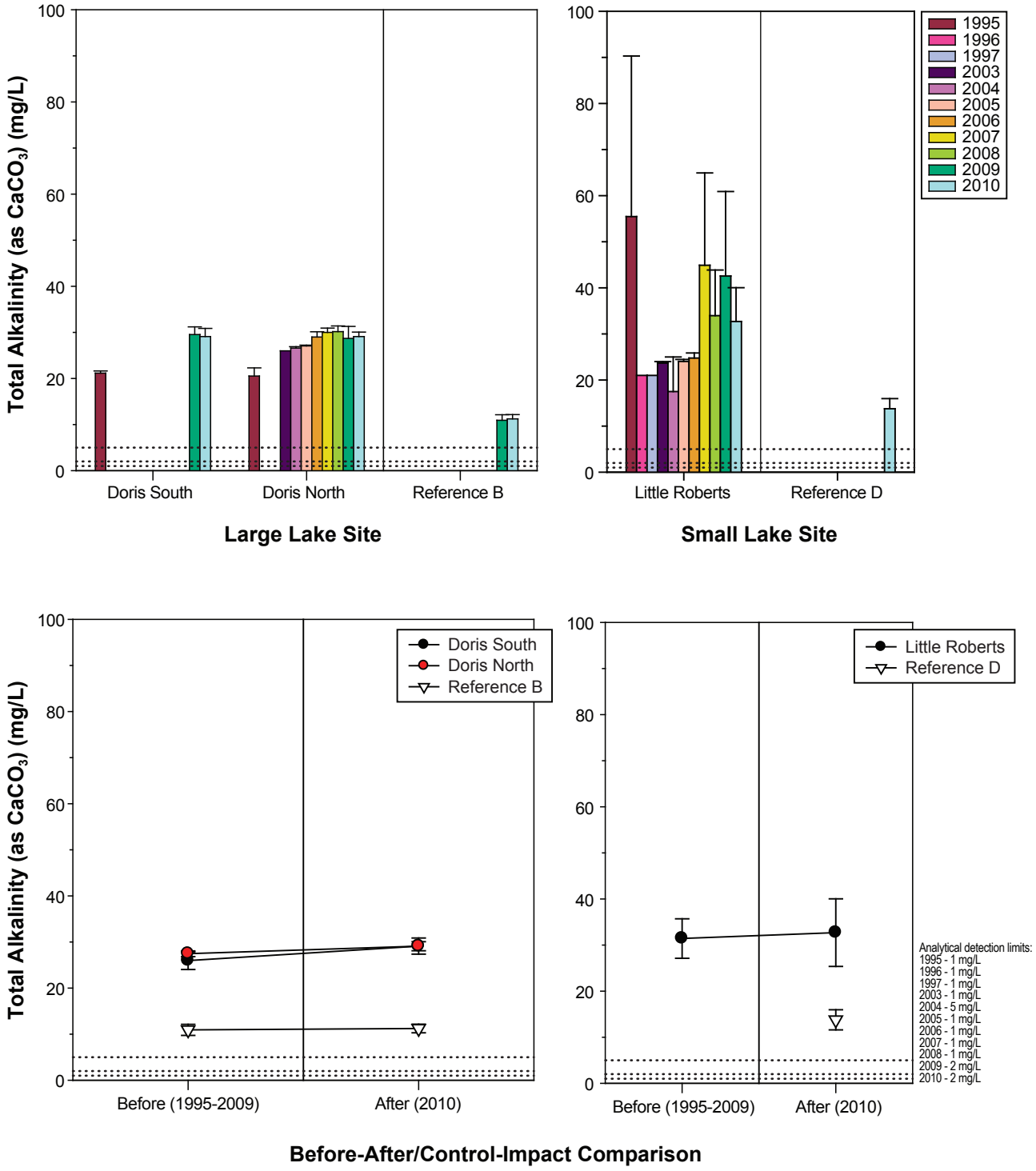

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Total Alkalinity in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-20

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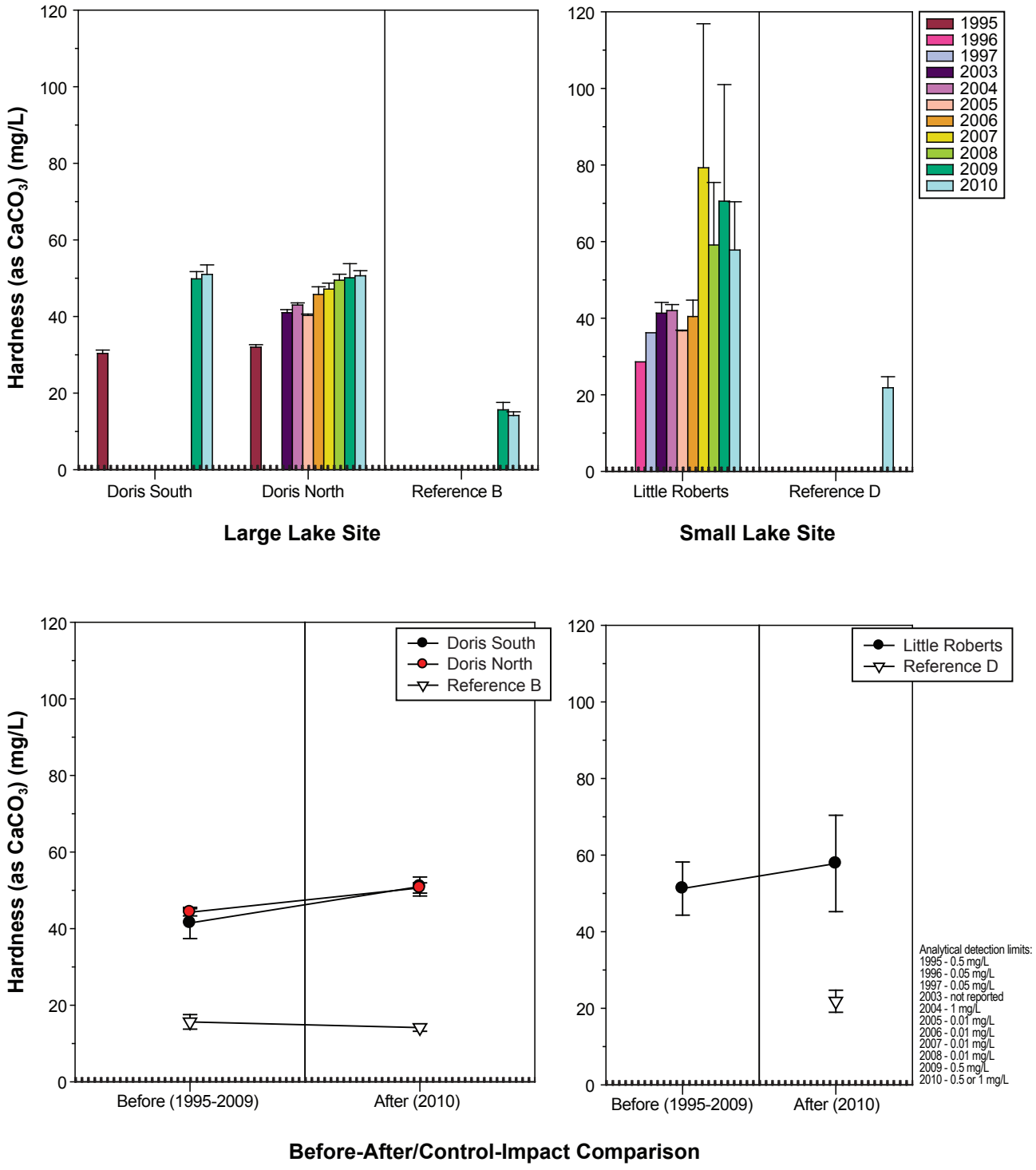

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.
Relatively high mean 2010 chlorophyll a concentration at site RBE was due to elevated August concentrations only.

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Hardness in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-21

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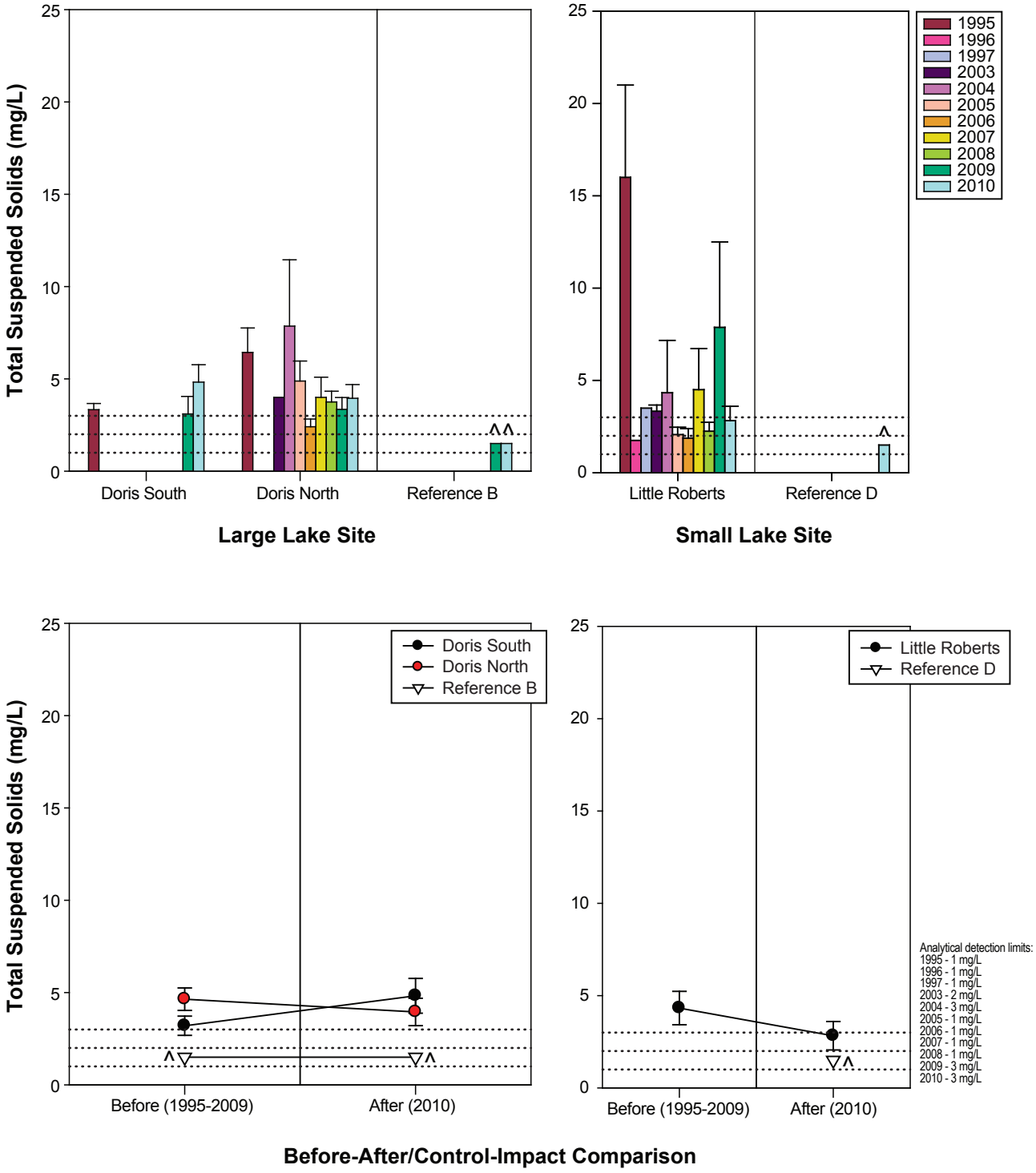

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME guideline for total suspended solids is dependent upon background levels.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Suspended Solids in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-22

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3.2.2.5 Total Ammonia

Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean ammonia concentrations for most years were near or below the analytical detection limit; however, there were some sporadically elevated mean concentrations in the historical dataset (e.g., Little Roberts Lake in 1995 and 2007; Figure 3.2-23). The before-after plot shows that total ammonia concentrations measured in 2010 were lower than historical means in all exposure lakes, indicating that 2010 activities did not cause an increase in ammonia levels (Figure 3.2-23). This was confirmed by the before-after analysis, which determined that there were no significant differences between historical and 2010 means for Doris Lake North ($p = 0.13$) and Little Roberts Lake ($p = 0.24$). Statistical analysis is not recommended for Doris Lake South because > 70% of the dataset consisted of censored values.

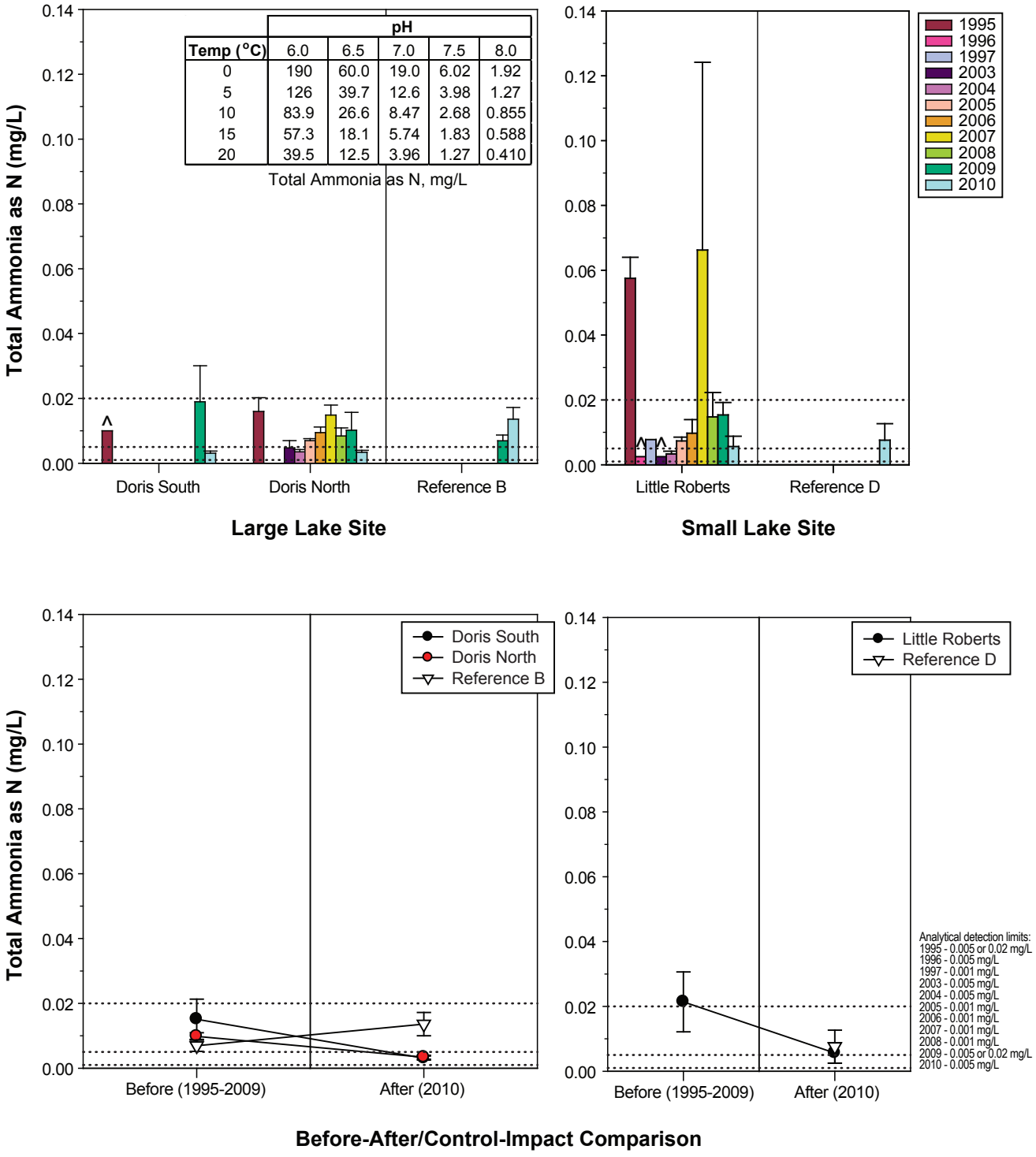
Mean 2010 concentrations of total ammonia in exposure and reference lakes were always well below the pH- and temperature-dependent CCME guideline (Figure 3.2-23).

3.2.2.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. More than 90% of nitrate concentrations measured in exposure lakes during 2010 were below the analytical detection limit of 0.005 mg nitrate-N/L, and all concentrations were well below the interim CCME guideline of 2.935 mg nitrate-N/L (Figure 3.2-24). Similar to the pattern for ammonia, nitrate concentrations have historically been near or below detection limits, with the exception of a few sporadically elevated measurements. Detection limits in 2010 were generally comparable to historical detection limits. There was therefore no evidence of an increase in nitrate concentration in 2010 in any exposure lake (Figure 3.2-24). In general, nitrate concentrations in the historical and 2010 dataset tended to be below detection limits during the summer and higher during the winter. Statistical analysis of changes in nitrate levels is not considered very reliable because of the high proportion of values that are below detection in the dataset for each lake (60% for Doris Lake South, 68% for Doris Lake North, and 70% for Little lake Roberts Lake). 2010 results indicate that on-site management of surface waters and quarry rock were successful in keeping ammonium nitrate salt and residues out of surface waters.

3.2.2.7 Total Cyanide

Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Similar to the pattern seen for streams, mean 2010 cyanide concentrations measured in the exposure (0.0045 mg/L in both Doris Lake South and Doris Lake North, and 0.0057 mg/L in Little Roberts Lake) and reference lakes (0.0025 mg/L in Reference Lake B, and 0.0036 mg/L in Reference Lake D) were higher than historical annual means in the exposure lakes, which generally did not exceed 0.001 mg/L (Figure 3.2-25). The mean 2010 total cyanide concentration in Little Roberts Lake was slightly higher than the CCME guideline; however, the CCME guideline of 0.005 mg/L as free cyanide (cyanide existing in the form of HCN and CN^-) is not directly comparable to total cyanide, which includes all forms of cyanide (free cyanides, metallocyanides, organocyanides, etc. (Singleton 1986)). Mean 2010 total cyanide concentrations in the remaining AEMP lakes were below this CCME guideline.



Before-After/Control-Impact Comparison

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Inset table shows the pH- and temperature-dependent CCME guideline for total ammonia.
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-23

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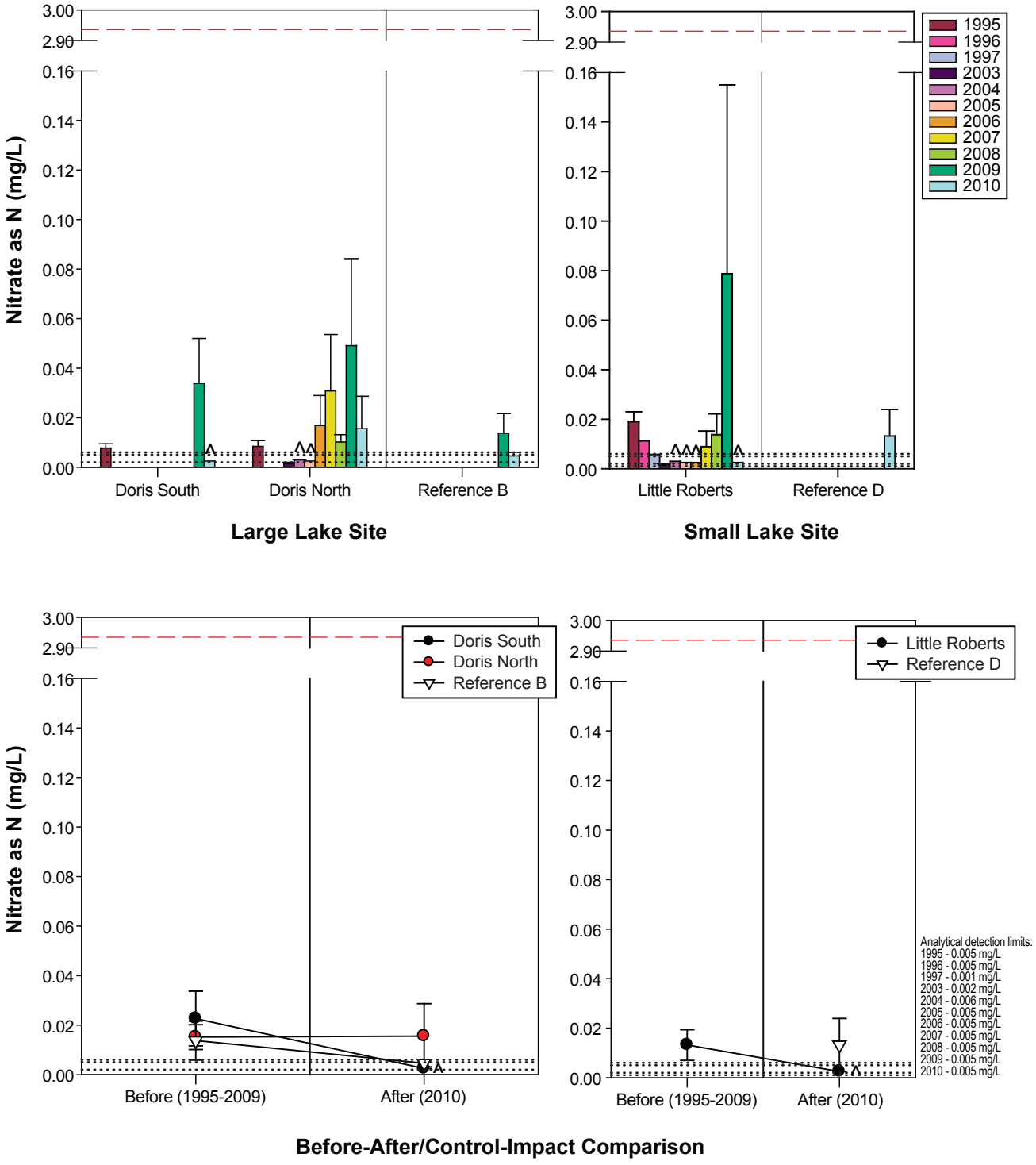

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME guideline for nitrate as N (2.935 mg/L).
The anomalously high nitrate concentration of 5.3 mg/L reported for Little Roberts Lake in September 2004 was considered an outlier and was excluded from plots.
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Nitrate Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-24

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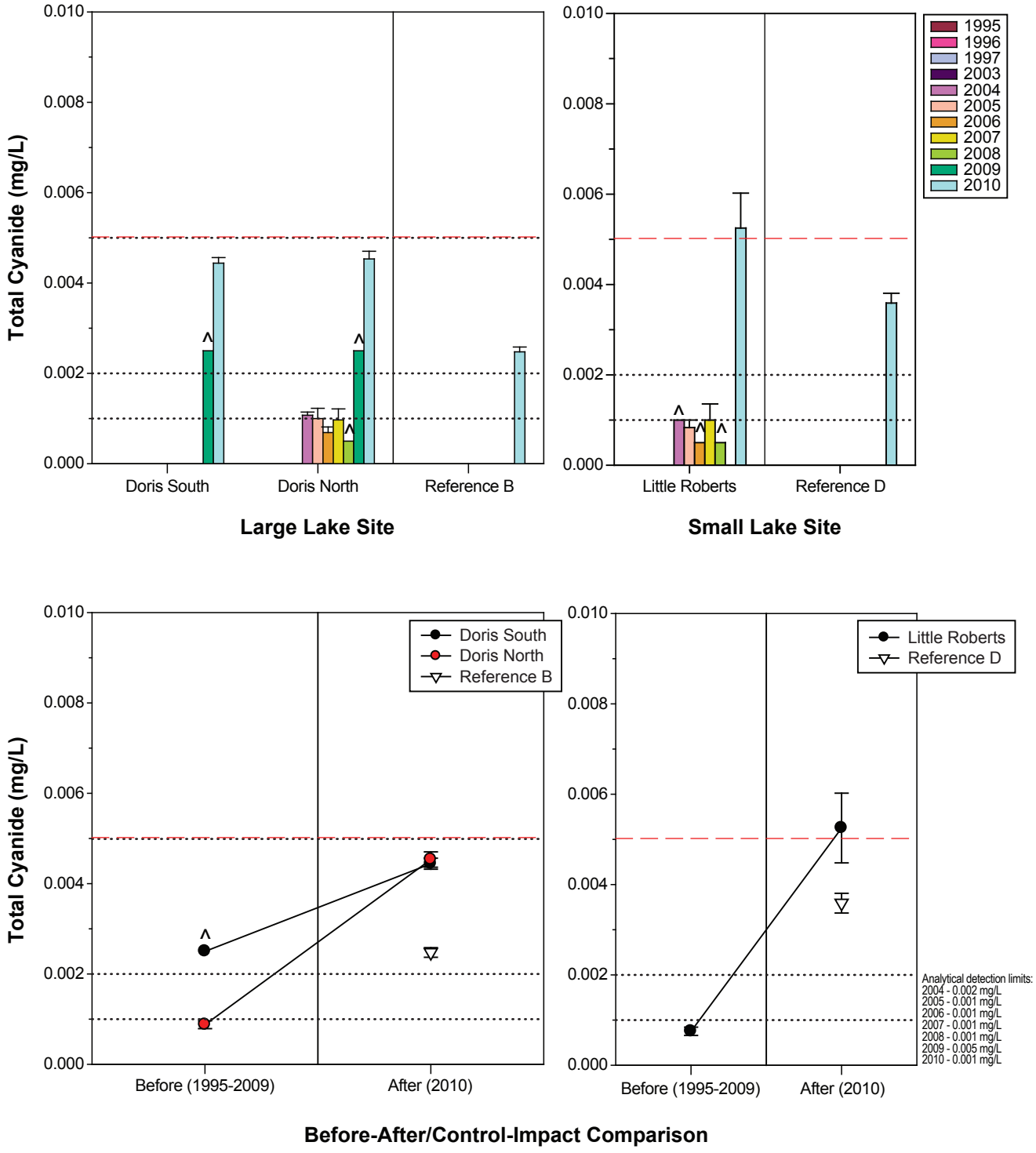

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for cyanide (0.005 mg/L as free cyanide).
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cyanide Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-25

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The 2009 total cyanide concentrations measured in Doris Lake South and Doris Lake North were below the analytical detection limit of 0.005 mg/L (which is higher than the detection limit achieved for other years), so it is unknown whether concentrations in 2009 may have been similar to those in 2010. This complicates the analysis of total cyanide for these large lakes, particularly Doris Lake South for which the only available historical cyanide data are from 2009. The before-after comparison for Doris Lake South and Doris Lake North shows that the 2010 mean cyanide concentrations were significantly higher than historical means ($p = 0.001$ for Doris Lake South, $p = 0.009$ for Doris Lake North). However, the determination of a significant increase in Doris Lake South is an artifact of the substitution of half the detection limit for the non-detectable concentrations recorded in 2009. If the full detection limit is used instead of half the detection limit for this substitution, the before-after difference for Doris Lake South becomes non-significant ($p = 0.39$).

For Little Roberts Lake, the before-after comparison shows that the 2010 mean total cyanide concentration was higher than the historical mean ($p < 0.001$). There is no 2009 cyanide data available for Little Roberts Lake, so the statistical analyses are not complicated by the high detection limit achieved in 2009.

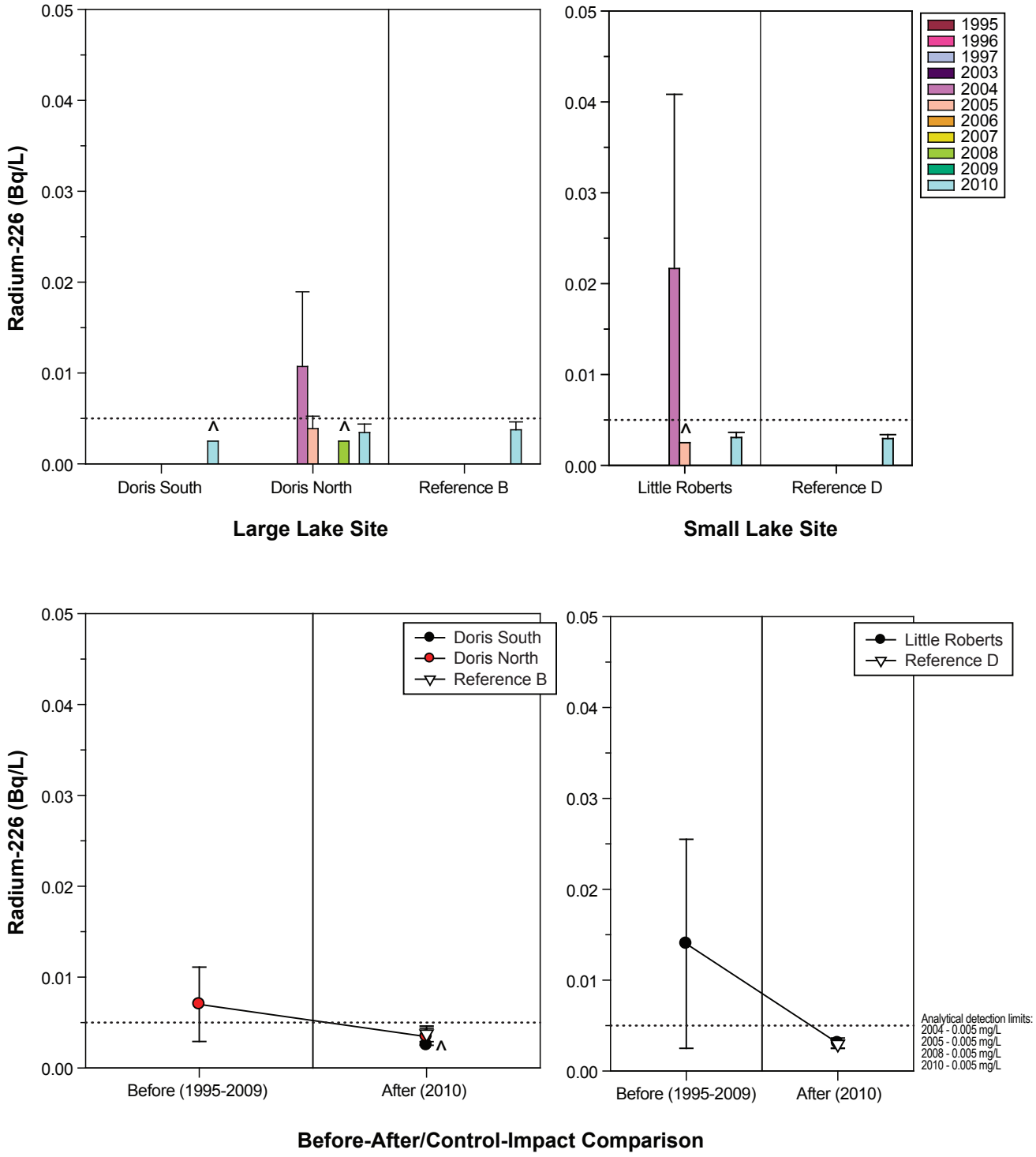
Because there is no historical cyanide data available for the reference lakes, a BACI analysis cannot be performed to determine whether the increase in cyanide observed in Little Roberts Lake, and possibly in Doris Lake South and Doris Lake North, is a phenomenon that also occurred in reference lakes. However, the mean cyanide concentrations in reference lakes in 2010 were also higher than measurable historical concentrations in exposure lakes (Figure 3.2-25), suggesting that this 2010 increase in cyanide is an analytical anomaly, a result of inadvertent contamination, or a natural phenomenon that also occurred in lakes outside of the Project area. Cyanide is naturally produced by a wide variety of plants and microorganisms (Knowles 1979; Singleton 1986). It is highly unlikely that there was an anthropogenic cause for this increase in cyanide, as cyanide was not brought to the Project site in 2010. The possibility that elevated cyanide concentrations measured in reference and exposure lakes were due to an analytical error or contamination is unlikely, because concentrations of cyanide in all equipment, travel, and field blanks analyzed as part of the 2010 sampling program were below the detection limit of 0.001 mg/L (Appendix A). Therefore, the increase in cyanide observed in reference and exposure sites in 2010 likely resulted from a natural process. Cyanide concentrations will continue to be closely monitored in both reference and exposure lakes in the future.

3.2.2.8 Radium-226

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010, more than 85% of radium-226 concentrations measured in exposure lakes were below the analytical detection limit of 0.005 mg/L, and the remaining concentrations were barely above this detection limit (Figure 3.2-26). Historical concentrations were similarly near or below the detection limit of 0.005 mg/L. Therefore, there is no evidence of an increase in radium-226 concentrations in 2010. Statistical analysis is not recommended for total radium, because > 70% of historical and 2010 concentrations were below analytical detection limits.

3.2.2.9 Total Aluminum

Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All 2010 mean concentrations of total aluminum in exposure lakes were similar to or less than historical means (Figure 3.2-27). Therefore, there was no apparent effect of 2010 Project activities on total aluminum concentrations. The before-after analysis confirms that the mean 2010 concentration was not distinguishable from the historical mean in any exposure lake ($p = 0.24$ for Doris Lake South, $p = 0.64$ for Doris Lake North, and $p = 0.59$ for Little Roberts Lake).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Radium-226 Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-26

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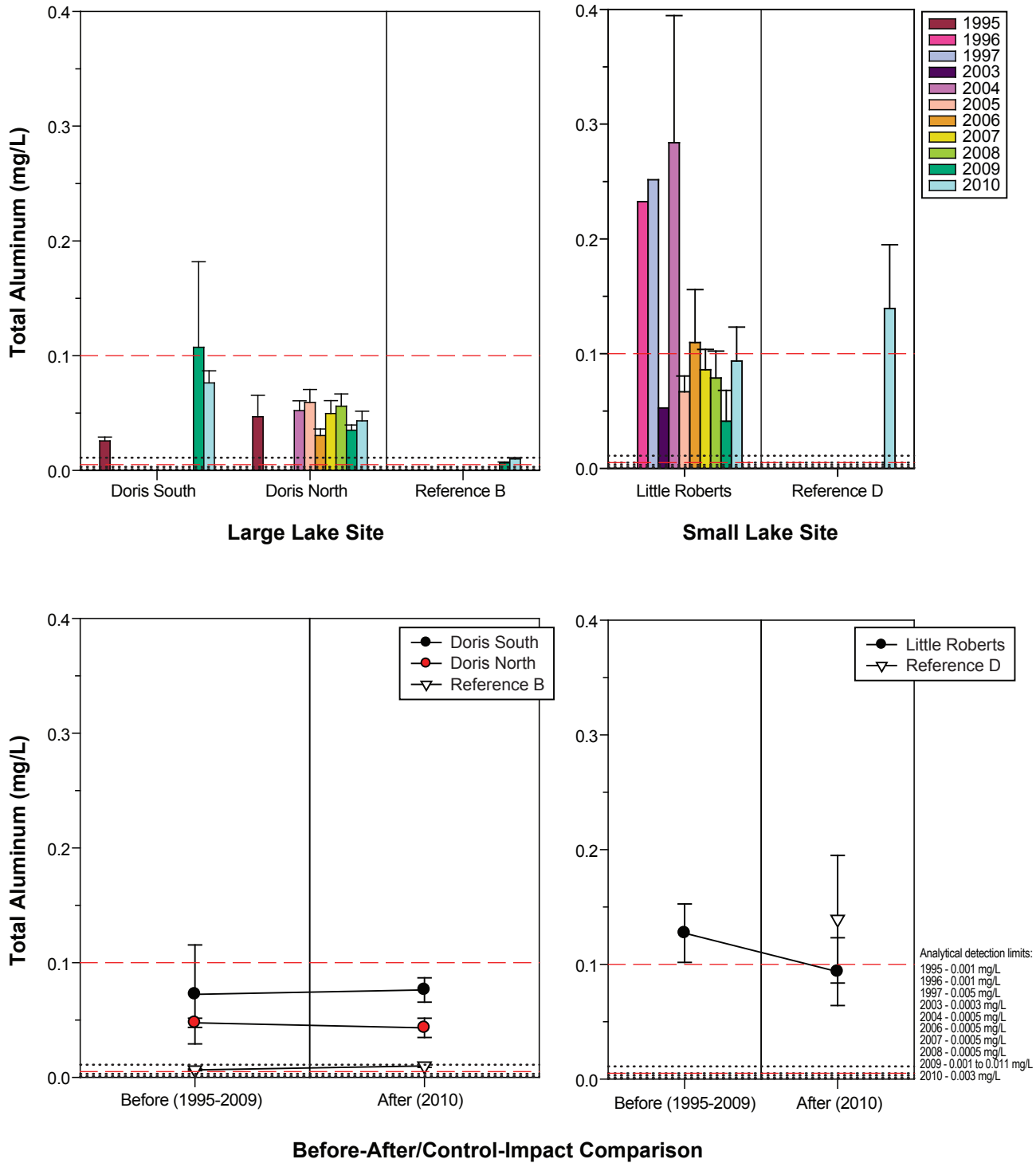

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5).
Mean annual pH levels in all exposure and reference lakes were ≥ 6.5, with the exception of Doris Lake South in 1995 (mean pH of 6.45).
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Aluminum Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-27

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Reference Lake D was the only lake in which mean 2010 total aluminum concentrations exceeded the pH-dependent CCME guideline of 0.1 mg/L. In Little Roberts Lake, historical aluminum concentrations frequently exceeded 0.1 mg/L, but the 2010 mean concentration was just below this guideline (Figure 3.2-27).

3.2.2.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2010 total arsenic concentrations in all exposure lakes were well below the CCME guideline of 0.005 mg/L, and were similar to or less than historical means (Figure 3.2-28), so 2010 activities did not cause an increase in arsenic concentrations in lakes. For Doris Lake South and Little Roberts Lake, the before-after comparison shows that there was no difference between 2010 mean arsenic concentrations and historical means ($p = 0.63$ for Doris Lake South, $p = 0.47$ for Little Roberts Lake). However, there was a significant difference between the historical and the 2010 mean for Doris Lake North ($p=0.006$). In this case, arsenic concentrations were significantly lower in 2010 compared to historical levels, which is not of concern. Regardless, the BACI analysis shows that a parallel decrease also occurred in Reference Lake B ($p=0.017$). There was therefore no apparent effect of 2010 Project activities on arsenic concentrations in the exposure lakes.

3.2.2.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In 2010, more than 85% of total cadmium concentrations measured in exposure lakes were below the analytical detection limit of 0.000005 mg/L (Figure 3.2-29). Historical concentrations were similarly near or below detection limits in most samples. There is no evidence of an increase in cadmium concentrations in 2010. Statistical analysis is not recommended for total cadmium, because > 70% of historical and 2010 concentrations were below analytical detection limits.

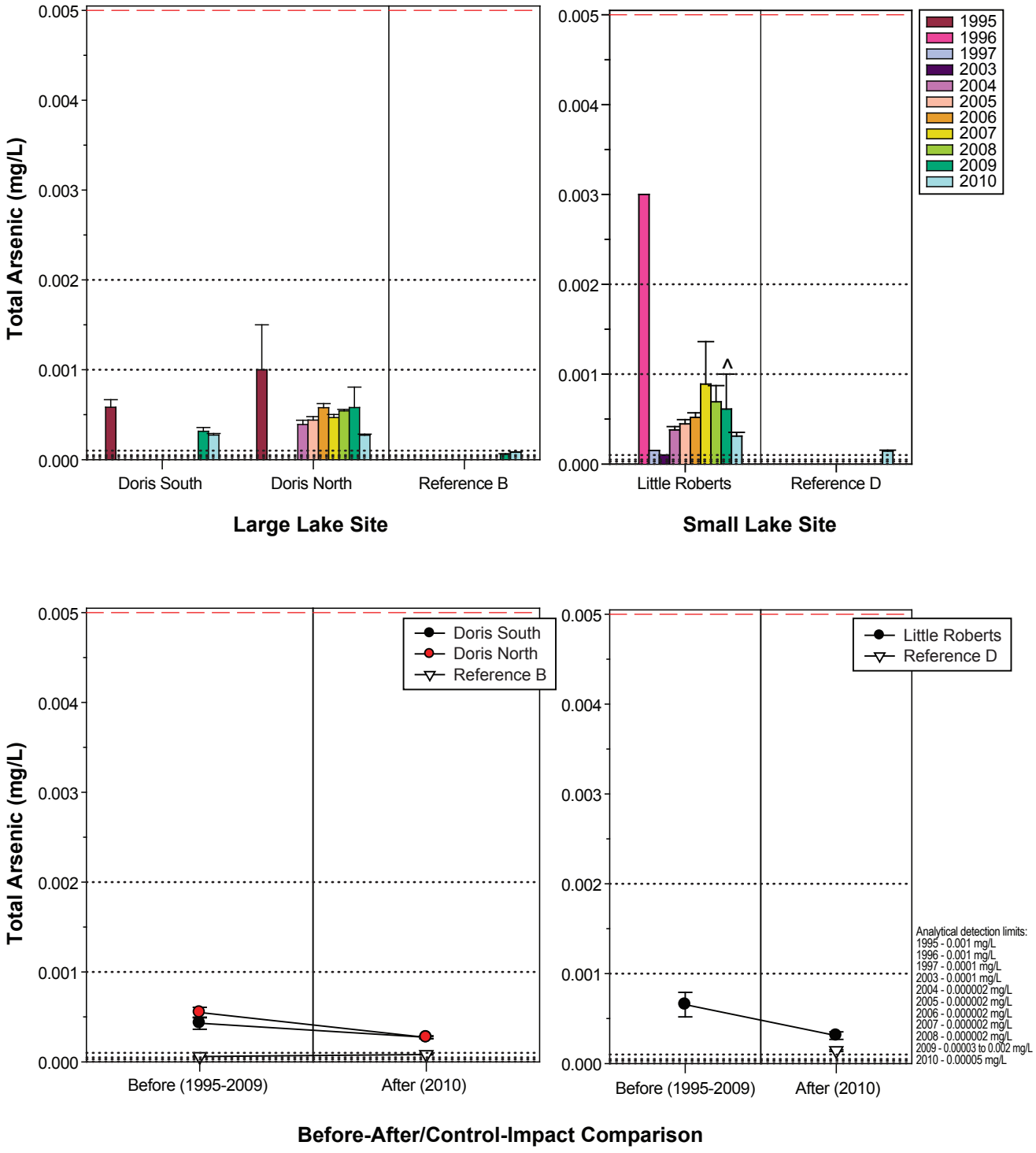
An anomalously high concentration of total cadmium was measured at Doris South in August 2010 (0.00019 mg/L); with the exception of this sample, all 2010 concentrations were below the hardness-dependent CCME guideline for cadmium (Figure 3.2-29).

3.2.2.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In all three exposure lakes, mean 2010 copper concentrations were within range of historical annual means (Figure 3.2-30). The mean 2010 copper concentration in Little Roberts Lake exceeded the hardness-dependent CCME guideline, but this was also observed in previous years (Figure 3.2-30). Therefore, there was no apparent effect of 2010 activities on total copper levels in any exposure lake. The before-after analysis confirms that 2010 mean copper concentrations were not distinguishable from historical means in the exposure lakes ($p = 0.46$ for Doris Lake South, $p = 0.92$ for Doris Lake North, and $p = 0.055$ for Little Roberts Lake).

3.2.2.13 Total Iron

Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total iron concentrations were inter-annually variable, particularly in Little Roberts Lake. Mean 2010 concentrations were below the CCME guideline of 0.3 mg/L at all sites. Overall, mean total iron concentrations in all exposure lakes in 2010 were within range of historical means, suggesting that 2010 Project activities had no effect on iron concentrations (Figure 3.2-31). The before-after comparison confirms that there was no change in iron concentrations in the exposure lakes in 2010 ($p = 0.19$ for Doris Lake South, $p = 1.0$ for Doris Lake North, and $p = 0.61$ for Little Roberts Lake).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for arsenic (0.005 mg/L).
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Arsenic Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-28

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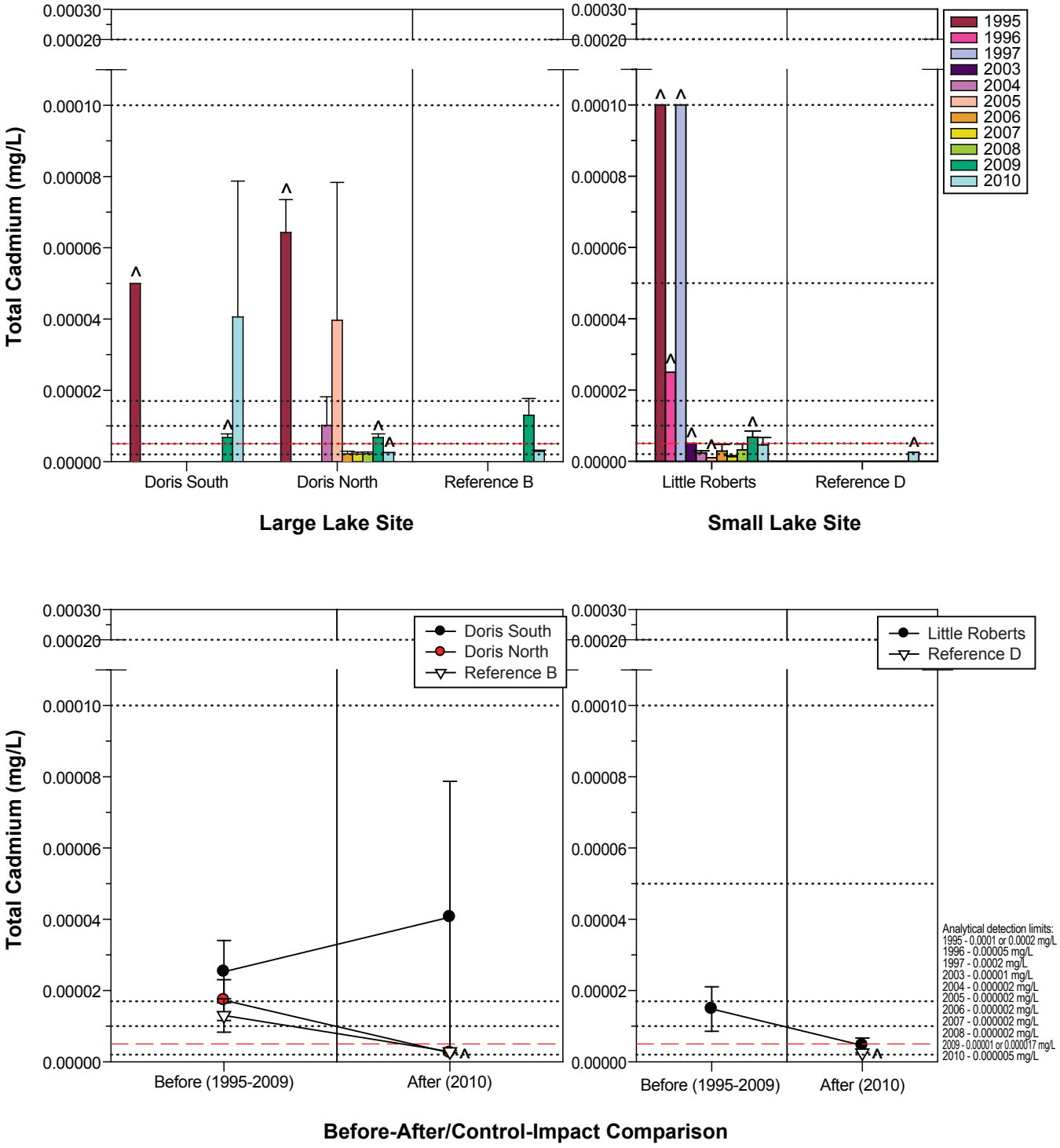

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME guideline for cadmium based on the minimum hardness measured in exposure and reference lakes between 1996 and 2010 (hardness: 12 mg/L; CCME guideline: 0.000005 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Cadmium Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-29

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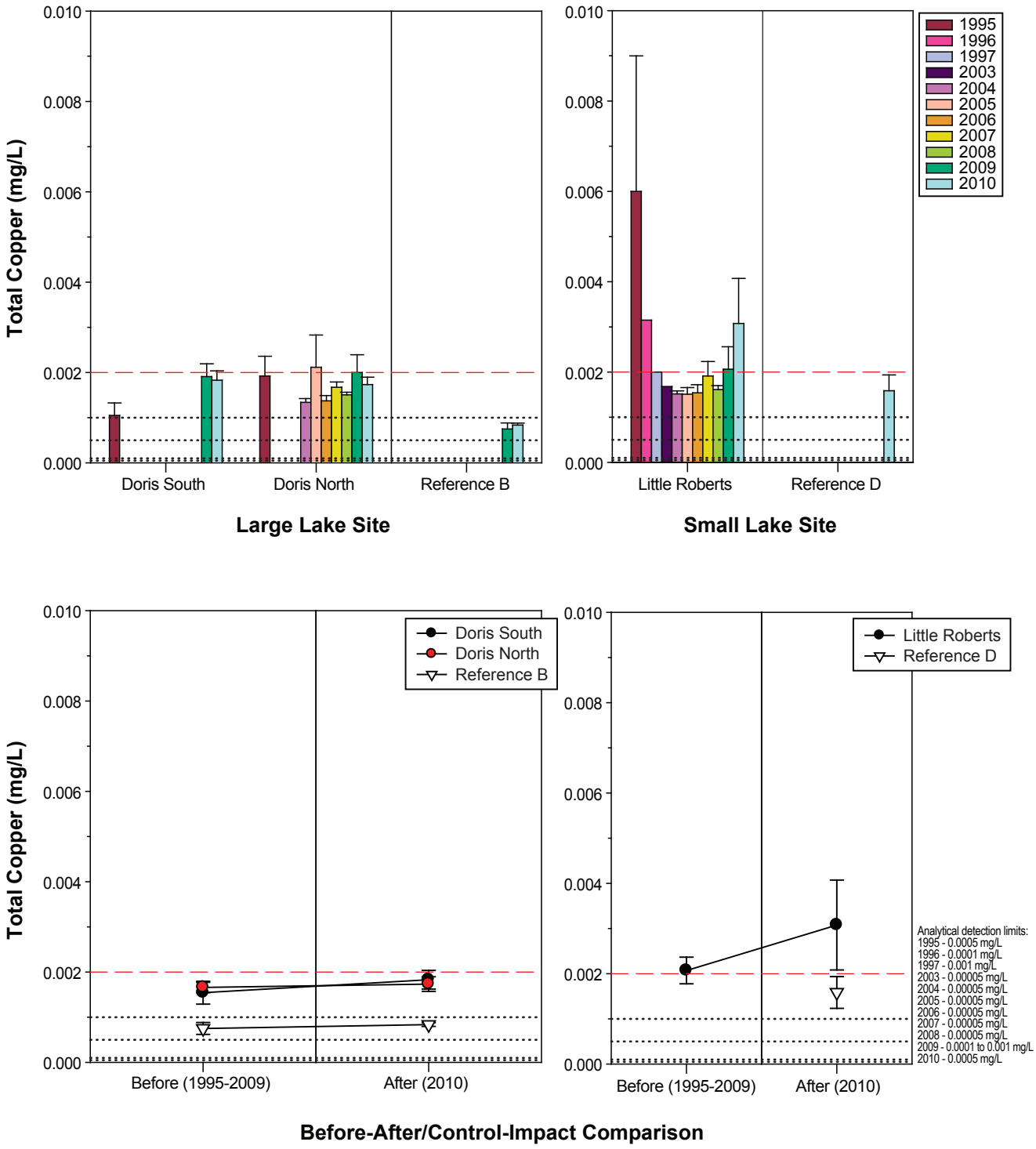

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The CCME guideline for copper is hardness dependent.
Red dashed lines represent the minimum CCME guideline for copper regardless of water hardness (0.002 mg/L).
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Copper Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-30

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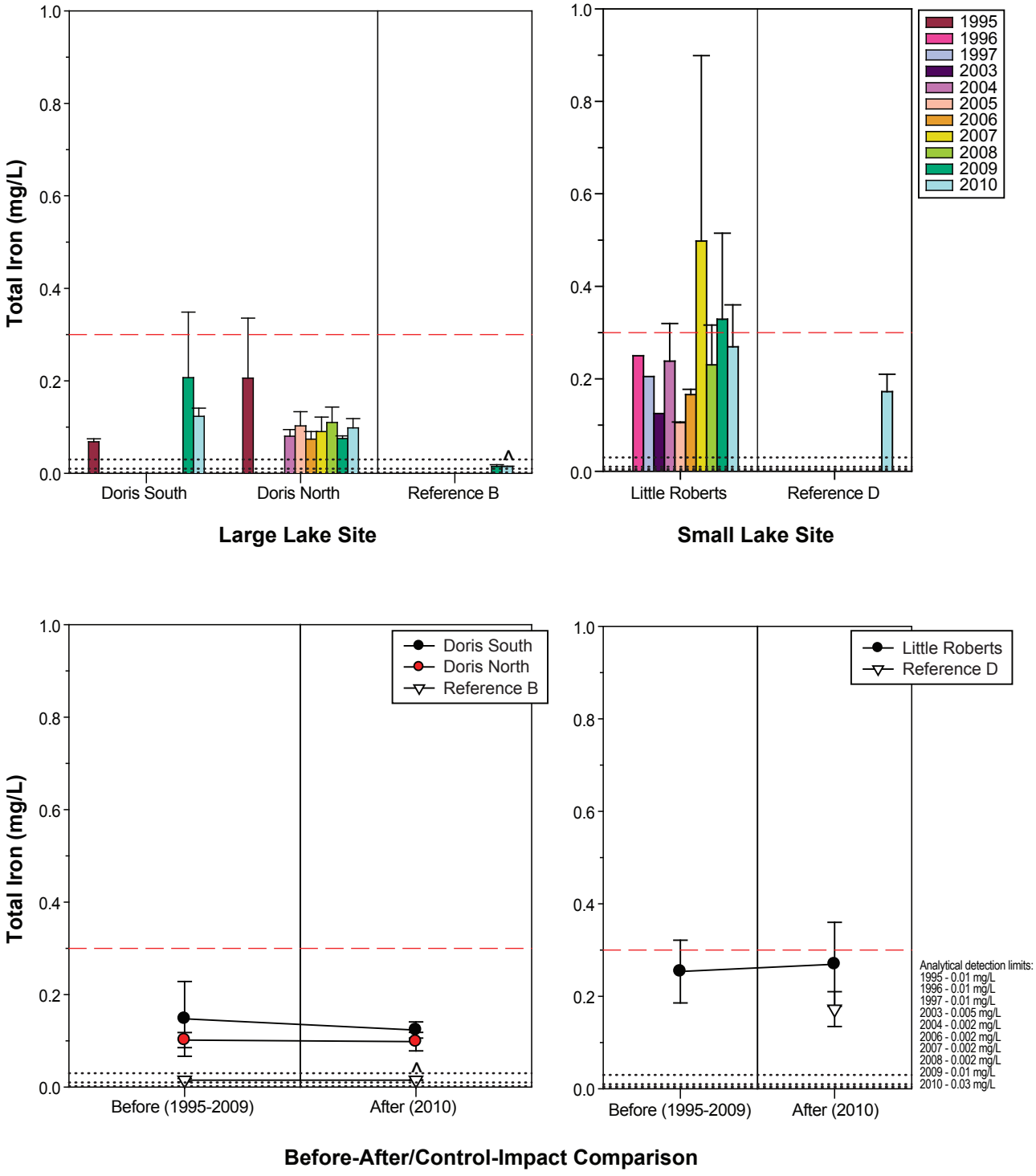

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME guideline for iron (0.3 mg/L).
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Iron Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-31

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3.2.2.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean concentrations of total lead were highly inter-annually variable in all lakes, making it difficult to distinguish potential Project-related effects from natural variability (Figure 3.2-32). For all exposure lakes, the before-after analysis shows that there was no detectable change in mean total lead concentrations in 2010 compared to historical means ($p = 0.66$ for Doris Lake South, $p = 0.40$ for Doris Lake North, and $p = 0.82$ for Little Roberts Lake), suggesting that 2010 Project activities had no effect on lead concentrations. Mean 2010 lead concentrations in all AEMP lakes were below the hardness-dependent CCME guideline for lead (Figure 3.2-32).

3.2.2.15 Total Mercury

Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All total mercury concentrations measured in exposure and reference lakes in 2010 were below the analytical detection limit of 0.00001 mg/L and the CCME guideline for inorganic mercury of 0.000026 mg/L (Figure 3.2-33). Therefore, there were no apparent Project effects on total mercury concentrations in lakes.

3.2.2.16 Total Molybdenum

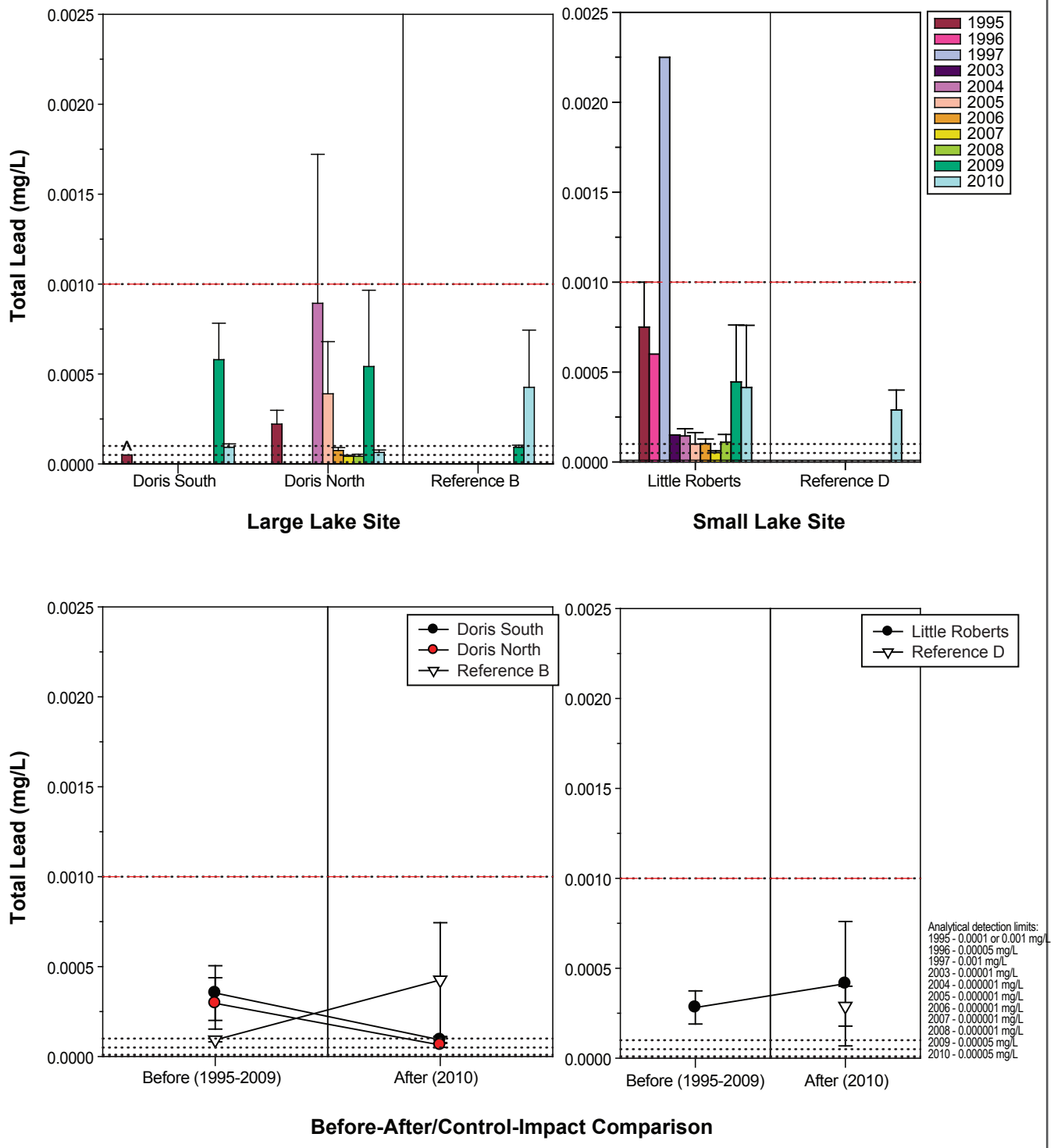
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total molybdenum concentrations were generally similar over time within each lake (Figure 3.2-34), suggesting that there was no effect of 2010 activities on total molybdenum concentrations. For all three exposure lakes, the before-after comparison confirms that there was no change in mean molybdenum concentrations in 2010 compared to historical means ($p = 0.39$ for Doris Lake South, $p = 0.086$ for Doris Lake North, and $p = 0.078$ for Little Roberts Lake). Mean 2010 total molybdenum concentrations in all lake sites were more than two orders of magnitude lower than the interim CCME guideline of 0.073 mg/L (Figure 3.2-34).

3.2.2.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2010 total nickel concentrations in all AEMP lakes were well below the hardness-dependent CCME guideline for nickel. In all three exposure lakes, mean 2010 nickel concentrations were similar to historical means (Figure 3.2-35), suggesting that 2010 Project activities did not cause an increase in total nickel concentration in these waterbodies. The before-after comparison confirms that mean nickel concentrations did not change significantly in any exposure lake in 2010 compared to previous years ($p = 0.56$ for Doris Lake South, $p = 0.92$ for Doris Lake North, and $p = 0.88$ for Little Roberts Lake).

3.2.2.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010, more than 90% of total zinc concentrations measured in exposure lakes were below the analytical detection limit of 0.003 mg/L, and all measured 2010 zinc concentrations were well below the CCME guideline of 0.03 mg/L (Figure 3.2-36). The before-after comparison confirms that there was no change in total zinc concentrations in the exposure lakes in 2010 compared to historical concentrations ($p = 0.35$ for Doris Lake South, $p = 0.55$ for Doris Lake North, and $p = 0.46$ for Little Roberts Lake).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME guideline for lead is hardness dependent.
Red dashed lines represent the minimum CCME guideline for lead regardless of water hardness (0.001 mg/L).
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Lead Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-32

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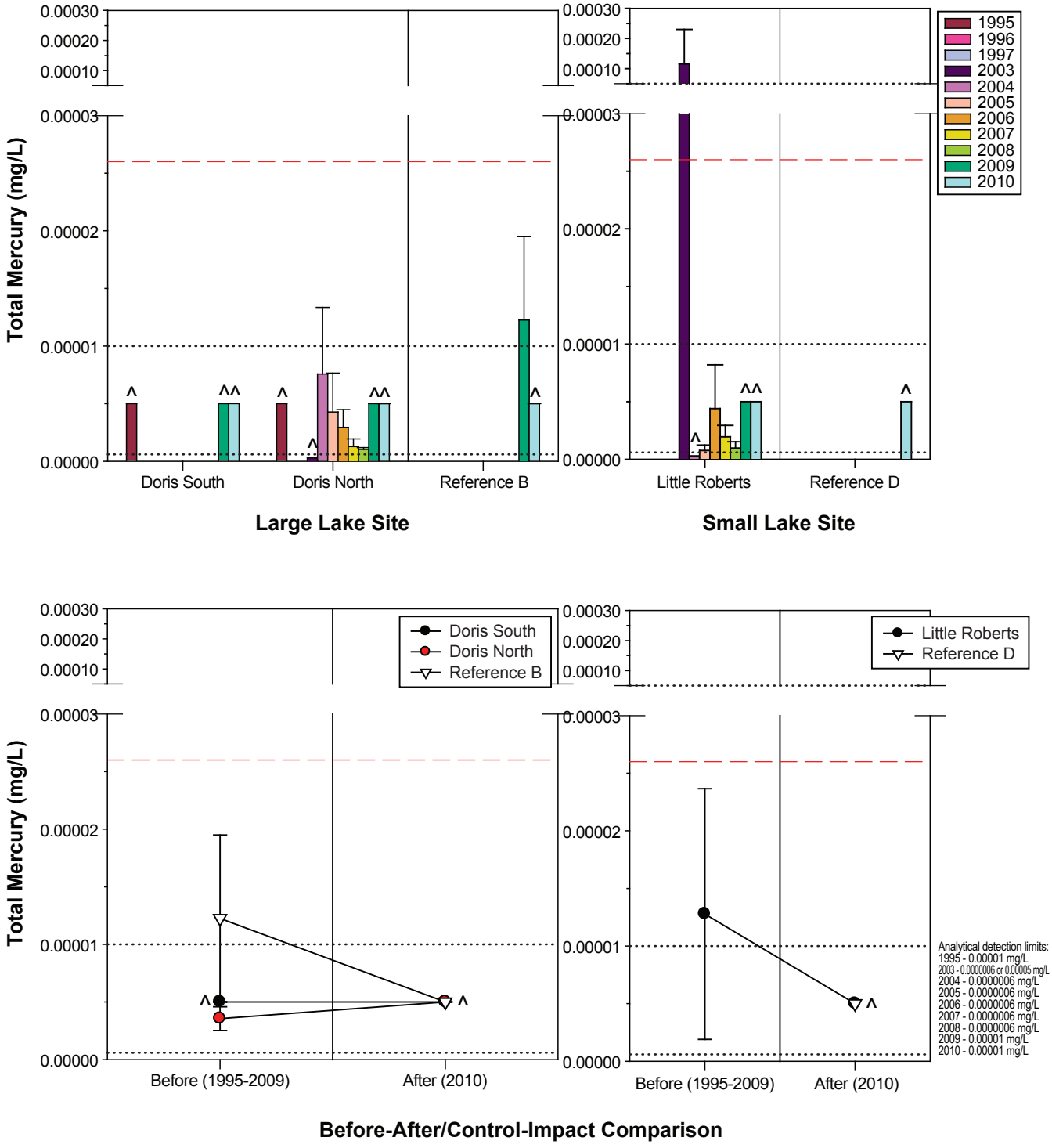


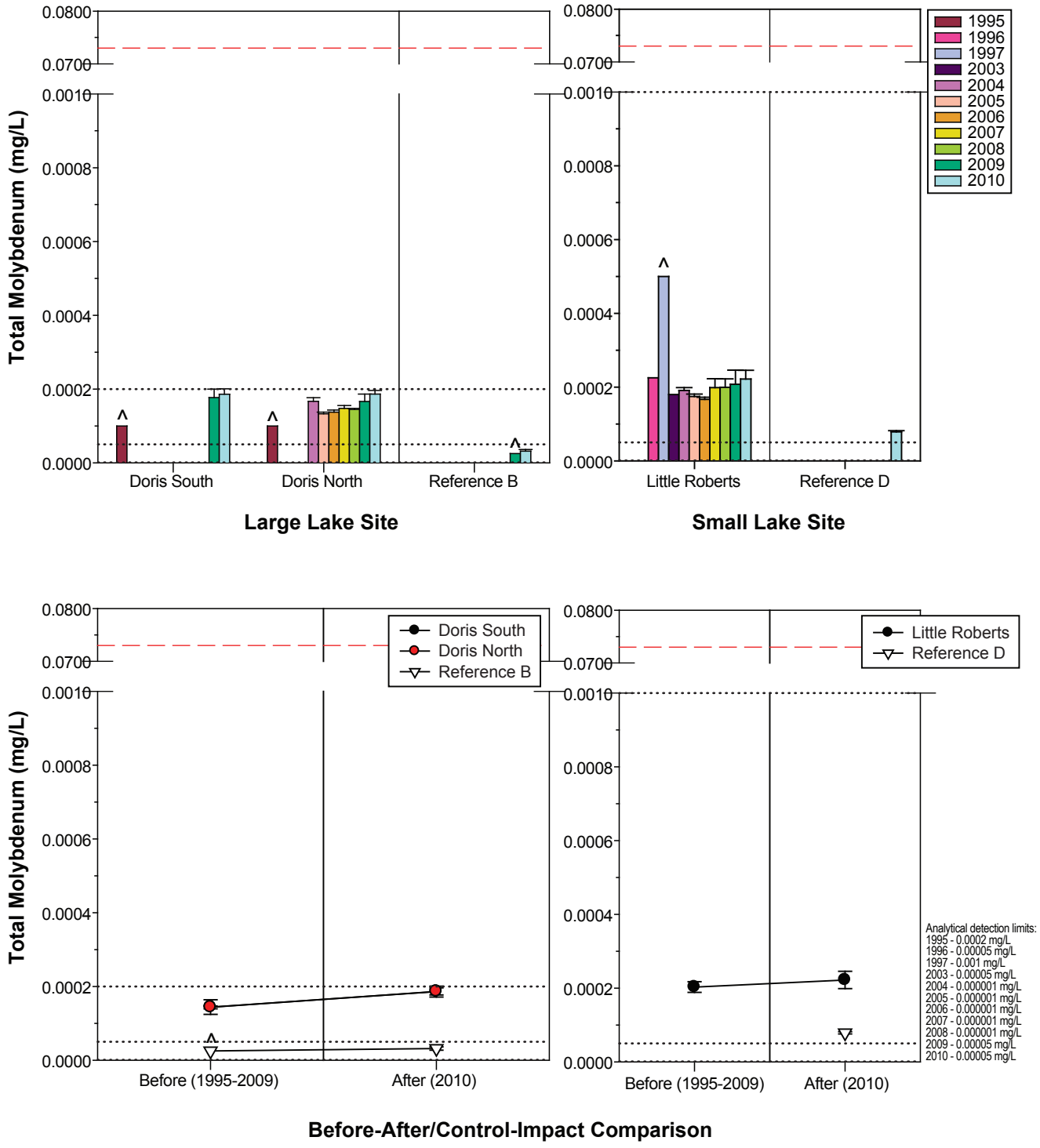
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for inorganic mercury (0.000026 mg/L).
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Mercury Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-33

Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME guideline for molybdenum (0.073 mg/L).
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Molybdenum Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-34

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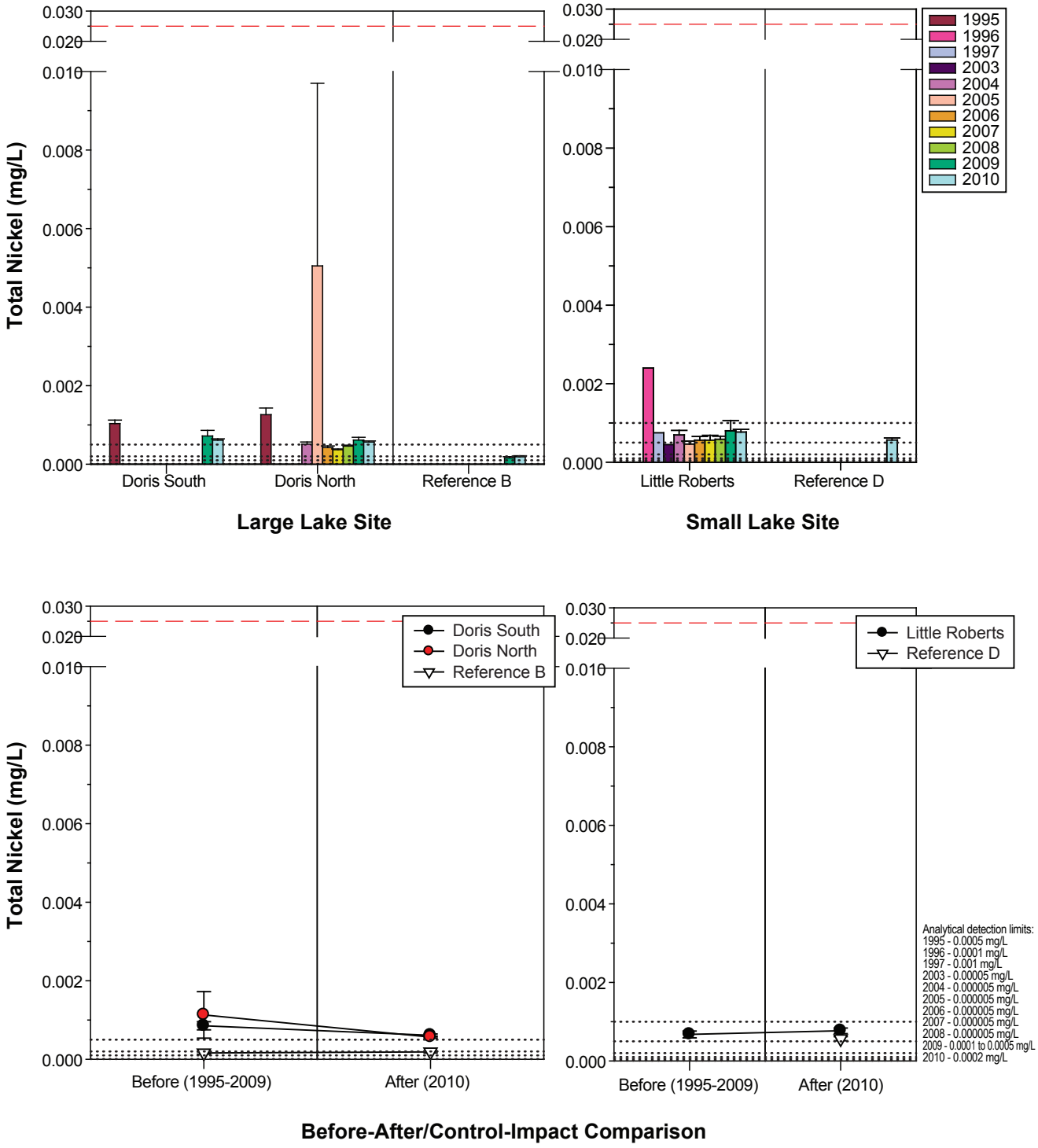


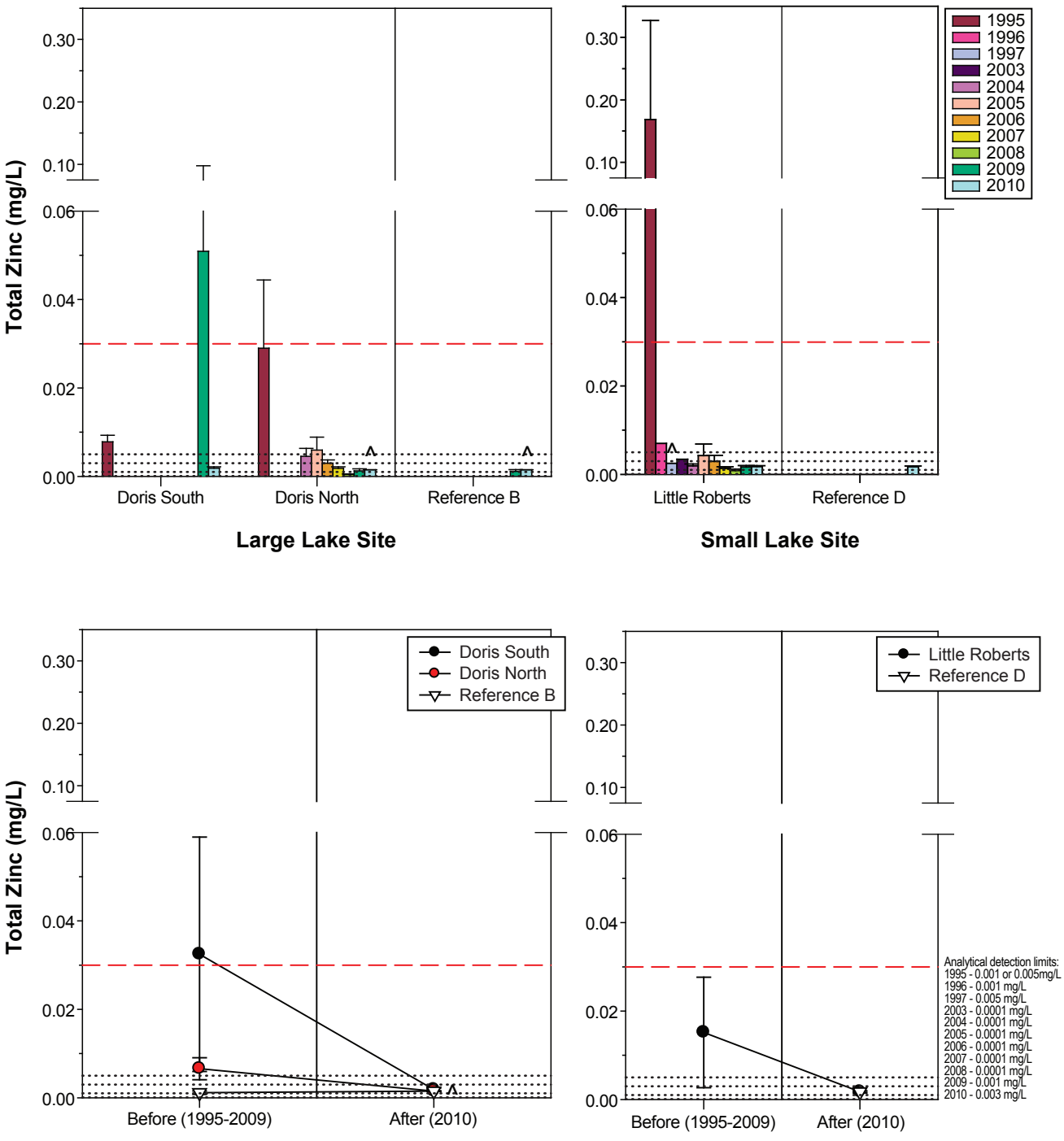
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the minimum CCME guideline for nickel regardless of water hardness (0.025 mg/L).
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Nickel Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-35

Rescan™ Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for zinc (0.03 mg/L).
Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Zinc Concentration in AEMP Lake Sites, Doris North Project, 1995–2010

Figure 3.2-36

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3.2.3 Marine

Water quality samples from marine areas were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Reference Bay (REF-Marine) in 2010. Historical data from 2009 are available for all sites, and additional historical data are available from 2004 to 2008 for site RBE. All 2010 data were surface samples, so any historical data collected from near the water-sediment interface were excluded from the historical dataset used for the effects analyses. The graphical effects analyses for marine water quality are shown in Figures 3.2-37 to 3.2-54. All statistical results are presented in Appendix C.

Marine water quality parameters were compared to applicable CCME water quality guidelines for the protection of marine aquatic life (CCME 2011b). All measured parameters in 2010 marine samples were below recommended CCME guidelines.

3.2.3.1 pH

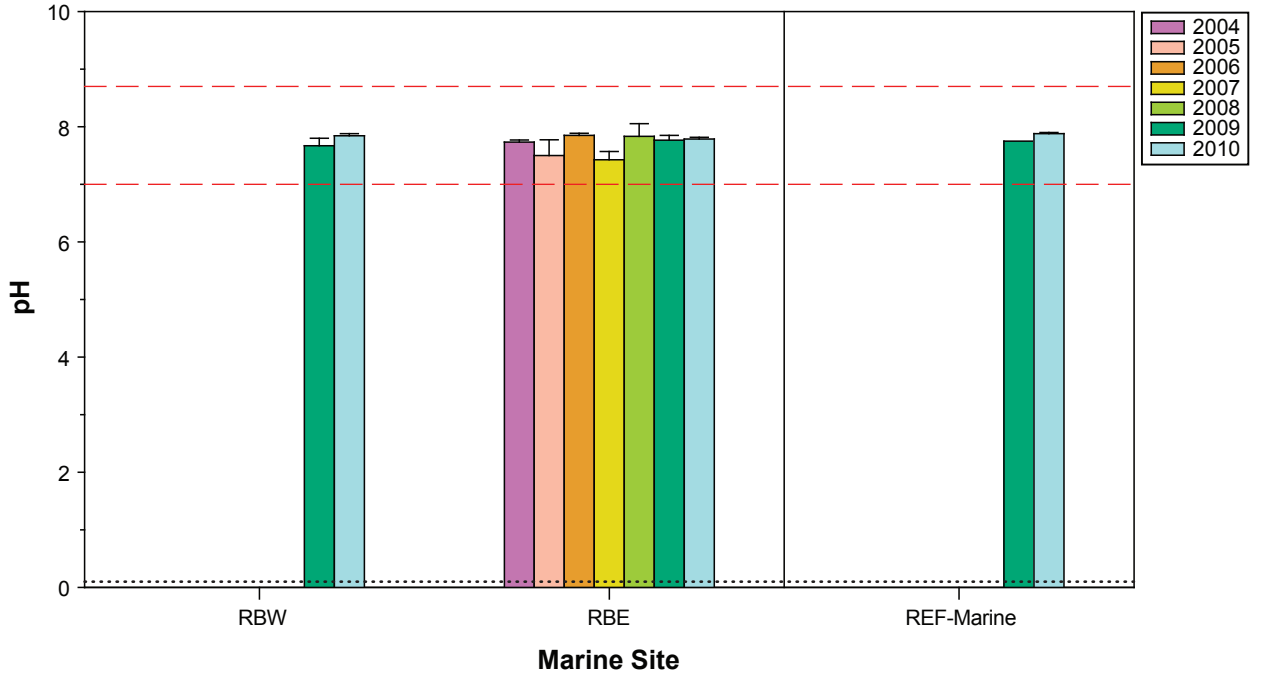
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. pH levels measured in Roberts Bay exposure sites in 2010 were similar to levels in Reference Bay and to historical ranges (Figure 3.2-37). Mean 2010 pH levels in marine exposure and reference sites were always within the recommended CCME guideline range of 7.0 to 8.7 (Figure 3.2-37). There was therefore no apparent effect of 2010 Project activities on marine pH. Marine environments have a high buffering capacity compared to freshwater systems, so pH levels are relatively insensitive to change. The before-after comparison confirms that there was no change in marine pH at the exposure sites in 2010 compared to previous years ($p = 0.018$ for RBW, $p = 0.71$ for RBE).

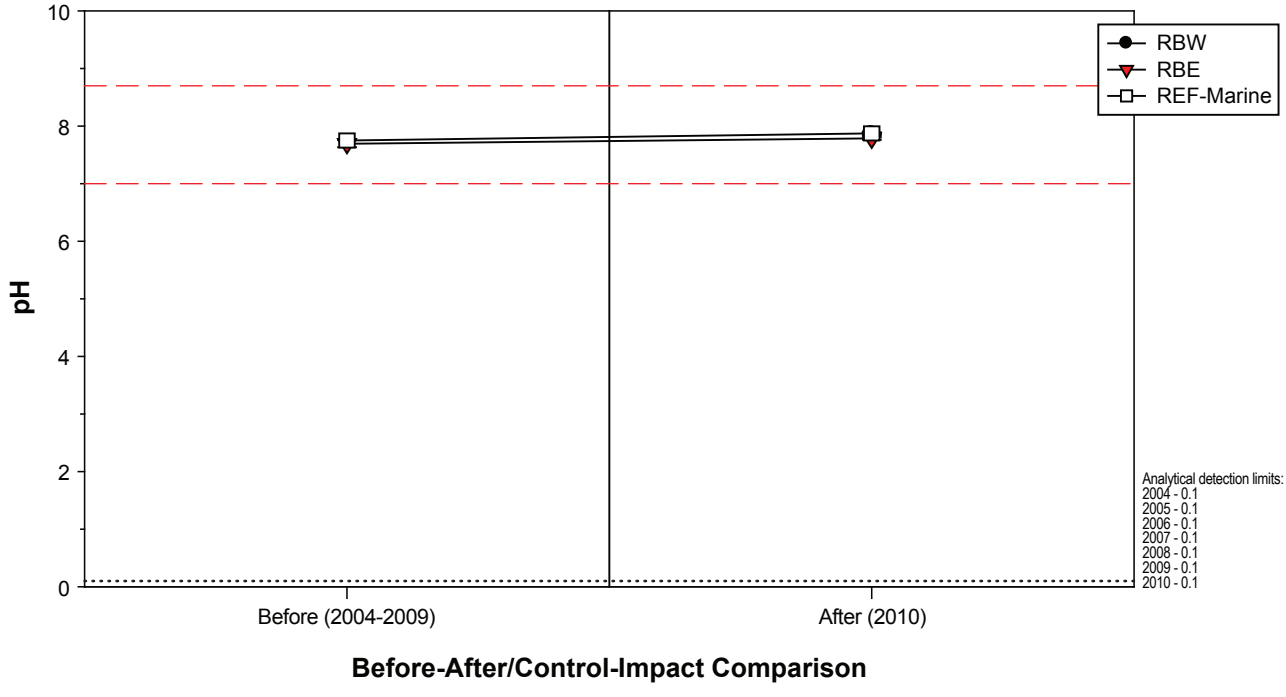
3.2.3.2 Total Alkalinity

Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. RBE is the only site for which historical total alkalinity data are available. At this site, mean 2010 alkalinity was slightly higher than historical means, but there was some overlap in alkalinity values because of large within-year differences. The before-after comparison confirms that there was no statistically significant change in alkalinity in 2010 at RBE compared to historical levels ($p = 0.090$). There is therefore no evidence of an effect of Project activities on alkalinity at this site. Although no statistical analysis is possible for site RBW, alkalinity levels were generally comparable among the three sites monitored in 2010 (RBE, RBW, and REF-Marine; Figure 3.2-38). Freshwater inputs can affect marine alkalinity because, as observed for waterbodies in the Doris North area, freshwater typically has lower alkalinity than marine water. Any variability in alkalinity levels in Roberts Bay was likely due to natural inter-annual variability in the volume of freshwater inflow to Roberts Bay.

3.2.3.3 Hardness

Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Hardness (as $CaCO_3$) levels in Roberts Bay sites in 2010 were generally similar to historical hardness levels, and were also similar to the hardness levels measured in Reference Bay in 2010 (Figure 3.2-39). The before-after comparison confirms that 2010 hardness levels at RBW and RBE were not distinguishable from historical levels ($p = 0.93$ for RBW, $p = 0.39$ for RBE). Therefore, there was no effect of 2010 Project activities on the hardness of marine waters.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME guideline pH range (7.0–8.7).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.

NEWMONT NORTH AMERICA

pH in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-37

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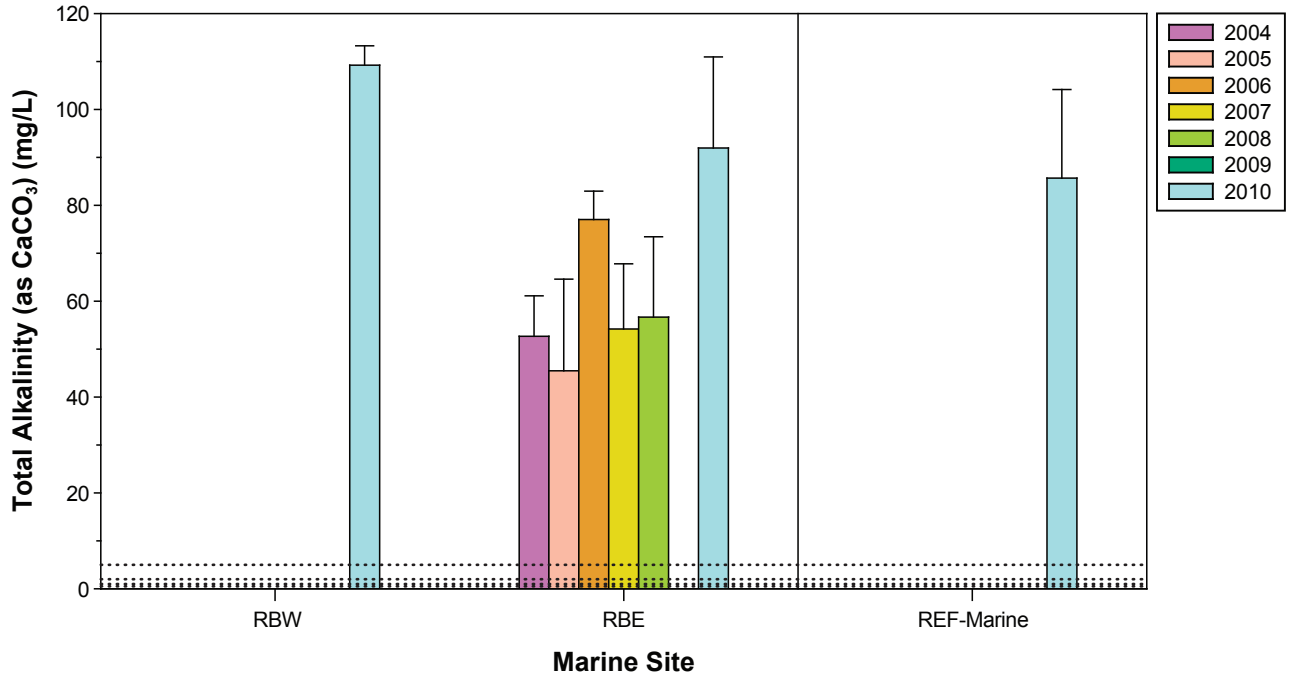

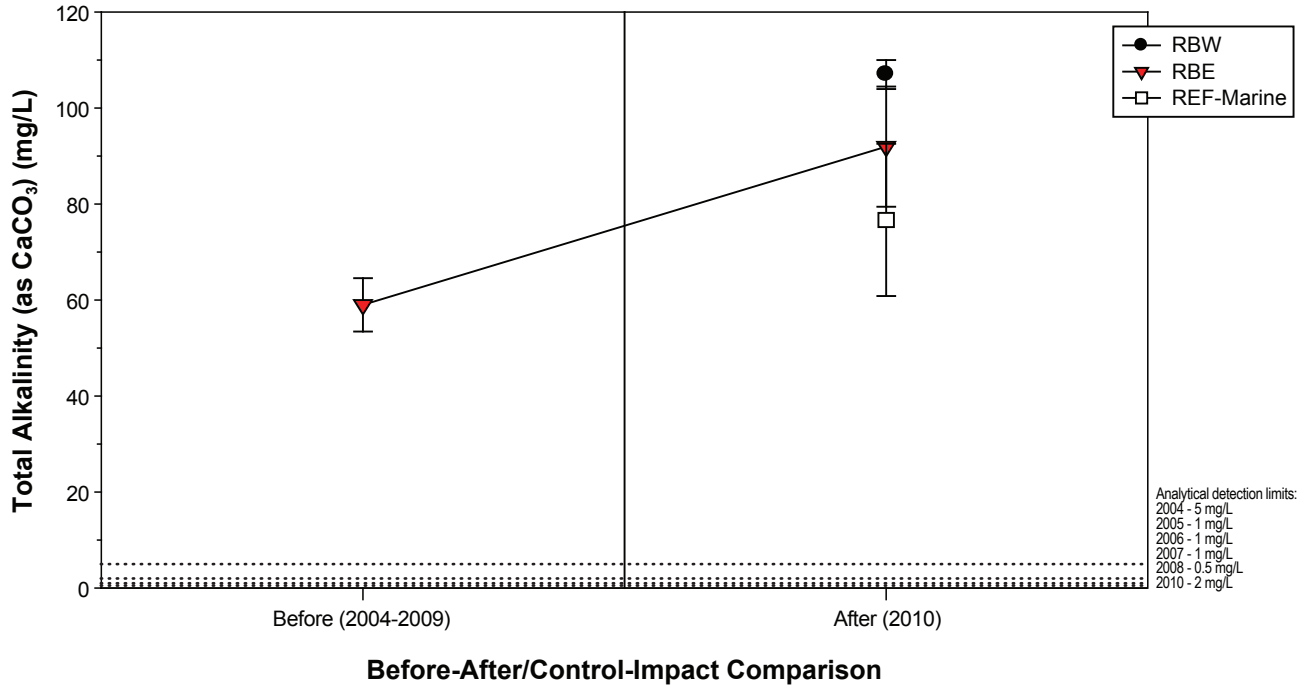

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Total Alkalinity in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-38

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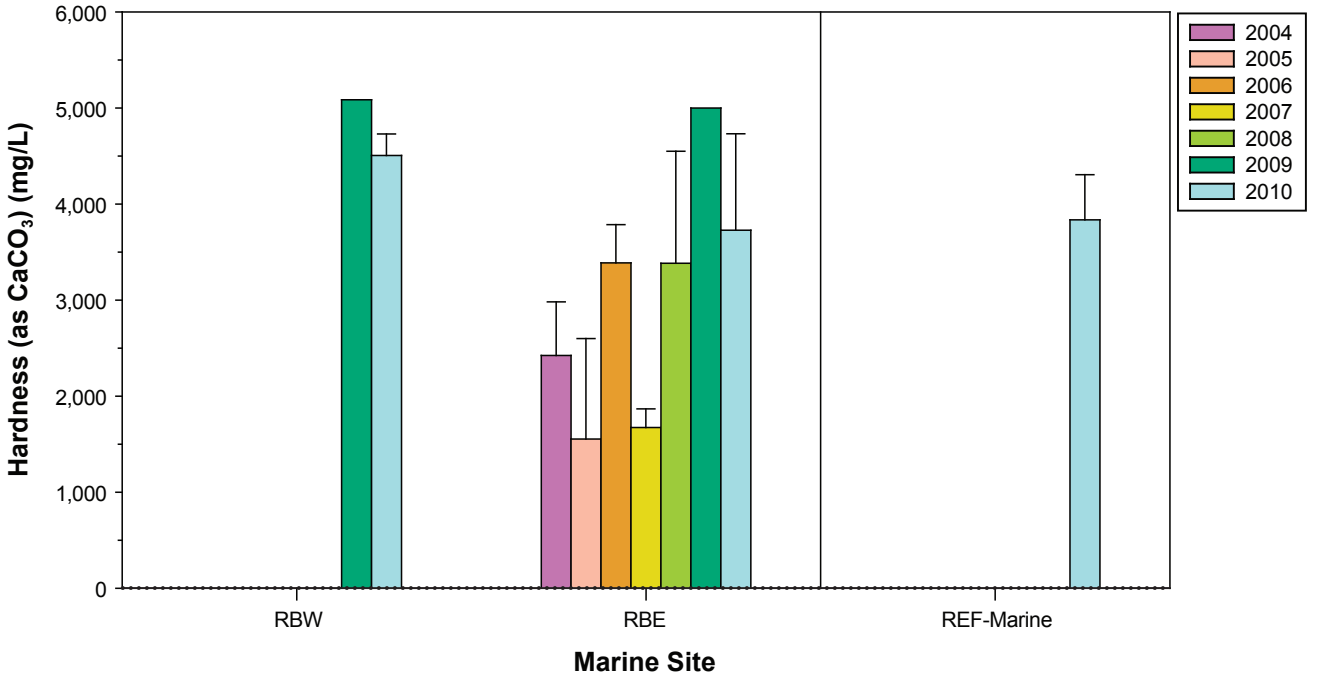

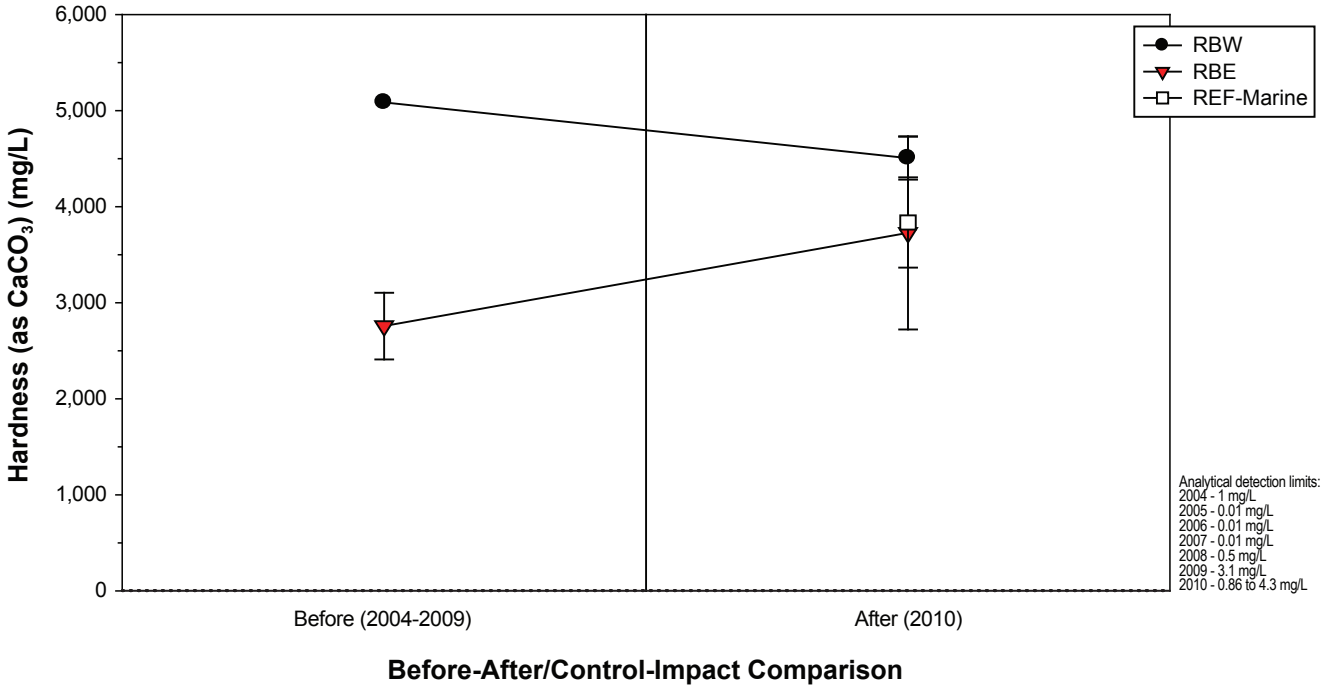

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

NEWMONT NORTH AMERICA

Hardness in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-39

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3.2.3.4 Total Suspended Solids

Total suspended solids (TSS) are regulated as deleterious substances in effluents as per Schedule 4 of the MMER. Mean 2010 TSS concentrations at RBW and RBE were slightly higher than historical means (Figure 3.2-40). However, the before-after comparison indicates that 2010 means were not statistically distinguishable from historical means ($p = 0.85$ for RBW and $p = 0.96$ for RBE). There was therefore no effect of 2010 Project activities on marine TSS.

The CCME guideline for TSS is dependent upon background levels (for clear-flow waters with background TSS levels below 25 mg/L, a maximum increase of 25 mg/L is allowable for any short-term exposure or 5 mg/L for longer term exposure; CCME 2011b). Because there was no increase in TSS concentrations from background levels, 2010 TSS concentrations in marine exposure sites were below the CCME guideline.

3.2.3.5 Total Ammonia

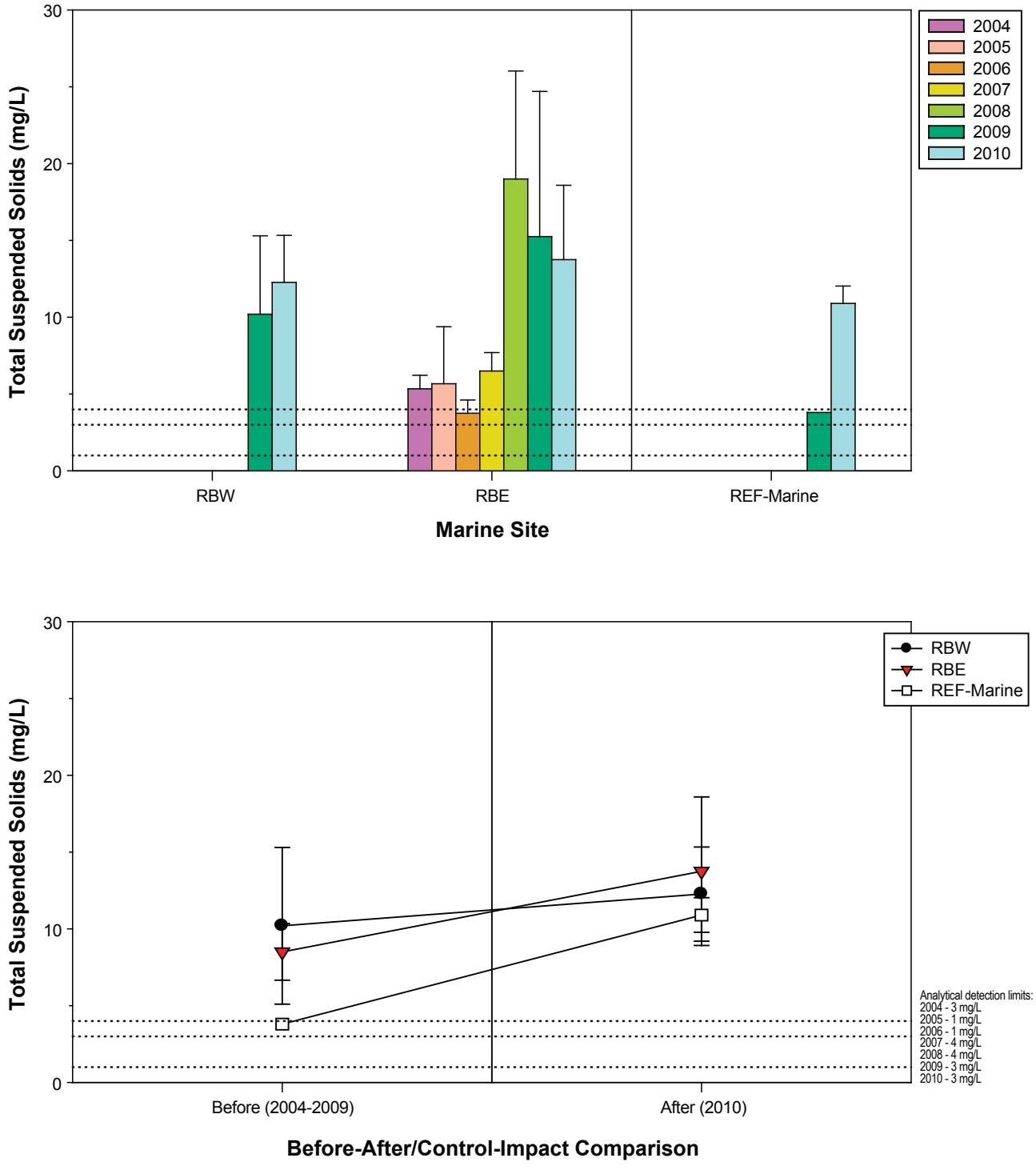
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total ammonia concentrations in all 2010 samples from Roberts Bay were below the analytical detection limit of 0.005 mg ammonia-N/L (Figure 3.2-41). At site RBW, all 2009 concentrations were also below the detection limit of 0.005 mg ammonia-N/L. At site RBE, historical ammonia concentrations were frequently higher than 2010 concentrations (Figure 3.2-41). Therefore, 2010 Project activities had no detectable effect on total ammonia concentrations in the marine environment.

3.2.3.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In 2010 marine samples, 78% of nitrate concentrations were below the variable detection limit of 0.006, 0.5, or 2.5 mg nitrate-N/L. Including the historical data, 78% of nitrate concentrations at site RBE and 67% of concentrations at site RWB were below the detection limit, so statistical analysis is not considered reliable for these data. The before-after plot shows no evidence of any increase in nitrate concentration at these sites (Figure 3.2-42); however, little can be said about the concentrations measured in September 2010 that were below the very high detection limit of 0.5 mg nitrate-N/L (the highest detection limit of 2.5 mg/L applied only to a single sample collected in July from REF-Marine, and was the result of a sample processing error). All 2010 and historical nitrate concentrations measured in marine reference and exposure sites were well below the CCME guideline of 3.612 mg nitrate-N/L (Figure 3.2-42). There was no apparent effect of Project activities on nitrate concentrations in the marine exposure sites.

3.2.3.7 Total Cyanide

Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. At site RBE, the only site for which historical cyanide data are available, historical cyanide concentrations were usually near or below the detection limit, with the exception of some relatively high concentrations measured in 2005 (Figure 3.2-43). The mean 2010 cyanide concentration was well within the range of historical concentrations, and the before-after analysis shows that the 2010 mean is not distinguishable from the historical mean ($p = 0.19$). Although statistical analysis is not possible for RBW because there is no historical data for this site, mean 2010 cyanide concentrations were very similar among exposure and reference sites (Figure 3.2-43). Cyanide was not brought to the Project site in 2010, so there is no reason to expect that cyanide concentrations would increase in either of the marine exposure sites.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The CCME guideline for total suspended solids is dependent upon background levels.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Suspended Solids in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-40

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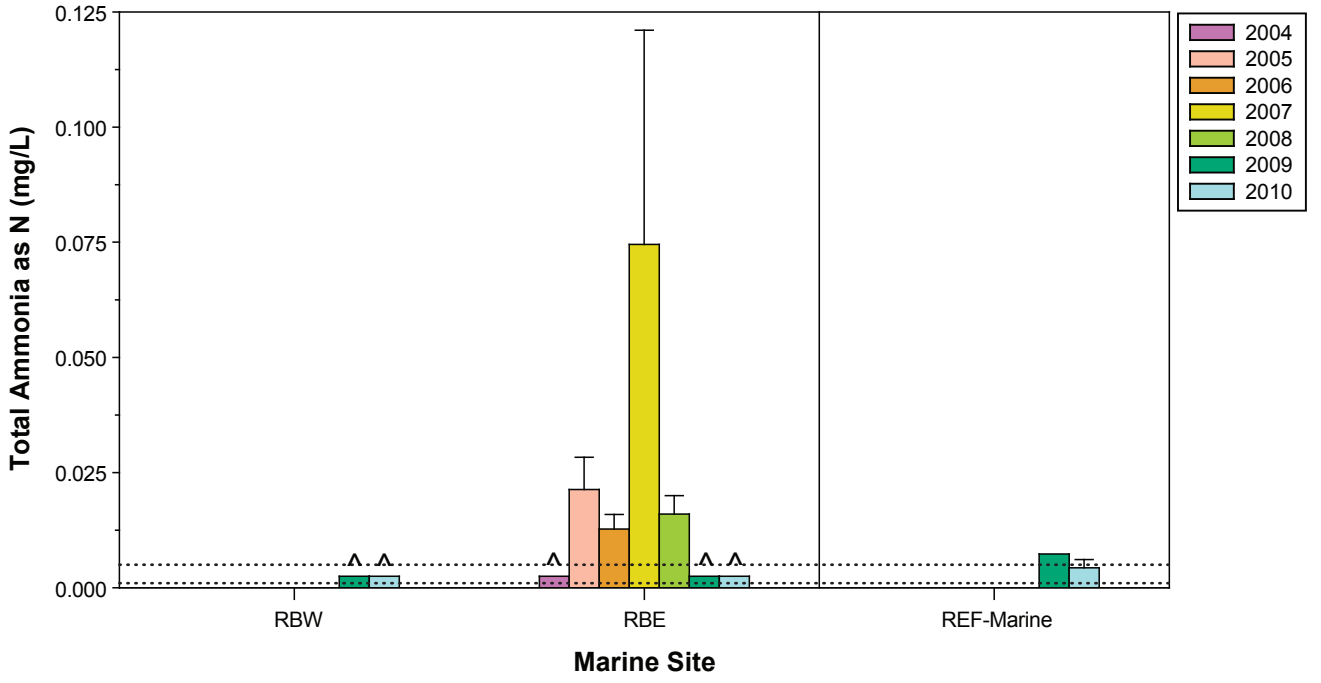

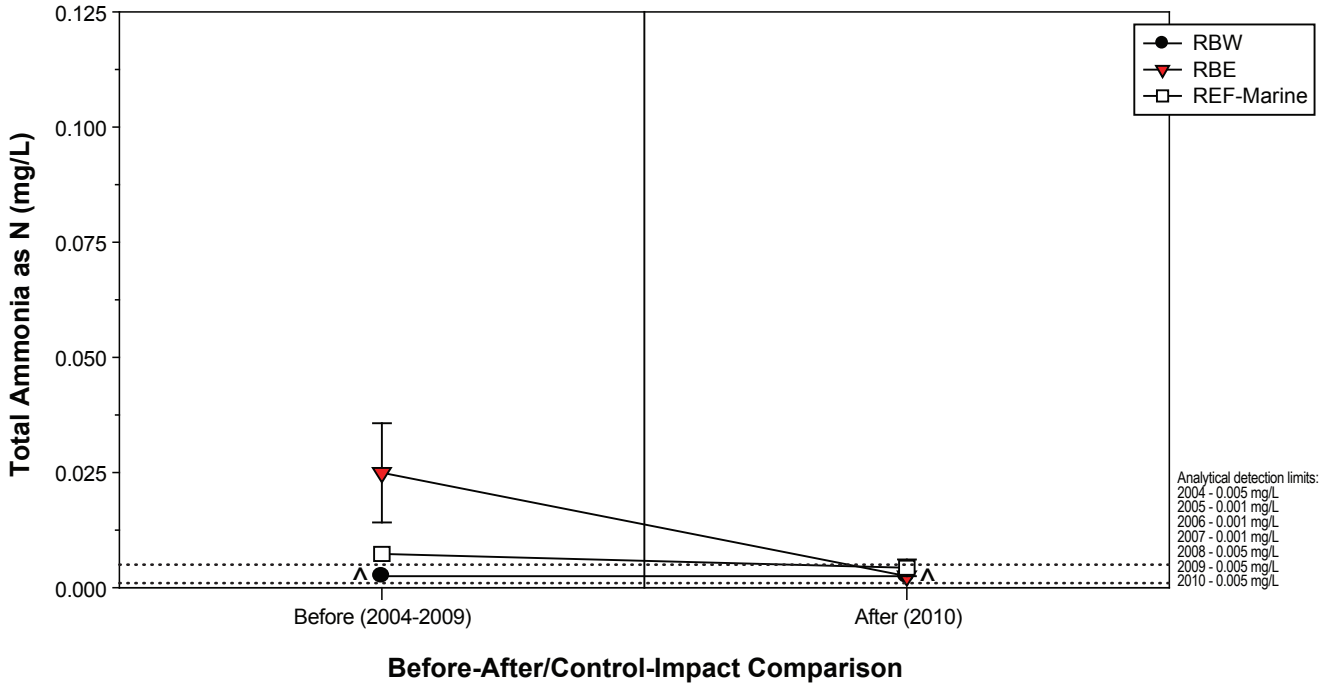

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-41

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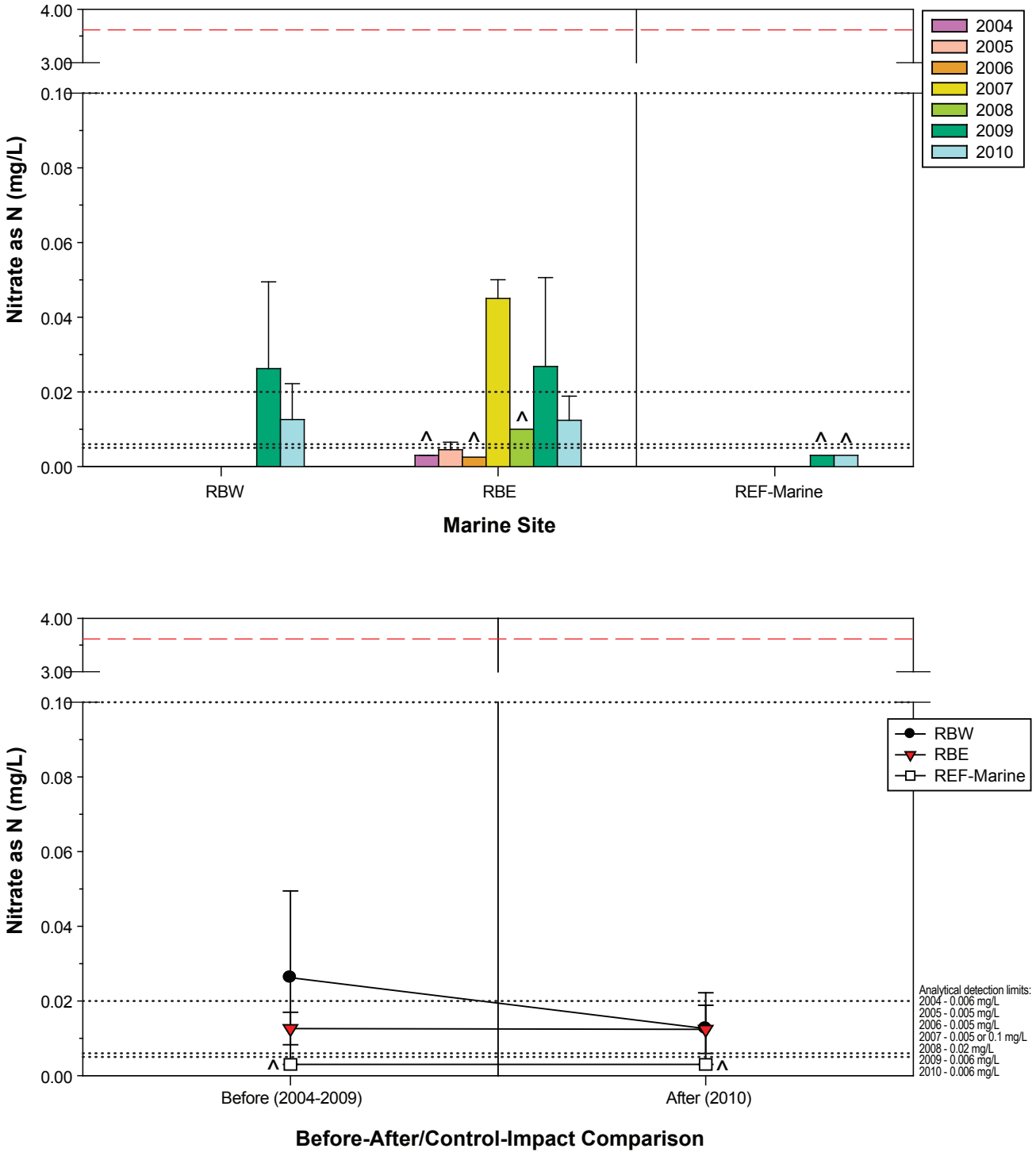

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Sample concentrations that were below the very high detection limits of 0.5 or 2.5 mg/L were excluded from plots.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME guideline for nitrate as N (3.612 mg/L).
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Nitrate Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-42

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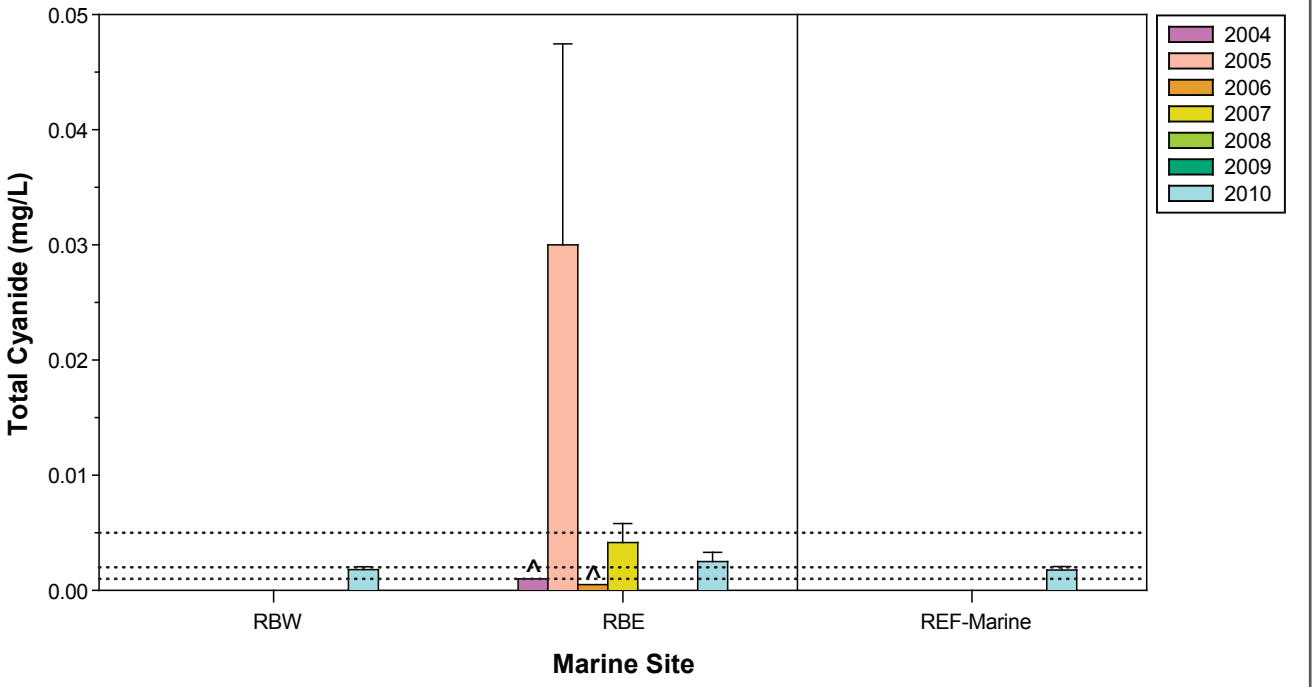

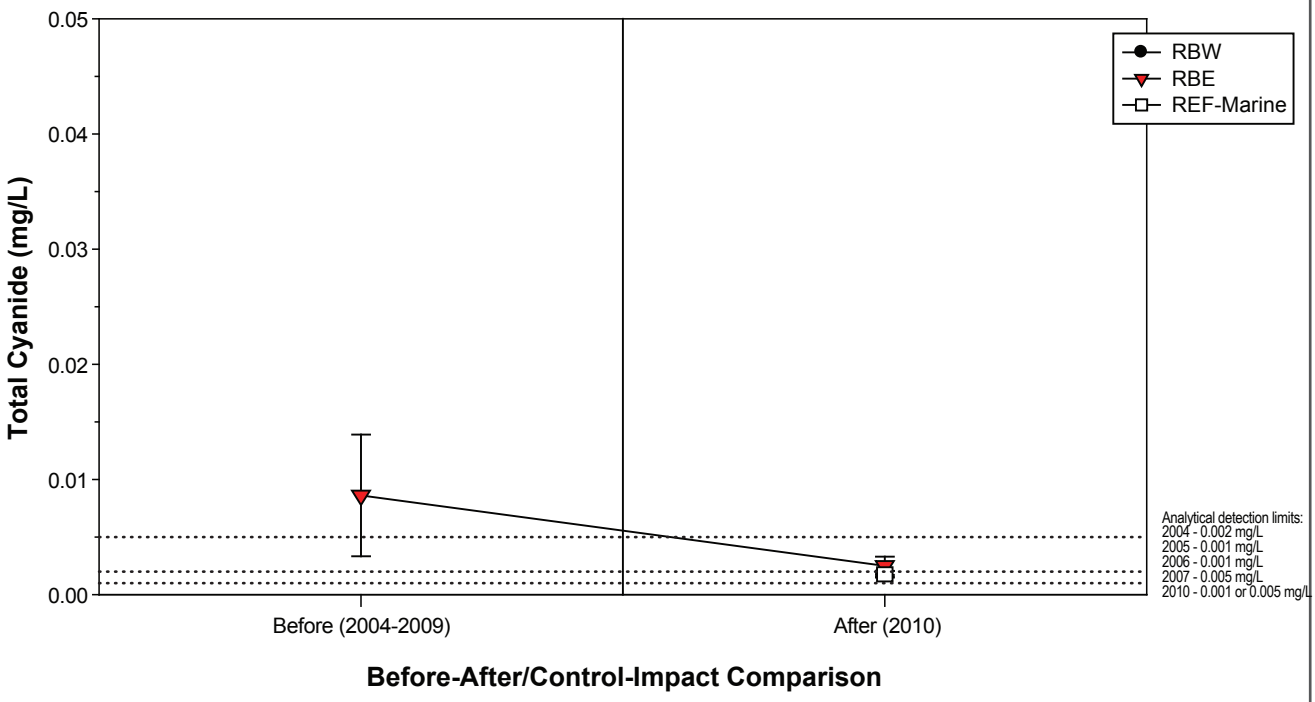

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The total cyanide concentrations in samples collected at RBE in May and July, 2007, were below the very high detection limits of 0.5 and 5 mg/L, respectively. These concentrations were not plotted at half the detection limit as they are beyond the range of the graphs.
^ Indicates that concentrations were below the detection limit in all samples.
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cyanide Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-43

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3.2.3.8 Radium-226

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010, radium-226 concentrations were below the analytical detection limit of 0.005 mg/L in 94% of marine samples (Figure 3.2-44). Historical concentrations at site RBE were near or below the detection limit of 0.005 mg/L. There is no historical radium-226 data available for either RBW or REF-Marine, but all 2010 concentrations at these sites were below the detection limit (Figure 3.2-44). There is therefore no evidence of an increase in radium-226 concentrations in the marine environment in 2010. Statistical analysis is not recommended for radium-226, because > 70% of historical and 2010 concentrations were below analytical detection limits.

3.2.3.9 Total Aluminum

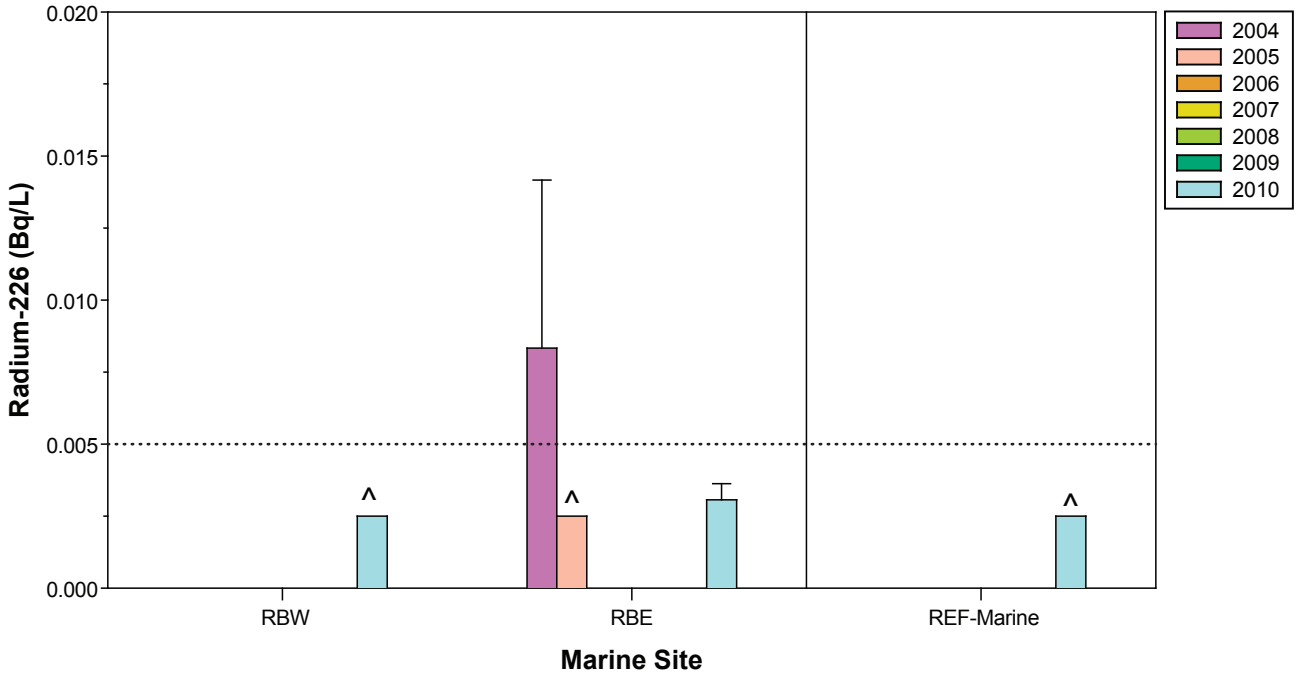
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, the mean 2010 total aluminum concentration was well within the range of historical means. At RBW, the 2010 mean was slightly higher than the 2009 mean, although variability was high (Figure 3.2-45). The before-after comparison shows that for both marine exposure sites, the 2010 mean was not statistically different from the historical mean ($p = 0.75$ for RBW and $p = 0.65$ for RBE). Therefore, there was no apparent effect of Project activities on total aluminum concentrations in Roberts Bay.

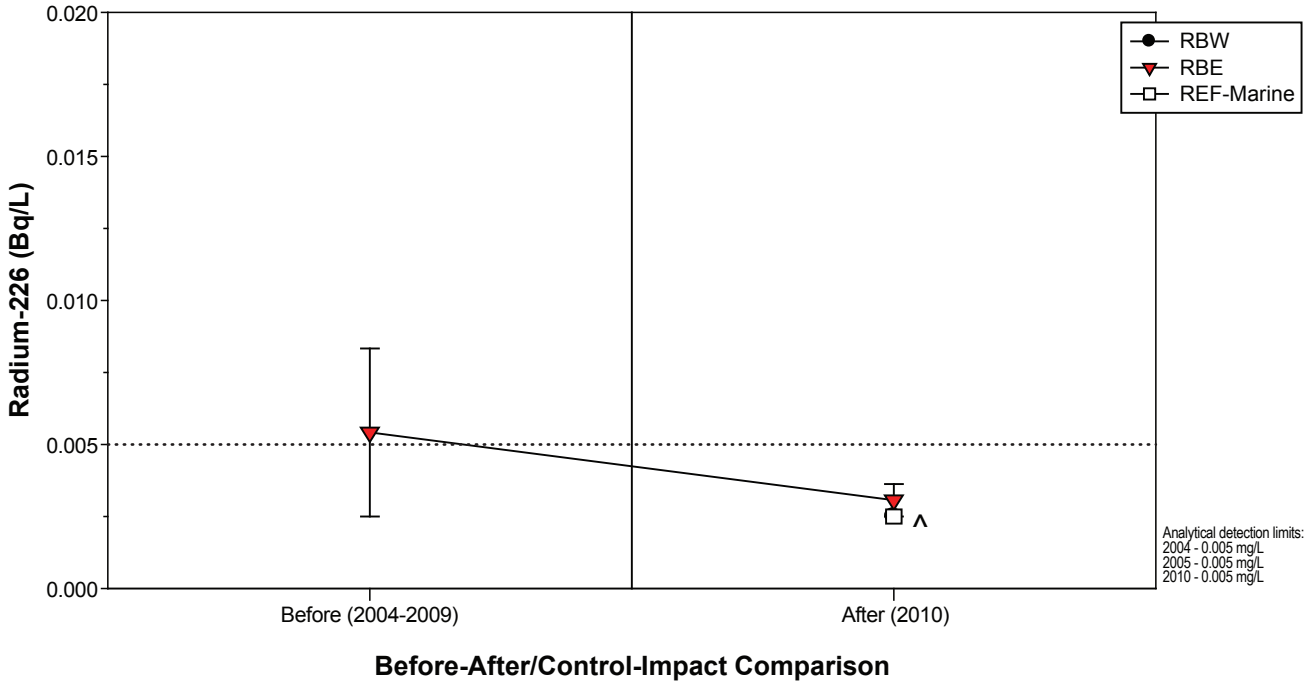
3.2.3.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010, all total arsenic concentrations collected in Roberts and Reference bays between April and August were below the analytical detection limit of 0.002 mg/L, and well below the CCME guideline of 0.0125 mg/L (Figure 3.2-46). For some September samples, a lower detection limit of 0.0004 mg/L was achieved, and concentrations of approximately 0.001 mg/L were measured in Roberts Bay sites. These concentrations were similar to historical concentrations measured between 2007 and 2009, but were much lower than the anomalously high arsenic concentrations measured at RBE between 2004 and 2006, which were nearly an order of magnitude higher than 2010 concentrations (Figure 3.2-46). These unusually high arsenic concentrations were treated as outliers and removed from the dataset for the statistical analyses, in order to increase the ability of statistical tests to detect differences. The before-after comparison indicates that the 2010 mean arsenic concentrations in RBW and RBE were not distinguishable from historical means ($p = 0.059$ for RBW and $p = 0.73$ for RBE). Therefore, 2010 Project activities did not affect total arsenic concentrations in the marine sites.

3.2.3.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In 2010, all total cadmium concentrations in samples collected from Roberts and Reference bays between April and August were below the analytical detection limit and the CCME guideline of 0.00012 mg/L (Figure 3.2-47). For some September samples, a lower detection limit of 0.00002 mg/L was achieved, and concentrations of approximately 0.00004 mg/L were measured in Roberts Bay sites. These 2010 concentrations were comparable to historical levels. When historical data are added to the 2010 cadmium dataset, the proportion of censored data ranges from 48% to 60% among sites. Results of statistical analyses can be presented for cadmium, but they should be interpreted cautiously because of the high proportion of censored data. The before-after plot shows that 2010 mean cadmium concentrations increased slightly in both of the exposure sites and at the reference site compared to historical means (Figure 3.2-47); however, the before-after statistical comparison indicates that these differences were not statistically significant ($p = 0.17$ for RBW, $p = 0.32$ for RBE). The conclusions of this analysis do not change if the full detection limit is used instead of the half detection limit as a substitute for values that are below the detection limit. Overall, there was no effect of 2010 activities on total cadmium concentrations in the marine environment.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Radium-226 Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-44

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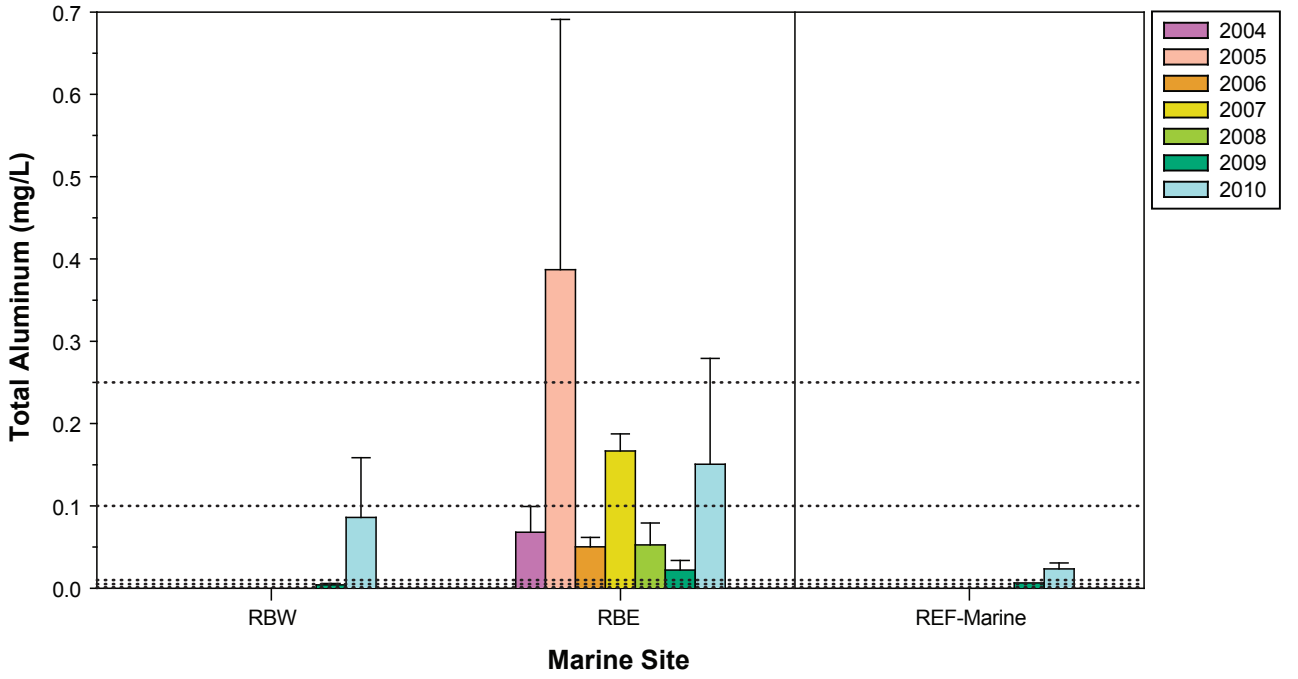

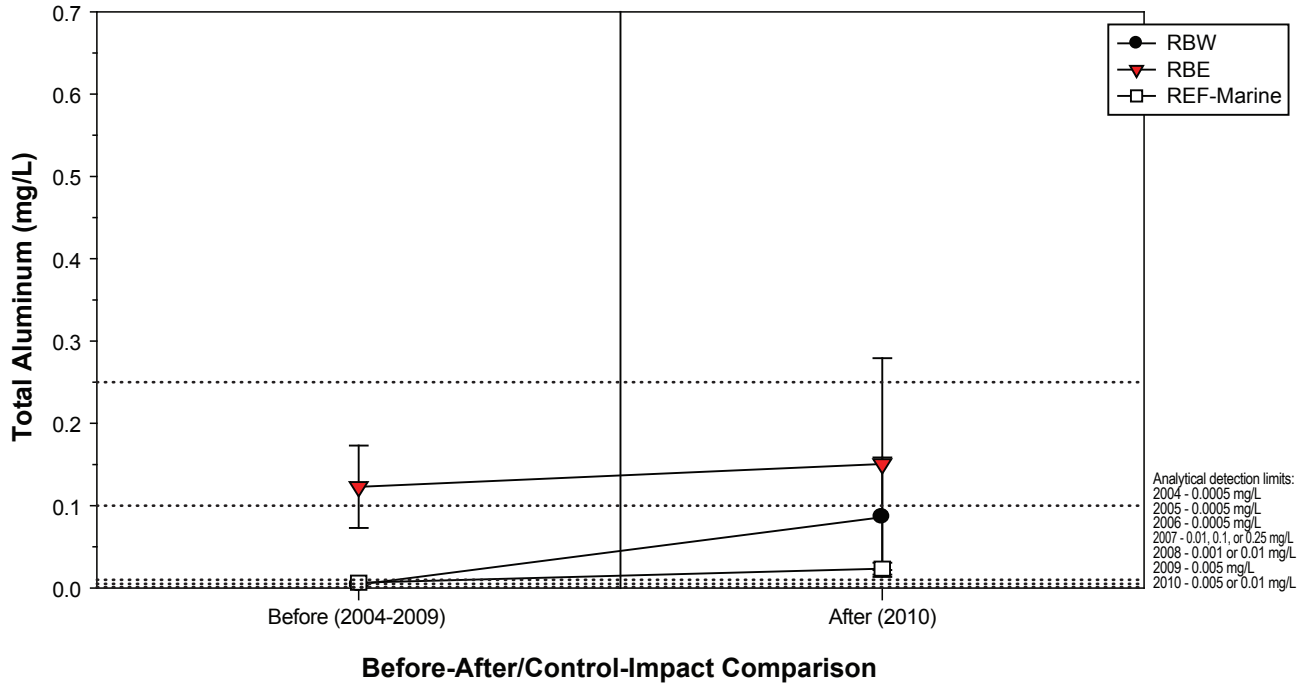

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Aluminum Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-45

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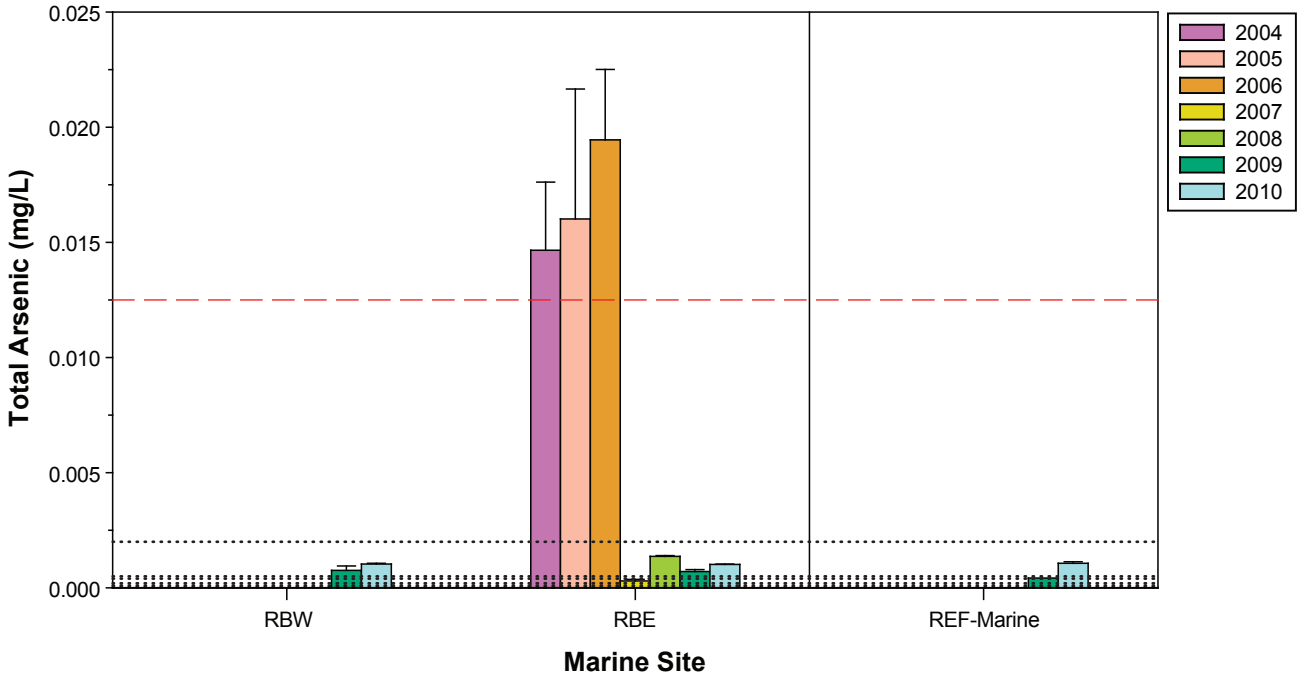

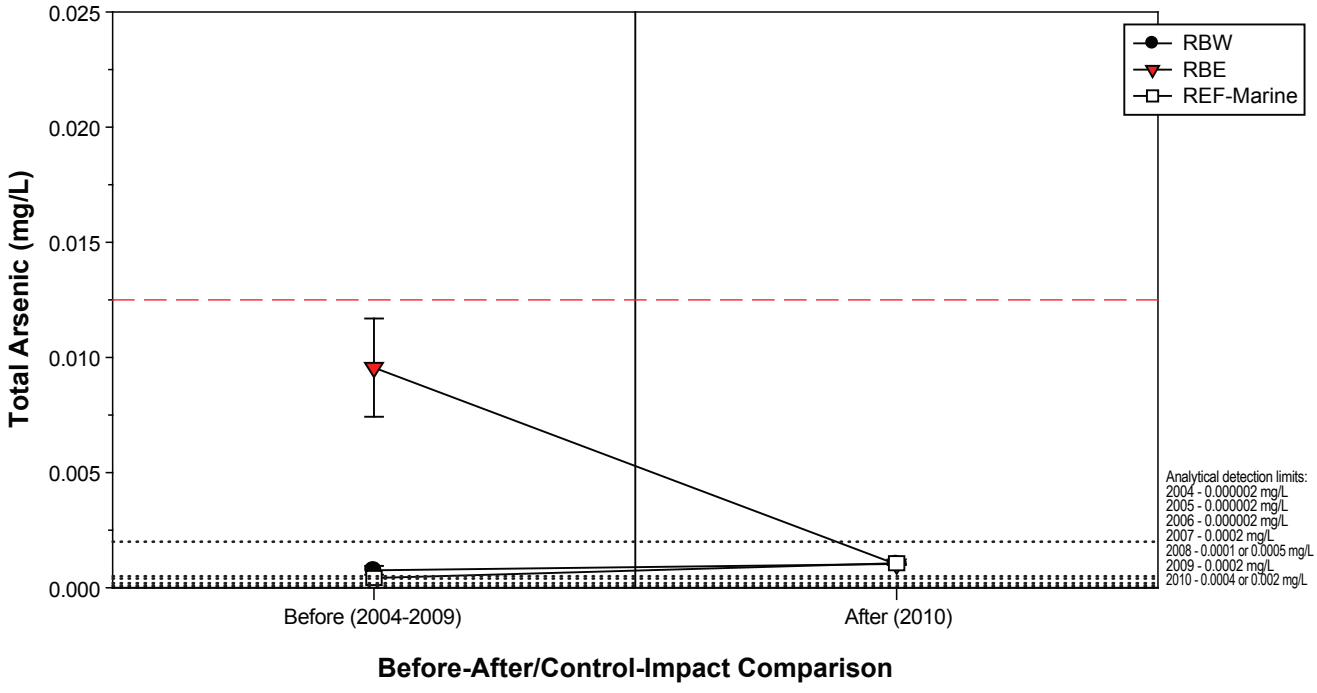

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the interim CCME guideline for arsenic (0.0125 mg/L).
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Arsenic Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-46

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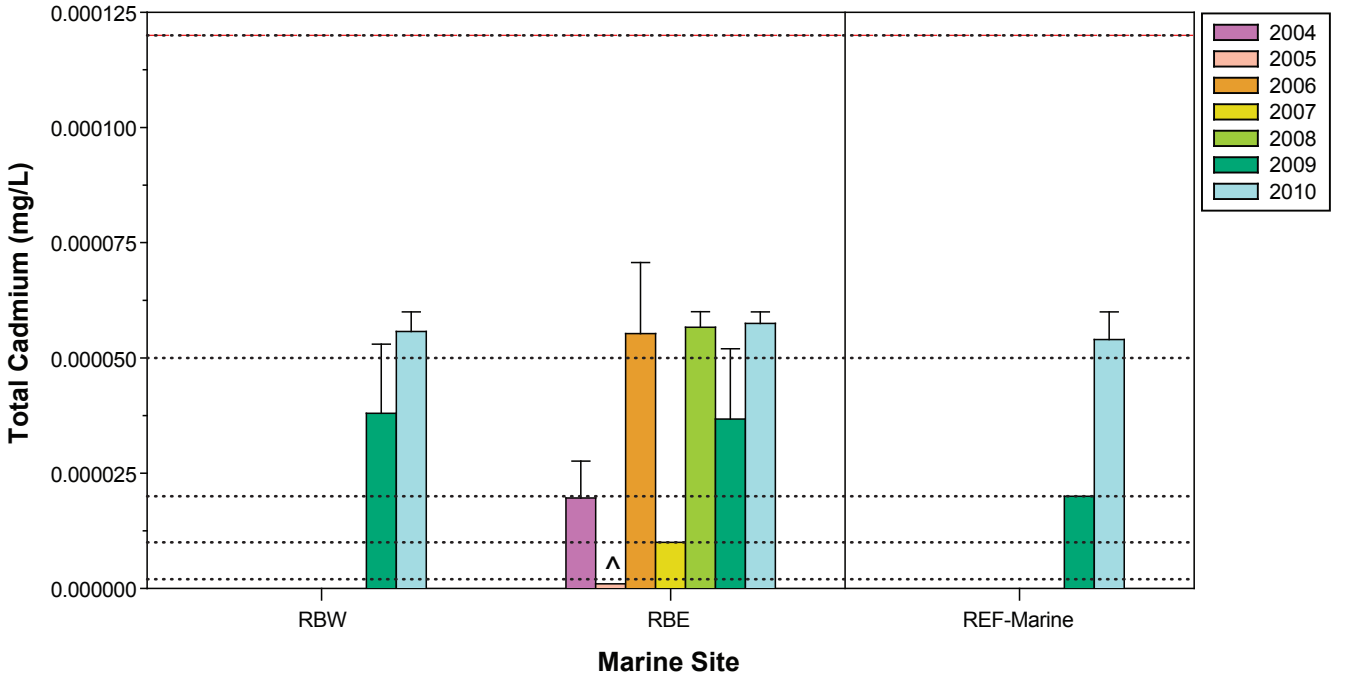

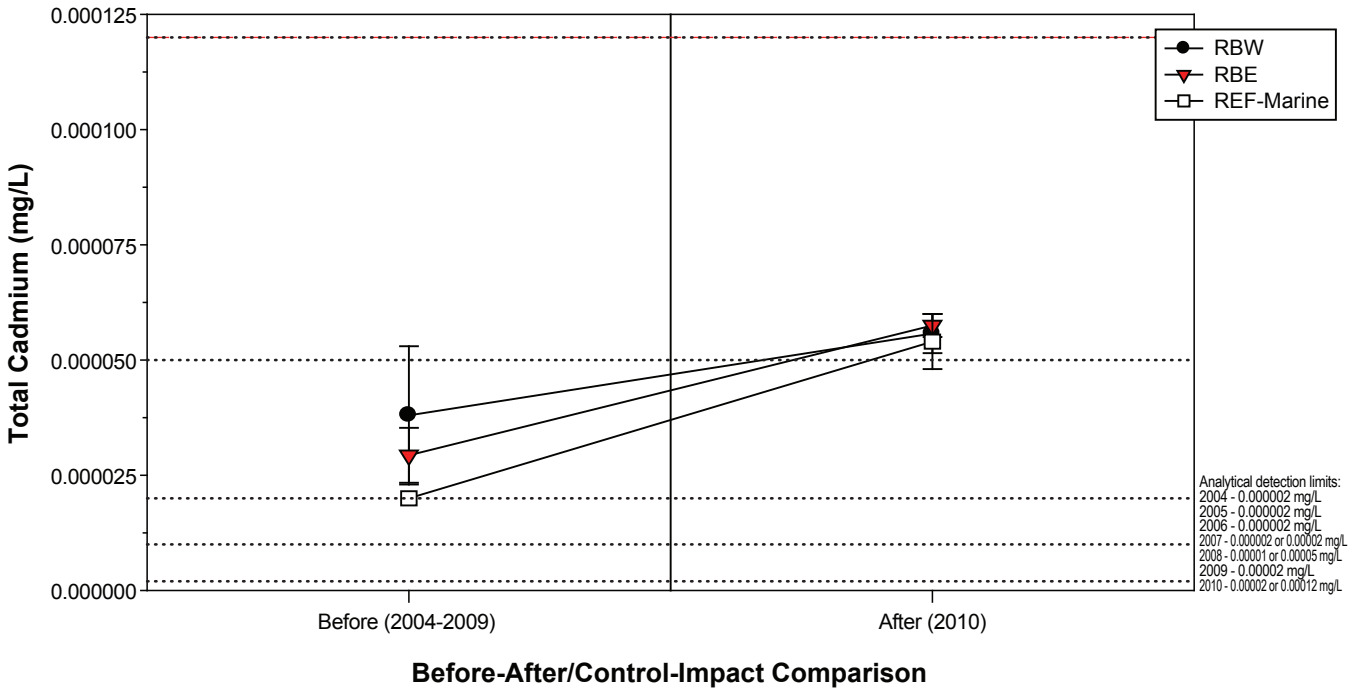

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME guideline for cadmium (0.00012 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Cadmium Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-47

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3.2.3.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Between 2004 and 2009, total copper concentrations at RBE were inter-annually variable. The 2010 mean concentration at RBE was within range of these historical levels (Figure 3.2-48). At RBW, 2010 total copper concentrations were slightly higher than 2009 concentrations (Figure 3.2-48). The before-after comparison shows that for both RBW and RBE, there was no difference between historical and 2010 mean copper concentrations ($p = 0.64$ for RBW, $p = 0.62$ for RBE). There was therefore no effect of 2010 Project activities on total copper concentrations in Roberts Bay.

3.2.3.13 Total Iron

Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, 2010 total iron concentrations were within range of historical values, and the before-after plot shows that the historical and 2010 mean concentrations were nearly identical (Figure 3.2-49). At site RBW, there was an increase in mean iron concentration in 2010 compared to 2009 (Figure 3.2-49). For both of the Roberts Bay sites, the before-after analysis shows that 2010 means were not distinguishable from historical means ($p = 0.70$ for RBW, $p = 0.97$ for RBE). Therefore, there was no apparent effect of 2010 activities on total iron concentrations in marine sites.

3.2.3.14 Total Lead

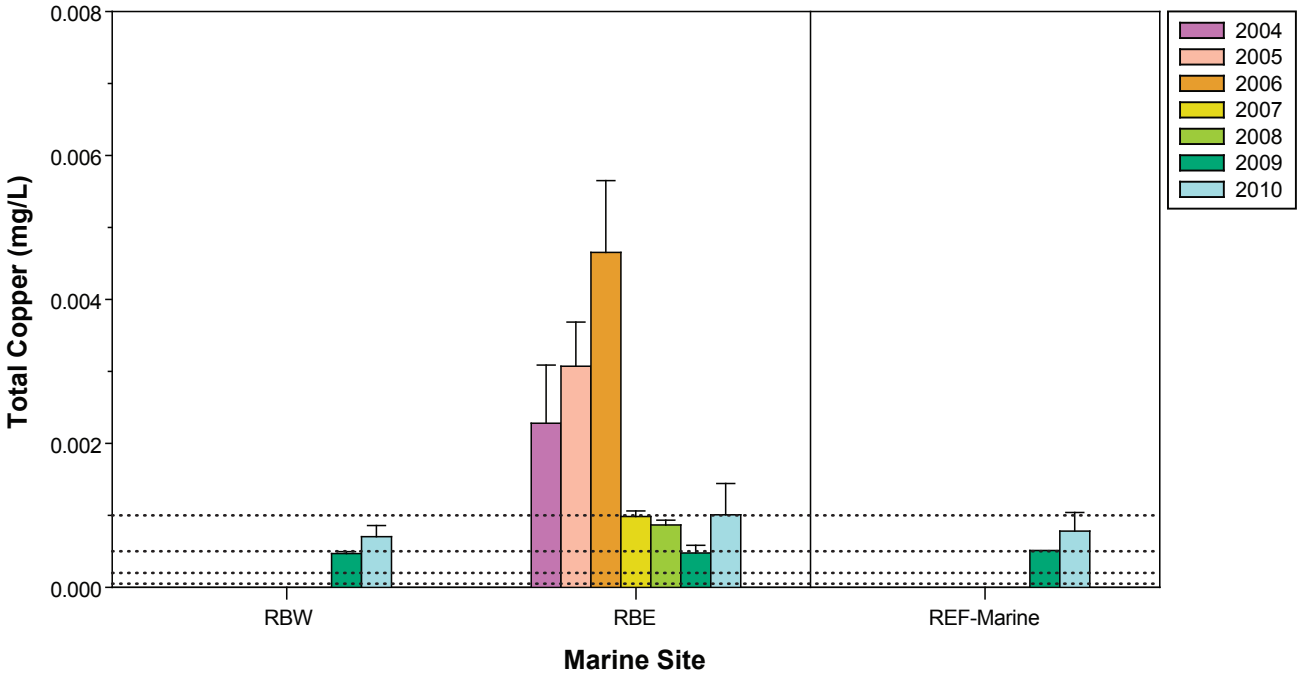
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010, total lead concentrations in all samples collected from sites RBW and REF-Marine and in the majority of samples collected from RBE were below the analytical detection limit of either 0.00005 or 0.001 mg/L (Figure 3.2-50). In the combined historical and 2010 dataset, lead concentrations in 78% of samples from RBW and 100% of samples from REF-Marine were below detection limits, so little can be said about before-after trends for these sites other than all concentrations were low. At site RBE, the single detectable concentration measured in 2010 (0.000052 mg/L) was within range of historical concentrations. The before-after comparison shows that the 2010 mean total lead concentration at RBE was significantly higher than the historical mean ($p = 0.003$); however, this is an artifact of the substitution of half the detection limit for concentrations below the detection limit, because the 2010 detection limit of 0.001 mg/L was higher than the detection limits achieved in previous years. Therefore, there was no effect of 2010 Project activities on total lead concentrations in marine exposure sites.

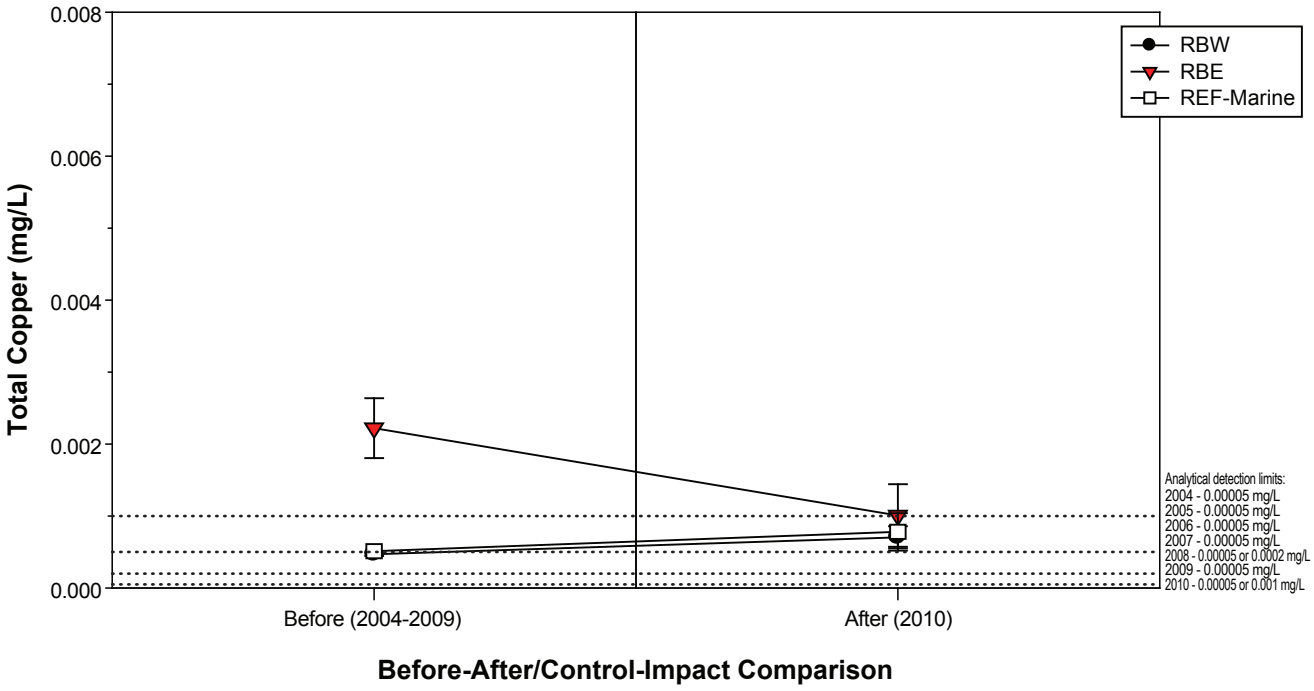
3.2.3.15 Total Mercury

Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All total mercury concentrations measured in marine sites in 2010 were below the analytical detection limit of 0.00001 mg/L and the CCME guideline of 0.000016 mg/L for inorganic mercury (Figure 3.2-51), indicating that 2010 activities did not cause an increase in mercury concentrations. All historical detectable and non-detectable concentrations were similarly below this concentration of 0.00001 mg/L (Figure 3.2-51).

3.2.3.16 Total Molybdenum

Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean 2010 total molybdenum concentrations at the two exposure sites and the reference site were relatively similar to historical levels (Figure 3.2-52). The before-after comparison confirms that there was no difference between 2010 mean concentrations and historical means for the Roberts Bay sites ($p = 0.14$ for RBW, $p = 0.37$ for RBE). Therefore, 2010 activities had no apparent effect on total molybdenum concentrations in the marine environment.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Copper Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-48

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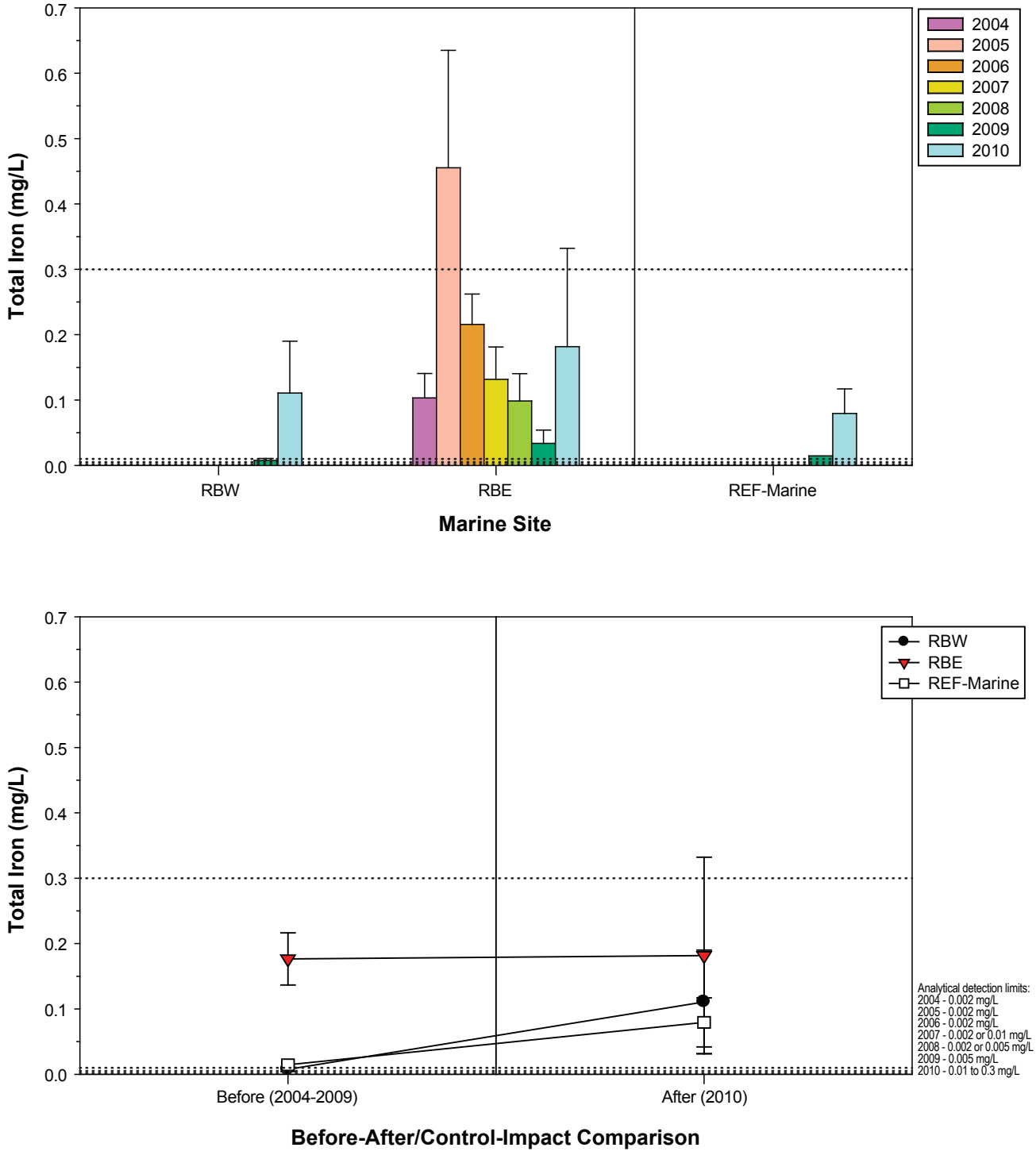

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Iron Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-49

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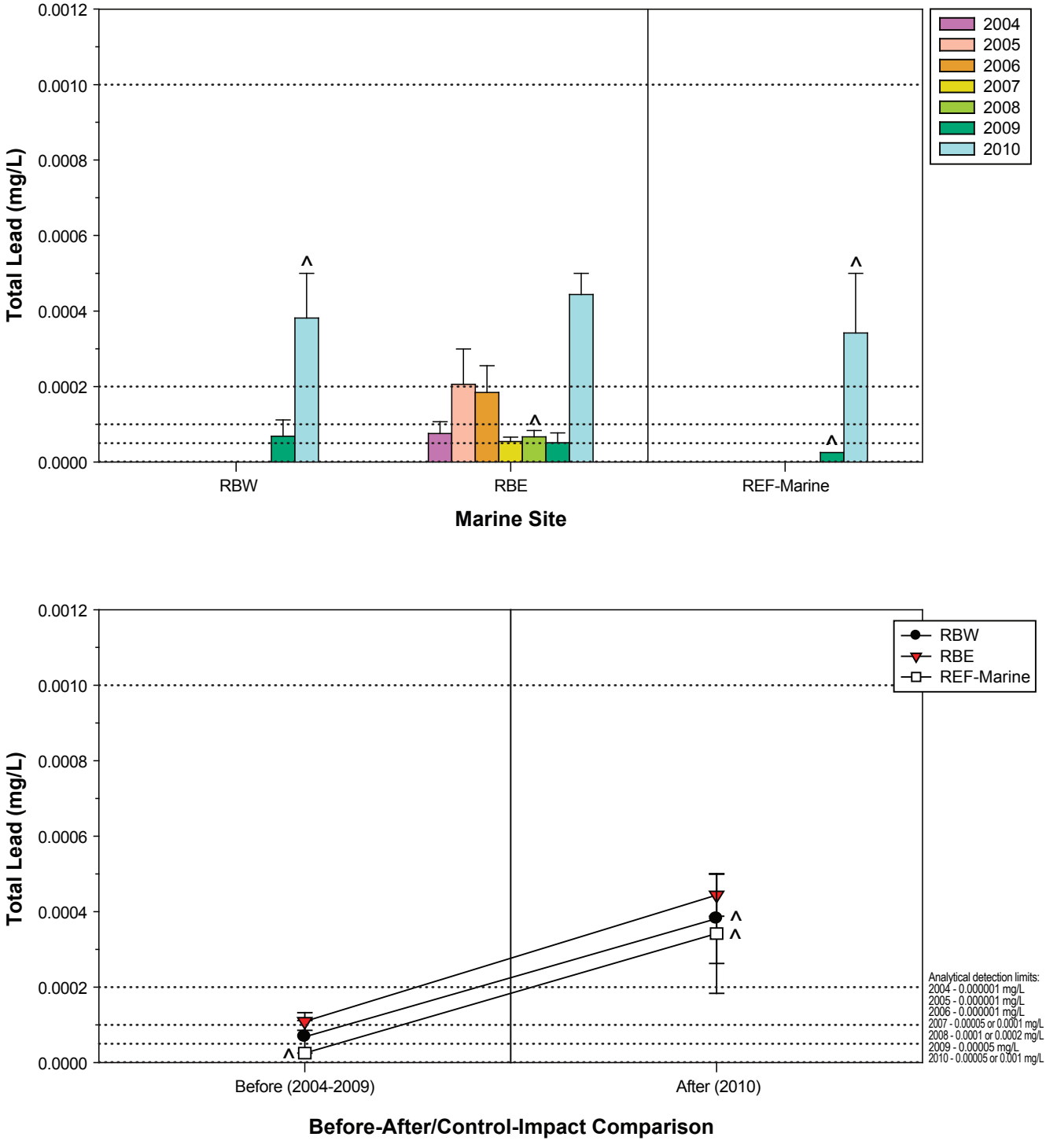

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Lead Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-50

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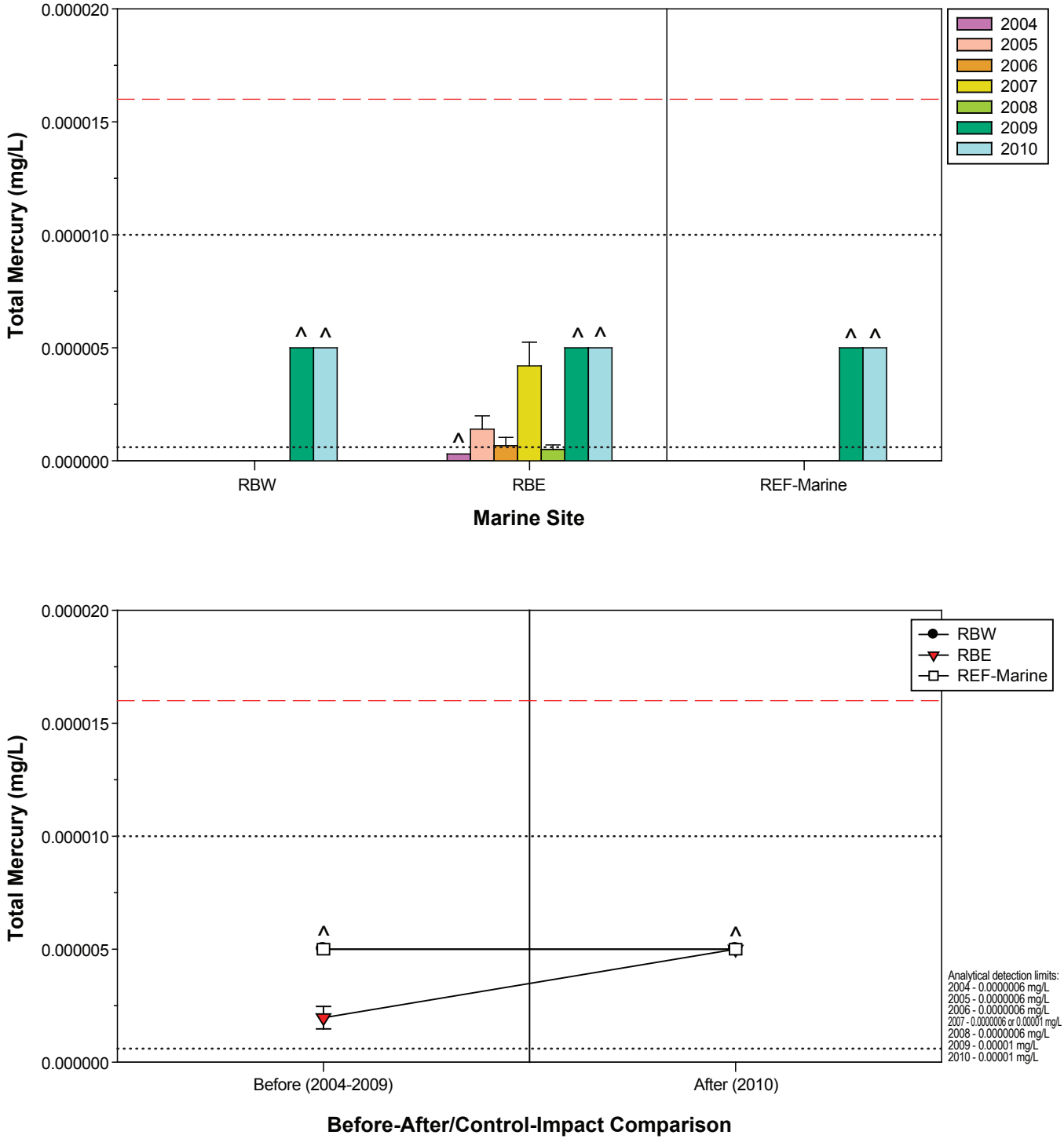

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME guideline for inorganic mercury (0.000016 mg/L).
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Mercury Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-51

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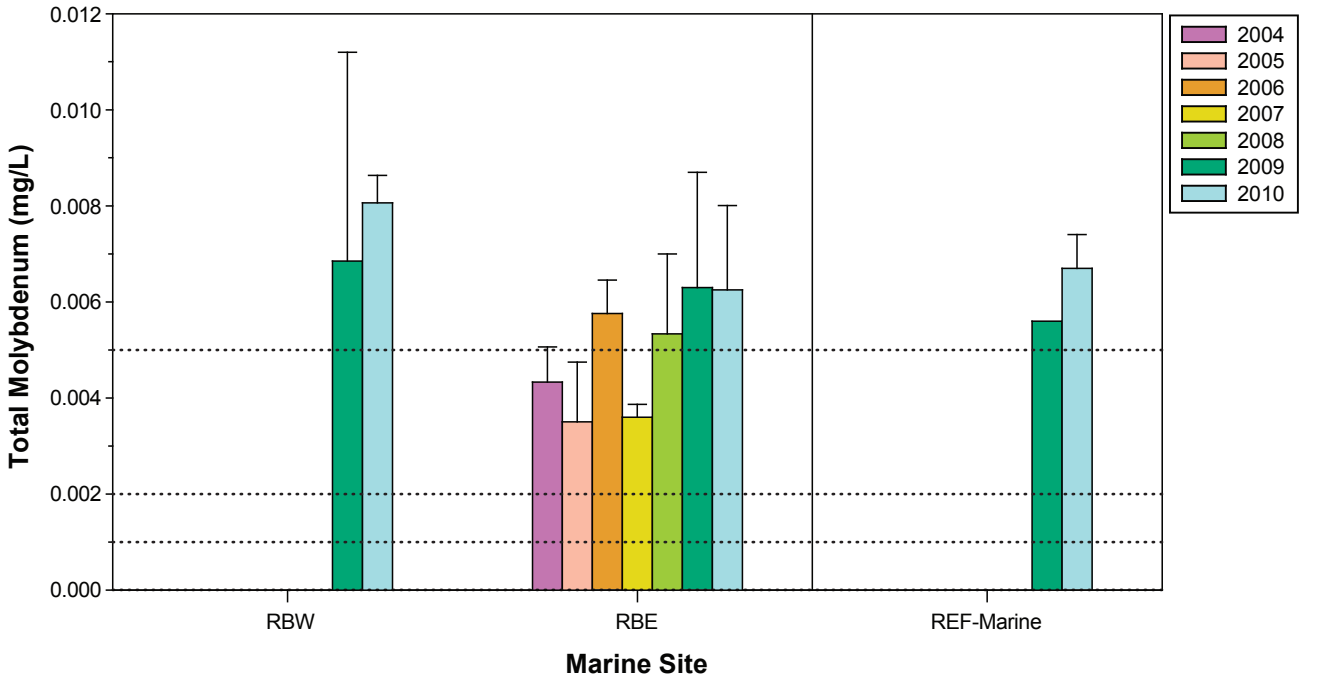

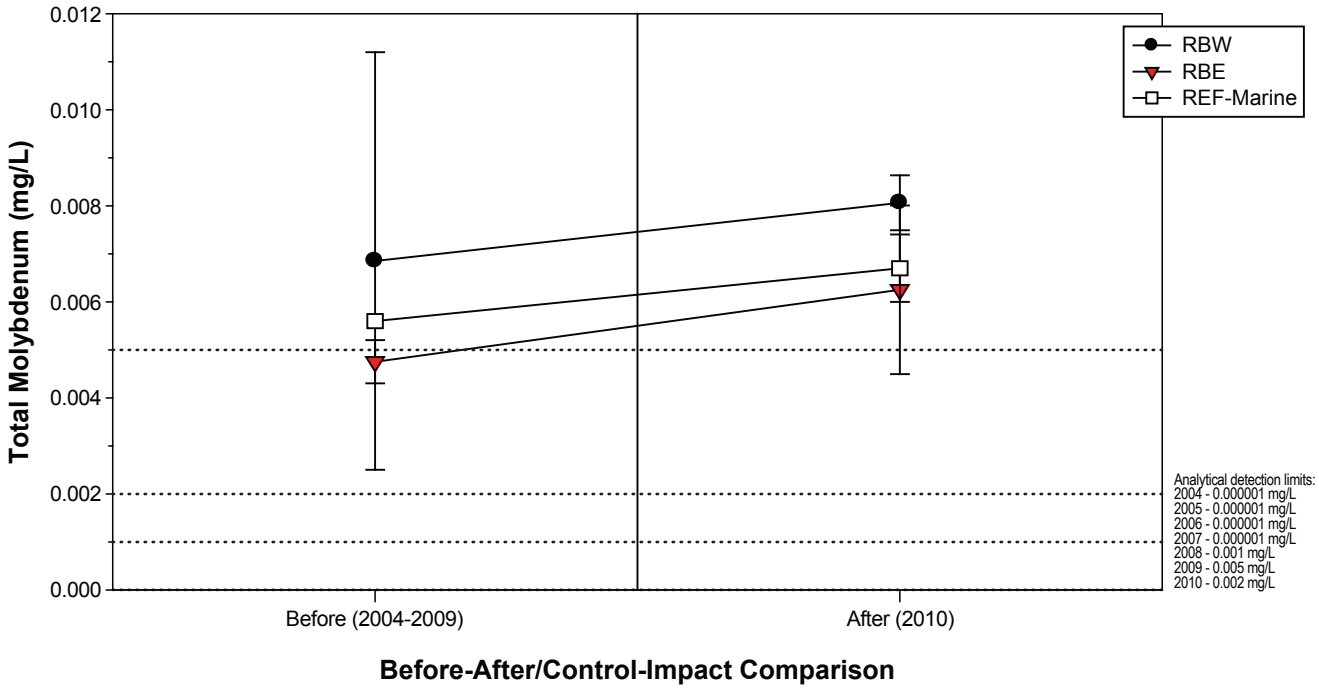

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Molybdenum Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-52

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3.2.3.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2010 nickel concentrations at the marine exposure sites were generally similar to historical concentrations (Figure 3.2-53), and the before-after analysis confirms that 2010 mean nickel concentrations were not distinguishable from historical means ($p = 0.83$ for RBW, $p = 0.82$ for RBE). There was therefore no effect of 2010 activities on total nickel concentrations in the marine environment.

3.2.3.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2010 marine samples, 78% of zinc concentrations were below the variable detection limit of 0.0008, 0.0013, or 0.005 mg/L (Figure 3.2-54). At site RBE, the only detectable zinc concentrations measured in 2010 were from replicate August samples; the average concentration of zinc in these replicates (0.0061 mg/L) was within the range of historical concentrations. The before-after comparison for this site shows that the 2010 mean zinc concentration was not distinguishable from the historical mean ($p = 0.90$). In the dataset for site RBW, 67% of concentrations were below detection limits, so statistical results should be interpreted cautiously. Detectable 2010 zinc concentrations at site RBW were higher than detectable concentrations measured in 2009; however, the before-after analysis reveals that this difference is not statistically significant ($p = 0.13$). There is therefore no evidence that 2010 Project activities affected total zinc concentration in the marine environment.

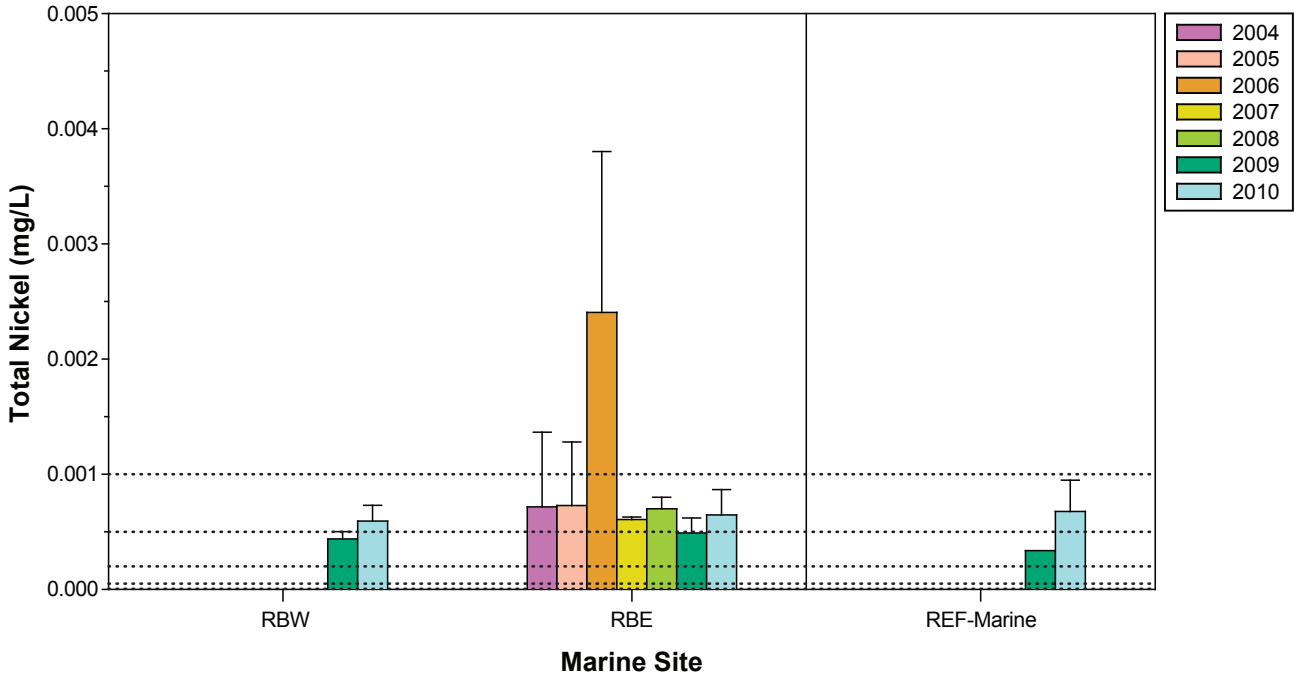
3.3 SEDIMENT QUALITY

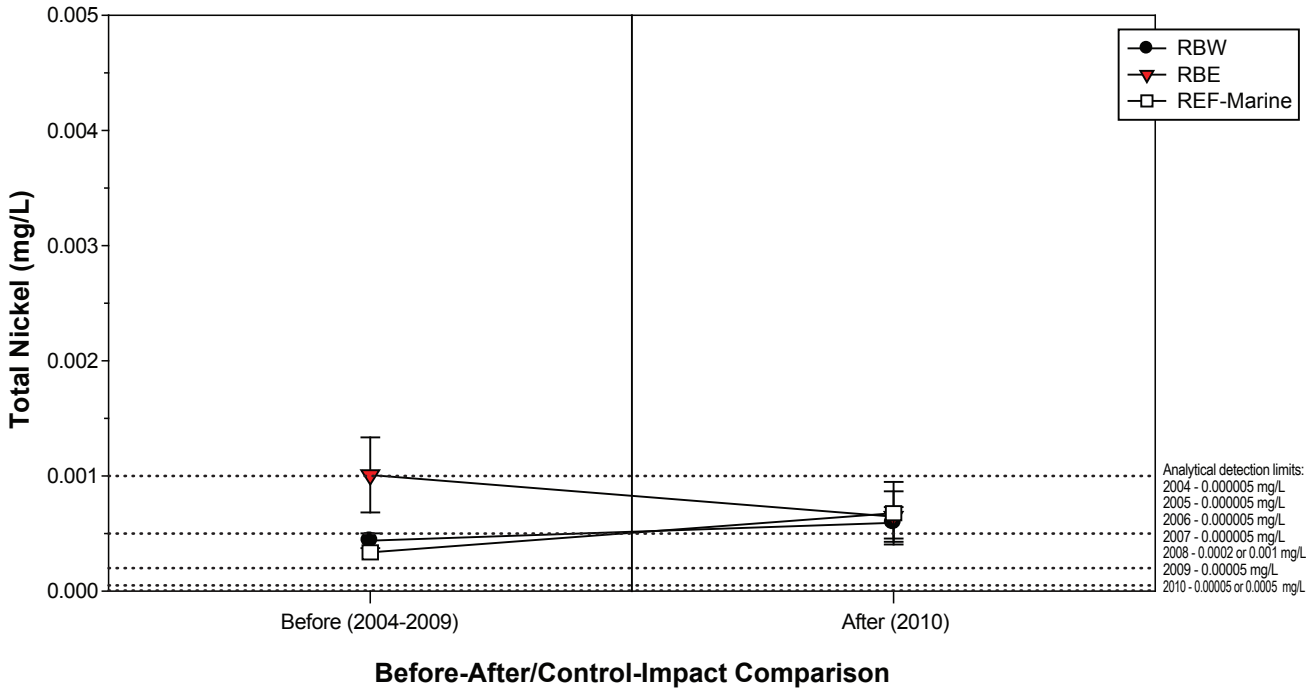
As per the MMER, Schedule 5, s. 16(a)(iii), sediment samples are to be collected and analyzed for particle size and total organic carbon content to complement the benthic invertebrate community surveys. In this section, the sediment quality data collected from stream, lake, and marine sites in 2010 are compared against available baseline information as well as reference sites to evaluate if 2010 Project activities caused changes to these sediment quality parameters. Sediment quality parameters with available CCME sediment quality guidelines for the protection of aquatic life (CCME 2011a) were also evaluated. 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 2011a).

For both graphical and statistical analyses, half the detection limit was substituted for sediment quality parameters that were below analytical detection limits. The complete results of all statistical methods and analyses are provided in Appendix C.

3.3.1 Streams

Sediment quality samples from streams were collected from three exposure streams (Doris Outflow, Roberts Outflow, and Little Roberts Outflow) and two reference streams (Reference B Outflow and Reference D Outflow). Historical baseline information for stream sediment characteristics is available only for 2009 and only for Doris, Little Roberts, and Reference B outflows. Data from 2010 were compared to 2009 to identify potential changes to sediment parameters. Stream sediment sampling was conducted in August during both years at the sampled sites. For the calculations of annual means for each parameter, all stream sediment replicates collected in a given year were averaged.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Nickel Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-53

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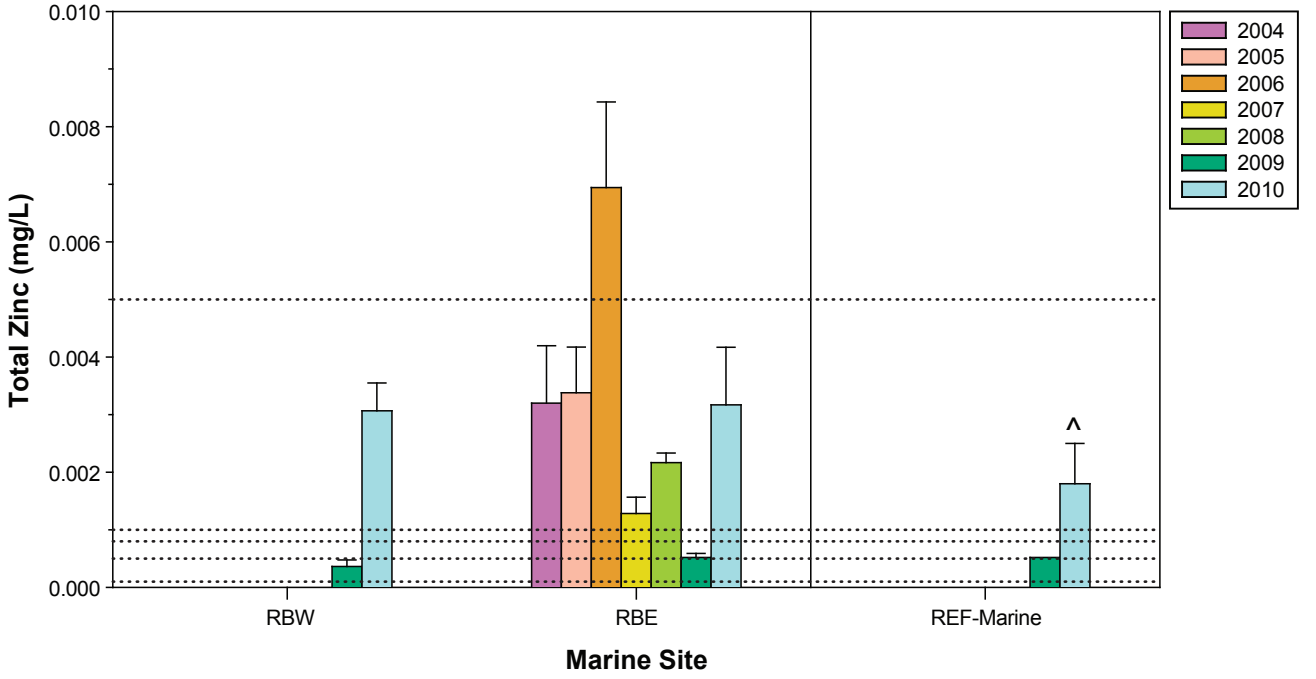

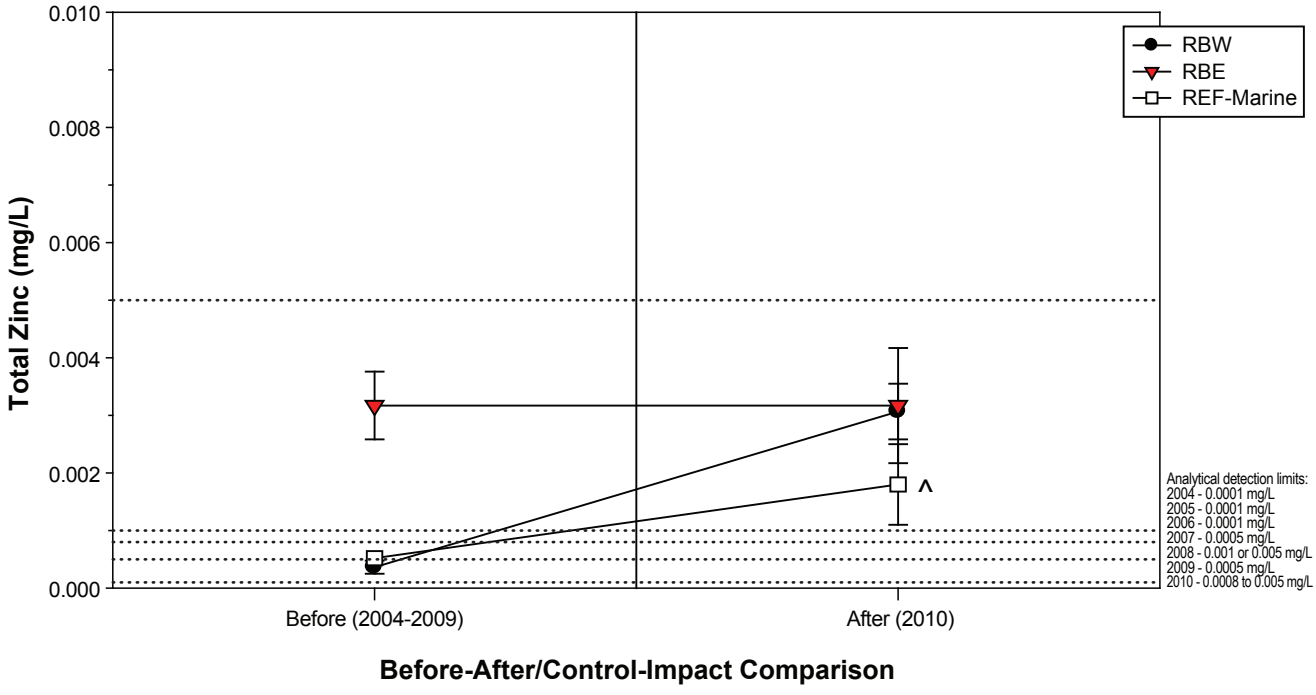

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Zinc Concentration in AEMP Marine Sites, Doris North Project, 2004–2010

Figure 3.2-54

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3.3.1.1 Particle Size

Particle size is a required sediment parameter to compliment the benthic invertebrate surveys as per Schedule 5, s. 16(a)(iii) of the MMER. The sediment particle size composition in Little Roberts and Reference B outflows was relatively similar from 2009 to 2010, as Little Roberts Outflow sediments remained high in fines (silt and clay), and Reference B Outflow continued to be dominated by coarser material (sand and gravel) (Figure 3.3-1). The before-after comparison shows that there were no changes in particle size distribution in either stream (Appendix C).

Some changes were apparent in the particle size composition of Doris Outflow, as 2010 samples contained approximately three times less gravel, three times more sand, and two times more silt and clay than 2009 samples (Figure 3.3-1); however, these changes were not statistically significant ($p = 0.014$ for gravel, $p = 0.022$ for sand, and $p = 0.16$ for silt). There is little reason to suspect that 2010 Project activities contributed to increased sand and fine sediments at this site, since there were no increases in TSS levels in the water in either Doris Outflow (Section 3.2.1.4) or upstream in Doris Lake (Section 3.2.2.4). There were also no in-water construction activities in Doris Outflow or upstream of this outflow. Differences in particle size composition at Doris Outflow between 2009 and 2010 were most likely due to natural environmental heterogeneity and spatial differences in sampling sites.

3.3.1.2 Total Organic Carbon

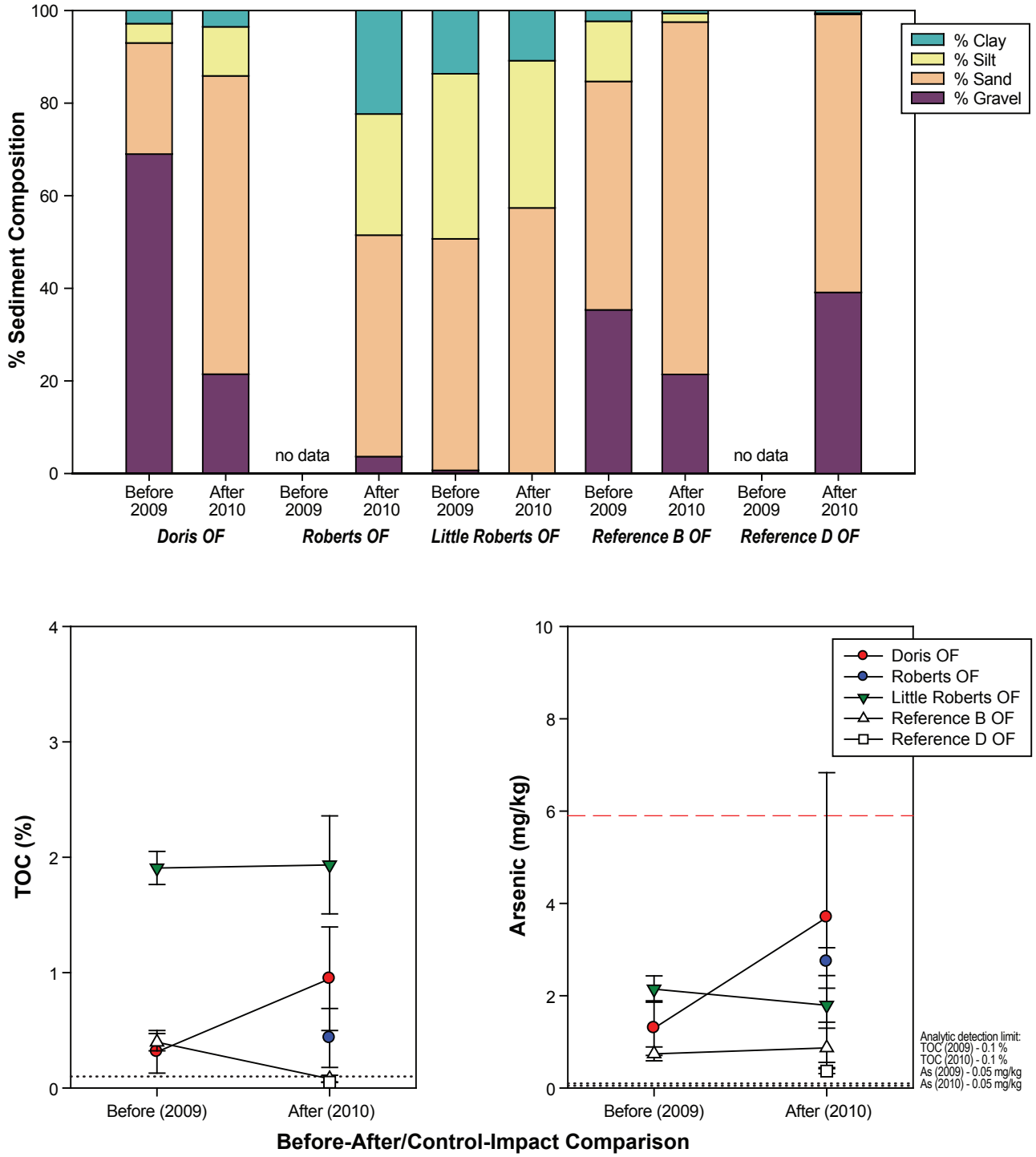
Total organic carbon content is a required sediment parameter that is meant to support the benthic invertebrate surveys as per Schedule 5, s. 16(a)(iii) of the MMER. There were no differences in sediment TOC levels in Little Roberts Outflow between 2009 and 2010 ($p = 0.20$; Figure 3.3-1), so there was no evidence of any changes in sediment TOC content at this site. In Doris Outflow, mean TOC concentrations increased 3-fold from 0.31% in 2009 to 0.95% in 2010. However, the before-after comparison shows that this increase was not statistically significant ($p = 0.20$), likely because of the large amount of variability in the 2010 replicates (0.26%, 0.79%, 1.79%). Therefore, there was no evidence that 2010 Project activities affected sediment TOC concentrations in exposure streams, and 2010 levels reflected natural variability.

3.3.1.3 Arsenic

Mean arsenic concentrations in Little Roberts and Reference B outflows were similar between 2009 and 2010 ($p = 0.49$ for Little Roberts Outflow, $p = 0.79$ for Reference B Outflow; Figure 3.3-1). Like TOC, mean arsenic levels in Doris Outflow sediments were nearly three times higher in 2010 (3.7 mg/kg) than 2009 (1.3 mg/kg); however, this was driven by one replicate that was almost 20 times higher (9.97 mg/kg) than the other two replicates (< 0.6 mg/kg), which was the only arsenic concentration in the AEMP stream sediments that was higher than the CCME ISQG of 5.9 mg/kg. The lower concentrations measured in Doris Outflow sediments in 2010 were similar to other 2010 observations. Given the high variability at Doris Outflow, there was no significant difference between arsenic concentrations in 2010 and 2009 ($p = 0.50$). There was therefore no effect of 2010 Project activities on arsenic concentrations in stream sediments.

3.3.1.4 Cadmium

Cadmium concentrations were undetectable (< 0.1 mg/kg) in all AEMP streams in 2010; therefore, 2010 Project activities were assumed to have no effect on sediment cadmium concentrations. No graphical assessment is presented for cadmium. All 2010 cadmium concentrations were well below CCME ISQG of 0.6 mg/kg.



Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed line represents the CCME interim sediment quality guideline (ISQG) for arsenic (5.9 mg/kg); the probable effects level (PEL) for arsenic (17 mg/kg) is not shown.

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Grain Size Composition, Total Organic Carbon, and Arsenic Concentrations in AEMP Stream Sediments, Doris North Project, 2009-2010

Figure 3.3-1

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3.3.1.5 Chromium

Chromium sediment concentrations varied among streams, but were consistent within each stream between the two sampled years (Figure 3.3-2). Because the mean 2010 chromium levels in the exposure streams were similar to or below their 2009 ranges, there was no effect of 2010 Project activities on stream sediment chromium levels. The before-after comparison confirms that there was no change in chromium concentrations in exposure stream sediments ($p = 0.40$ for Doris Outflow, $p = 0.39$ for Little Roberts Outflow). Mean chromium concentrations in Roberts Outflow (41.4 mg/kg) were naturally higher than the CCME ISQG of 37.3 mg/kg in 2010. A single replicate in Reference Lake B was also higher (41.2 mg/kg) than this guideline limit, indicating there was some natural enrichment of chromium in the region.

3.3.1.6 Copper

Mean sediment copper levels decreased in Little Roberts and Reference B outflows from 2009 to 2010, while concentrations in Doris Outflow sediments remained unchanged (Figure 3.3-2). The before-after analysis shows that mean 2010 copper concentrations in exposure stream sediments were not statistically distinguishable from 2009 means ($p = 0.97$ for Doris Outflow, $p = 0.036$ for Little Roberts Outflow). Therefore, 2010 Project activities were assumed to have no effect on sediment copper concentrations. No 2010 copper concentrations in AEMP stream sediments surpassed the CCME ISQG of 35.7 mg/kg (Figure 3.3-2).

3.3.1.7 Lead

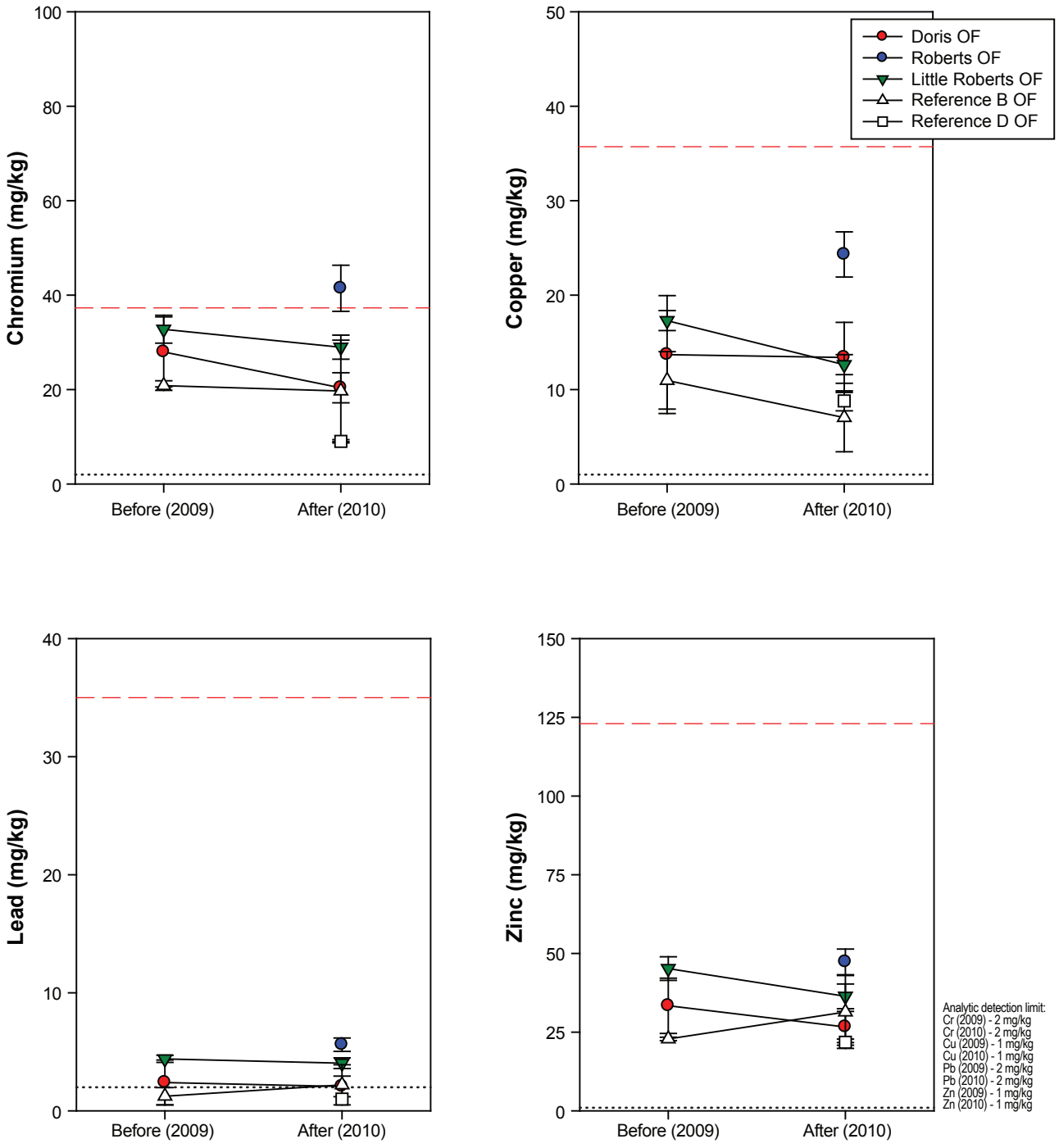
Mean lead concentrations varied among the AEMP streams, but remained similar within stream sites between 2009 and 2010 (Figure 3.3-2). There were no significant before-after effects for any exposure stream ($p = 0.80$ for Doris Outflow, $p = 0.53$ for Little Roberts Outflow). Therefore, 2010 activities had no apparent effect on lead concentrations. All stream sediment lead concentrations were far below the CCME ISQG of 35 mg/kg.

3.3.1.8 Mercury

More than half (53.3%) of the 2010 mercury samples were below their analytic detection limit (< 0.005 mg/kg) in the AEMP stream sediments; therefore, no graphical effects assessment is presented. Little Roberts Outflow was the only site at which mercury concentrations in all three replicates were measurable above the detection limit. The mean 2010 mercury concentration in Little Roberts Outflow sediments (0.0099 mg/kg) was lower than the mean concentration measured in 2009 (0.013 mg/kg). The highest 2010 mercury concentration was found in one replicate collected at Reference B outflow (0.017 mg/kg), while the mercury concentrations in the other two replicates from this site were below the detection limit. The before-after comparison suggests that there were no significant changes in sediment mercury levels between 2009 and 2010 in the exposure streams ($p = 0.43$ for Doris Outflow, $p = 0.28$ for Little Roberts Outflow). There was no evidence of an increase in sediment mercury concentrations in AEMP exposure streams. No 2010 mercury concentrations in AEMP stream sediments exceeded the CCME ISQG of 0.17 mg/kg.

3.3.1.9 Zinc

Sediment zinc concentrations varied among streams sites in 2009 and 2010, and generally ranged between 25 mg/kg and 50 mg/kg. Mean zinc concentrations decreased over time at the exposure AEMP stream sites, Doris and Little Roberts outflows, and increased at the reference site, Reference B Outflow. However, the before-after comparison indicates that mean 2010 zinc concentrations in exposure stream sediments were not distinguishable from 2009 means ($p = 0.26$ for Doris Outflow, $p = 0.96$ for Little Roberts Outflow). Consequently, there is no evidence that 2010 Project activities had any effect on the zinc concentration in the AEMP exposure stream sediments. All zinc concentrations were well below the CCME ISQG of 123 mg/kg in the AEMP stream sediments in 2010.



Before-After/Control-Impact Comparison

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guideline (ISQG) for chromium (37.3 mg/kg), copper (35.7 mg/kg), lead (35 mg/kg), and zinc (123 mg/kg). The probable effects levels (PEL) for chromium (90 mg/kg), copper (197 mg/kg), lead (91.3 mg/kg), and zinc (315 mg/kg) are not shown.

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Chromium, Copper, Lead, and Zinc Concentrations in AEMP Stream Sediments, Doris North Project, 2009-2010

Figure 3.3-2

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3.3.2 Lakes

AEMP sediment quality samples in 2010 were collected from three exposure sites (Doris Lake North, Doris Lake South, and Little Roberts Lake) and two reference sites (Reference Lake B and Reference Lake D). Historically, sediment samples have been collected in the Doris North area since 1995; however, very few of these sediment surveys were directly comparable to the locations of the 2010 AEMP sampling stations, the depth strata of the AEMP stations, the levels of replication, or the analyzed parameters. Only those historical sites that were in the immediate vicinity and depth strata of the AEMP sites and were suitably replicated ($n \geq 3$) were included in the before-after comparisons (Appendix C). Before-after comparisons were possible for Doris Lake North and Little Roberts Lake using data from 2009. No before-after comparisons were possible for Doris Lake South or the reference lakes because of the absence of historical data at these sampling locations (historical samples from Doris Lake South and Reference Lake B were not collected from the 2010 sampling locations and Reference Lake D sampling was initiated in 2010). Therefore, before-after comparisons were only possible for Doris Lake North and Little Roberts Lake. Sediment sampling was conducted in August during both years at the sampled sites. For the calculations of annual means for each parameter, all lake sediment replicates collected in a given year were averaged.

3.3.2.1 Particle Size

The AEMP lakes were dominated by fine sediments (Figure 3.3-3). Between 2009 and 2010, the silt fraction increased significantly in sediments from Doris Lake North and Little Roberts Lake (both $p < 0.001$), while the proportion of clay decreased significantly in both lakes ($p < 0.001$ for Doris Lake North, $p = 0.001$ for Little Roberts Lake). The change was most substantial at Doris Lake North where silt increased from 50% to 89% and clay content decreased nearly five-fold, from 48% to 11%. The sediment grain size composition was generally similar among the lake sites in 2010, with the exception of Reference Lake D, where sediments contained more sand and less clay than the other AEMP sites.

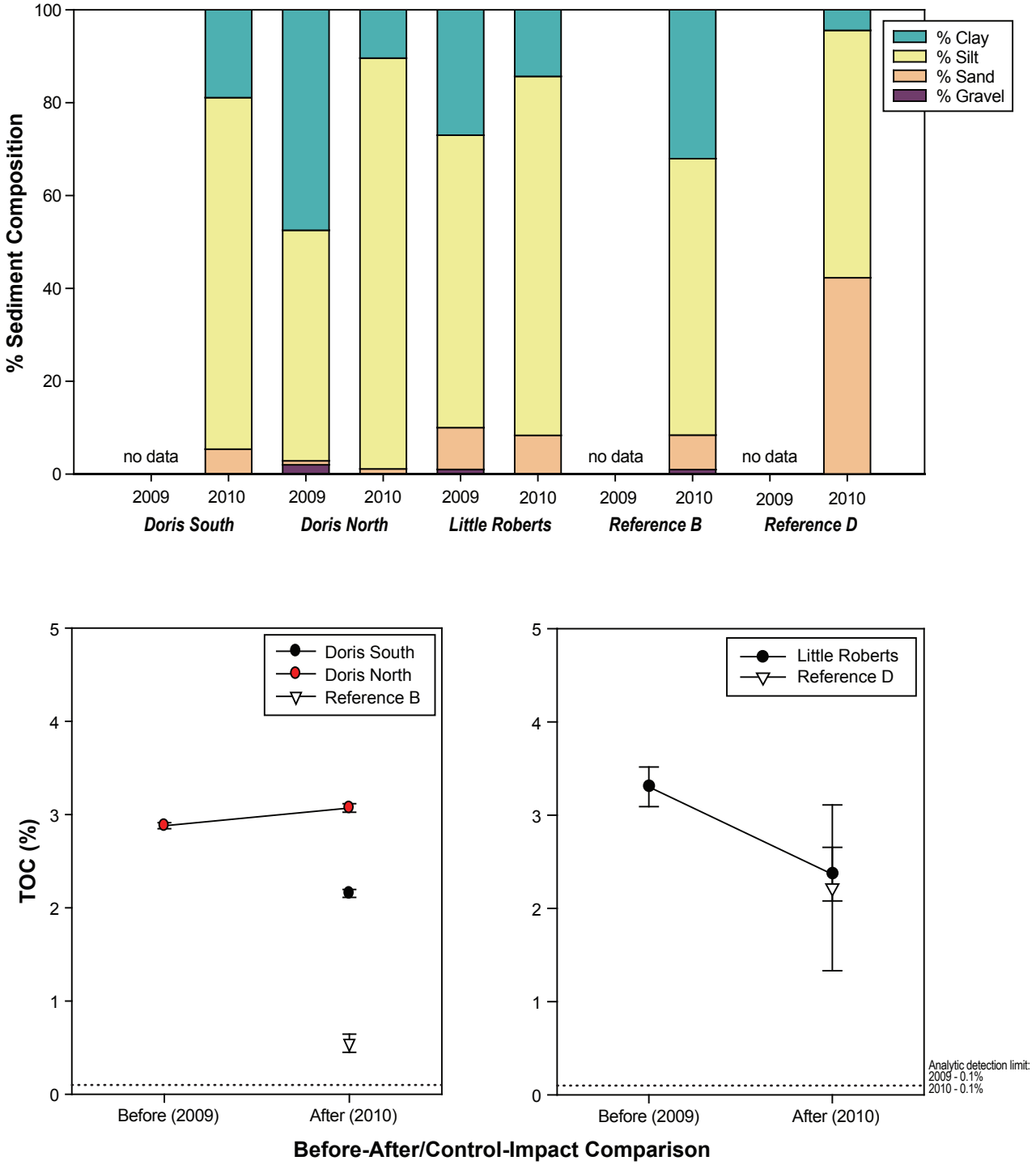
The change in the sediment composition between 2009 and 2010 was unlikely due to 2010 Project activities. There was no major construction along the shorelines of Doris and Little Roberts lakes that could cause bulk material transport (i.e., slumping, dumping). As well, there was no increase in TSS concentrations detected in the Doris Lake North water column in 2010 (Section 3.2.2.4), suggesting there was no measurable increase of deposited particles into the lake. The changes in sediment structure at both Doris Lake North and Little Roberts Lake were probably due to the natural spatial heterogeneity of sediments, and the likelihood that the 2009 and 2010 samples were collected from slightly different areas.

3.3.2.2 Total Organic Carbon

The mean total organic carbon content in Doris Lake North sediments was relatively consistent from 2009 (2.9%) to 2010 (3.1%), and declined in Little Roberts Lake from 2009 (3.3%) to 2010 (2.4%; Figure 3.3-3). The before-after comparison shows that these apparent changes were not statistically significant ($p = 0.057$ for Doris Lake North, $p = 0.59$ for Little Roberts Lake). Therefore, there was no apparent effect of 2010 Project activities on the proportion of TOC in the sediments of these lakes.

3.3.2.3 Arsenic

From 2009 to 2010, mean arsenic concentrations decreased slightly in Doris Lake North, but remained similar in Little Roberts Lake (Figure 3.3-4). Arsenic concentrations were highly variable among replicates collected in both 2009 and 2010 at Doris Lake North, and concentrations were naturally elevated at this site as at least one replicate surpassed the CCME ISQG of 5.9 mg/kg during each year (2009: 3 replicates; 2010: 2 replicates) as was the case for the PEL limit of 17 mg/kg (2009: 23.1 mg/kg; 2010: 21.0 mg/kg). The before-after comparison indicates that 2009 and 2010 mean arsenic levels were not statistically different in either Doris Lake North ($p = 0.71$) or Little Roberts Lake ($p = 0.36$). Consequently, there were no 2010 Project effects on arsenic levels in the AEMP exposure lake sediments.



Note: Error bars represent the standard error of the mean for replicate samples. Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.

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Grain Size Composition and Total Organic Carbon Concentrations in AEMP Lake Sediments, Doris North Project, 2009-2010

Figure 3.3-3

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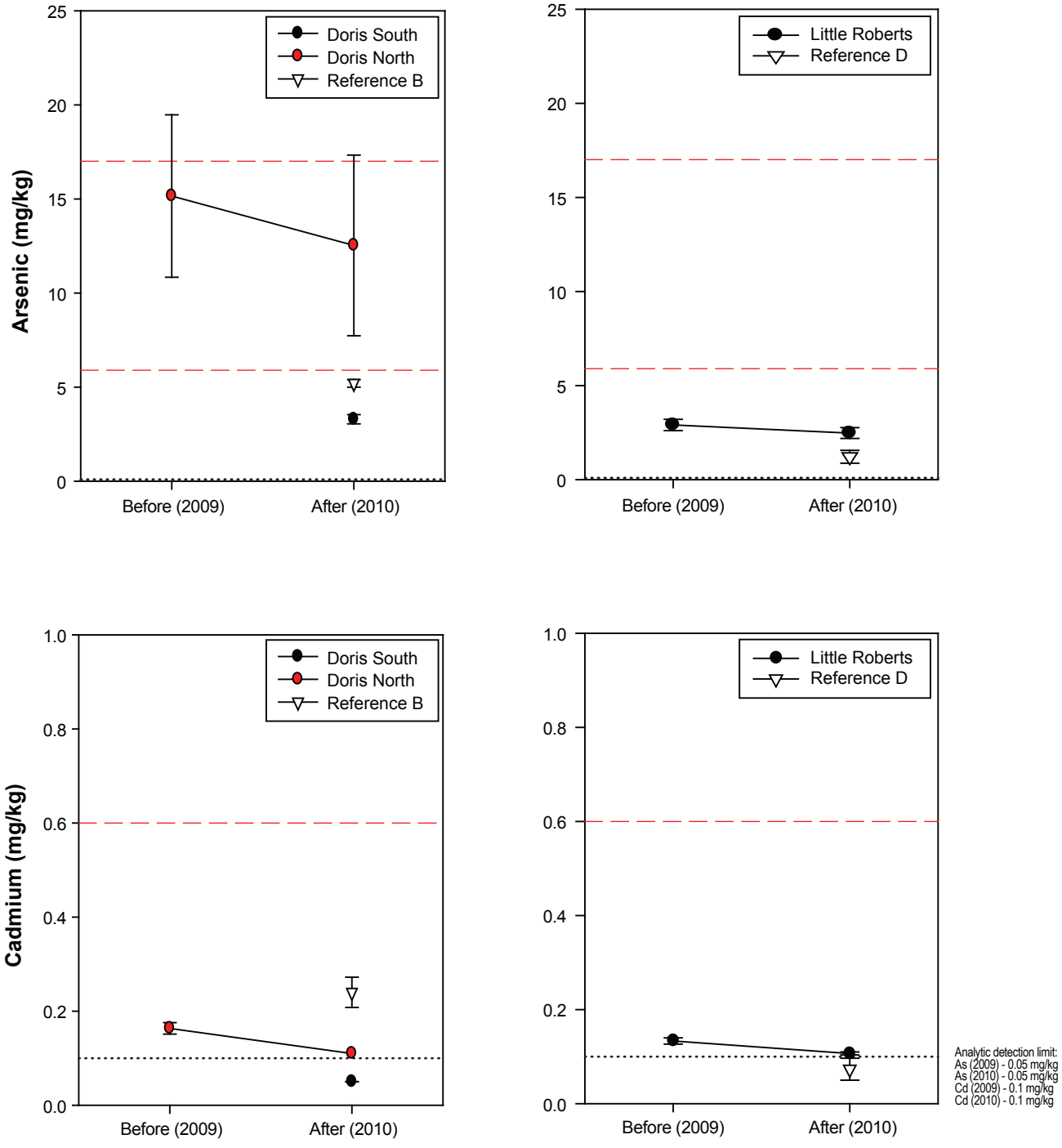

Before-After/Control-Impact Comparison

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for arsenic (5.9 mg/kg) and cadmium (0.6 mg/kg), and the probable effects level (PEL) for arsenic (17 mg/kg). The PEL for cadmium (3.5 mg/kg) is not shown.

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Arsenic and Cadmium Concentrations in AEMP Lake Sediments, Doris North Project, 2009-2010

Figure 3.3-4

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3.3.2.4 Cadmium

Mean cadmium levels were low in the AEMP lake sediments, and decreased slightly in the Doris Lake North and Little Roberts Lake sediments from 2009 to 2010 (Figure 3.3-4). Cadmium was not detectable in the shallow sediments of Doris Lake South, and concentrations were just above the detection limit at the other AEMP sites. The variability among replicates was relatively low. Based on the before-after analysis, there were no significant changes in sediment concentrations between 2009 and 2010 in the exposure lakes ($p = 0.011$ for Doris Lake North, $p = 0.023$ for Little Roberts Lake). Therefore, 2010 activities were assumed to have no effect on cadmium concentrations in the AEMP exposure lake sediments. All 2010 cadmium concentrations in AEMP lake sites were well below the CCME ISQG of 0.6 mg/kg.

3.3.2.5 Chromium

Chromium levels were naturally high in the AEMP lake sediments, as replicate concentrations were always above the CCME ISQG of 37.3 mg/kg at four of the five lake sites, including Reference Lake B (Figure 3.3-5). The exception was Reference Lake D, where only one out of three 2010 replicates was above the ISQG. Chromium concentrations were variable among sites. There were slight, but non-significant increases in sediment chromium levels in Doris Lake North ($p = 0.12$) and Little Roberts Lake ($p = 0.58$) from 2009 to 2010. Based on the similarity between the 2009 and 2010 means in the exposure lakes, there was no evidence of an effect of 2010 activities on chromium concentrations in sediments.

3.3.2.6 Copper

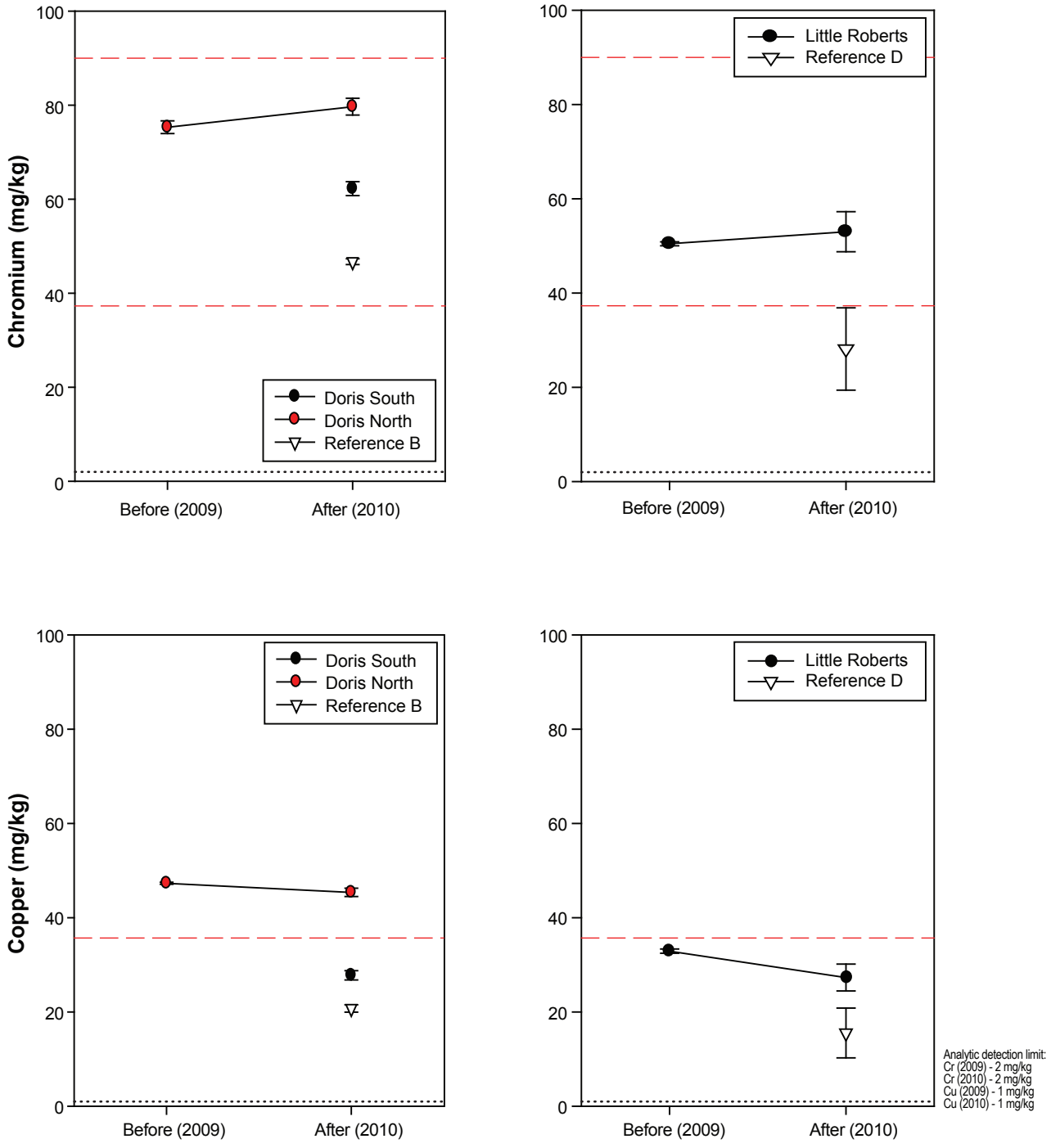
Sediment copper concentrations were naturally higher in Doris Lake North than the other AEMP sites, and mean concentrations were above the CCME ISQG of 35.7 kg/mg during both 2009 and 2010. Concentrations were similar in Doris Lake North between 2009 and 2010, and concentrations decreased slightly in Little Roberts Lake over the same period (Figure 3.3-5). The differences between 2009 and 2010 means were not statistically significant in either exposure lake ($p = 0.10$ for Doris Lake North, $p = 0.12$ for Little Roberts Lake). Therefore, there were no 2010 effects on total copper concentrations in exposure lake sediments.

3.3.2.7 Lead

Mean sediment lead concentrations decreased in Doris Lake North between 2009 and 2010, but remained relatively consistent in Little Roberts Lake (Figure 3.3-6). The before-after comparison shows that the mean 2010 lead concentration in Doris Lake North was significantly lower than the 2009 mean ($p = 0.009$). A decrease in lead is not of concern. There was no significant difference in means between 2009 and 2010 in Little Roberts Lake ($p = 0.16$). 2010 activities did not cause an increase in lead concentrations in AEMP exposure lake sediments. All lake sediment lead concentrations were far below the CCME ISQG of 35 mg/kg.

3.3.2.8 Mercury

Sediment mercury concentrations were frequently below detection in the AEMP stream and marine sites (Appendix A), but were always detectable in the AEMP lakes (Figure 3.3-6). Mean concentrations were twice as high in Doris Lake North than in other lakes. Mean mercury concentrations were relatively similar in Doris Lake North sediments between 2009 (0.067 mg/kg) and 2010 (0.074 mg/kg). This before-after comparison confirms that 2009 and 2010 means in Doris Lake North were not significantly different ($p = 0.33$). In Little Roberts Lake, mean mercury levels decreased from 0.0259 mg/kg in 2009 to 0.0186 mg/kg in 2010, but this decrease was not statistically significant ($p = 0.028$). Given these trends, there was no evidence that 2010 activities affected mercury concentrations in the exposure lake sediments. No 2010 mercury concentrations in the AEMP lake sediments exceeded the CCME ISQG of 0.17 mg/kg.



Before-After/Control-Impact Comparison

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for chromium (37.3 mg/kg) and copper (35.7 mg/kg), and the probable effects level (PEL) for chromium (90 mg/kg). The PEL for copper (197 mg/kg) is not shown.

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Chromium and Copper Concentrations in AEMP Lake Sediments, Doris North Project, 2009-2010

Figure 3.3-5

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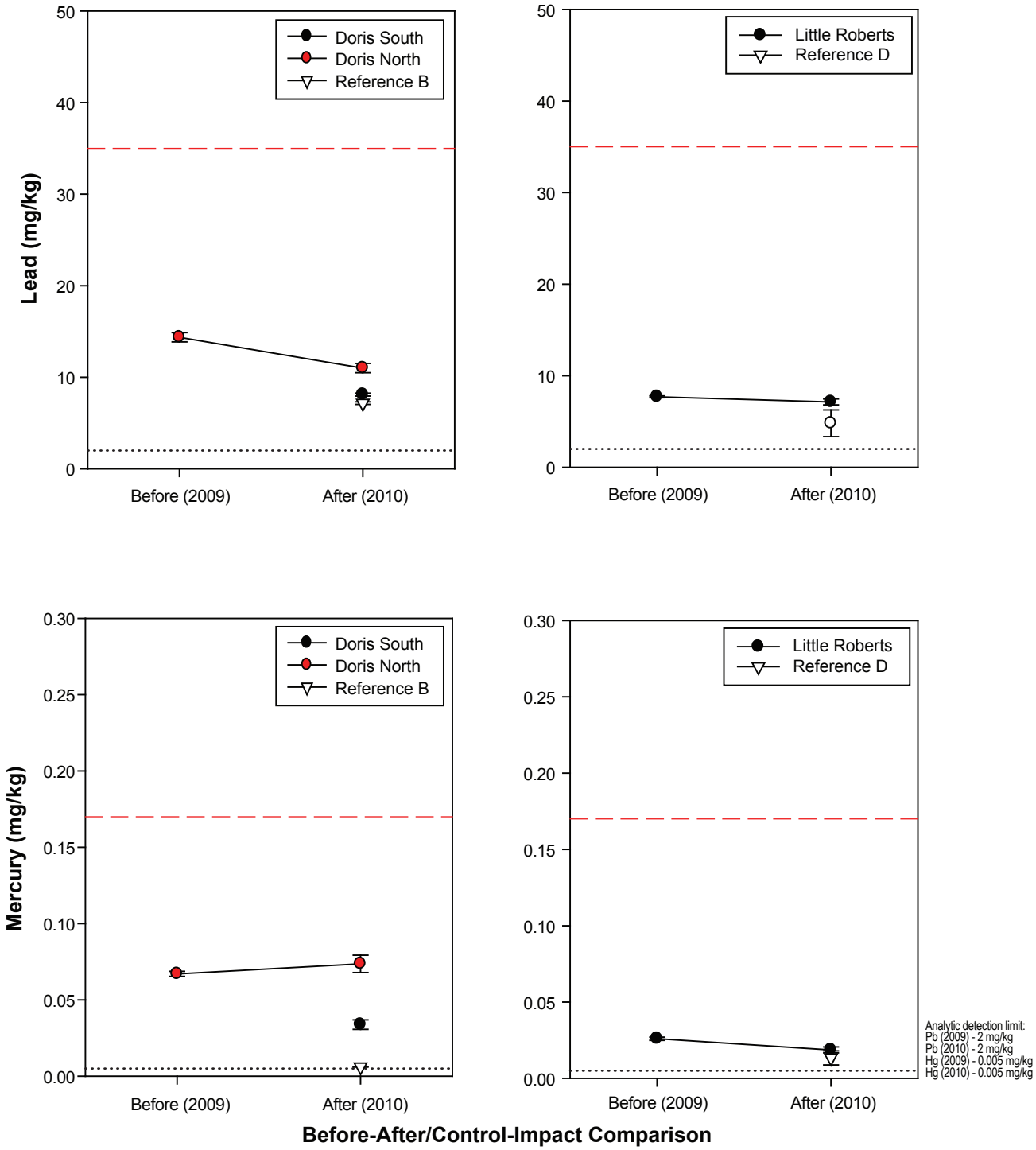

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for lead (35 mg/kg) and mercury (0.17 mg/kg); probable effects levels (PEL) for lead (91.3 mg/kg) and mercury (0.486 mg/kg) are not shown.

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Lead and Mercury Concentrations in AEMP Lake Sediments, Doris North Project, 2009-2010

Figure 3.3-6

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3.3.2.9 Zinc

Mean zinc concentrations were variable among AEMP lake sediments. In the larger lakes, 2010 zinc levels were highest in Doris Lake North, intermediate in Doris Lake South, and lowest in Reference Lake B (Figure 3.3-7). This was also the case for several other metals in the AEMP lake sediments (e.g., chromium, copper, lead, and mercury). Little Roberts Lake zinc concentrations in 2010 were higher than those found in Reference Lake D. Overall, zinc concentrations were similar from 2009 to 2010 in both Doris Lake North ($p = 0.027$) and Little Roberts Lake ($p = 0.059$; Figure 3.3-7). Thus, there were no apparent 2010 effects on zinc concentrations in the sediments of the AEMP lakes.

All 2010 zinc concentrations were below the CCME ISQG of 123 mg/kg in AEMP lake sediments. Mean zinc concentrations in the Doris Lake North sediments were naturally high as both 2009 and 2010 concentrations (~ 105 mg/kg) were near the CCME ISQG.

3.3.3 Marine

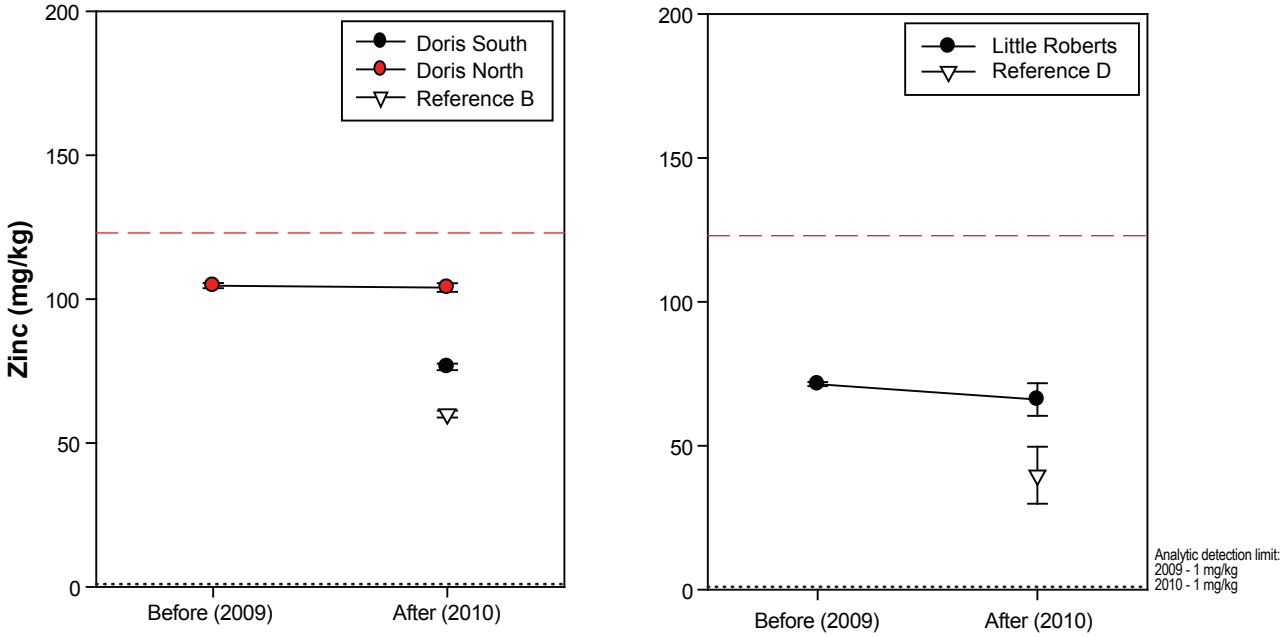
Sediment quality samples from the marine environment were collected from two exposure sites (RBW and RBE) and one reference site (REF-Marine). Historically, sediment samples have been collected in Roberts Bay since 1997; however, very few of these surveys were directly comparable to the locations of the 2010 AEMP sampling stations, the levels of replication, or the analyzed parameters. Only those historical sites that were in the immediate vicinity of the AEMP sites and were suitably replicated ($n \geq 3$) were included in the before-after and BACI comparisons. No suitable historical data were available for RBE, but there was one year of historical data available for each RBW (2002) and REF-Marine (2009).

Because the available historical data are from two different years, a change in any parameter at the exposure site, RBW, from 2002 to 2010 cannot be directly compared to the change at the reference station, REF-Marine, between 2009 and 2010. Any change at REF-Marine can only be used to show the inherent inter-annual variability that occurs in the AEMP sediment parameters. Also, caution must be exercised when interpreting changes at RBW since there is an eight-year gap between the collection of before and after data. Because no historical sediment data were collected near RBE, no statistical analyses could be performed for this location.

Marine sediment quality parameters were compared to applicable CCME sediment quality guidelines for the protection of marine aquatic life (CCME 2011a). All measured parameters in 2010 marine samples were below recommended CCME guidelines.

3.3.3.1 Particle Size

The sediment composition in the three AEMP marine sites was largely made up of sand, with the mean proportion of sand ranging from 52% at RBW in 2002 to 93% at RBE in 2010 (Figure 3.3-8). Sediments at REF-Marine contained a significantly higher proportion of silt ($p < 0.001$) and a lower proportion of sand ($p = 0.001$) in 2010 compared to 2009. Between 2002 and 2010, the sand content in sediments collected at RBW near the jetty increased significantly from 52 to 70% ($p < 0.001$), while the clay fraction decreased significantly from 20 to 4.4% ($p < 0.001$; Figure 3.3-8). The higher sand content in RBW sediments in 2010 suggests that this area may have been a higher energy system in 2010 than in 2002. The high TSS concentration in the overlying waters at RBW in August, 2010 (16 mg/L) is evidence of the high winds that were present during this sampling event. The changes in sediment structure at RBW and REF-Marine are most likely attributable to the natural spatial heterogeneity of sediments, and the likelihood that the 2009 and 2010 samples were collected from slightly different areas.



Before-After/Control-Impact Comparison

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guideline (ISQG) for zinc (123 mg/kg); the probable effects level (PEL) for zinc (315 mg/kg) is not shown.

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Zinc Concentrations in AEMP Lake Sediments, Doris North Project, 2009-2010

Figure 3.3-7

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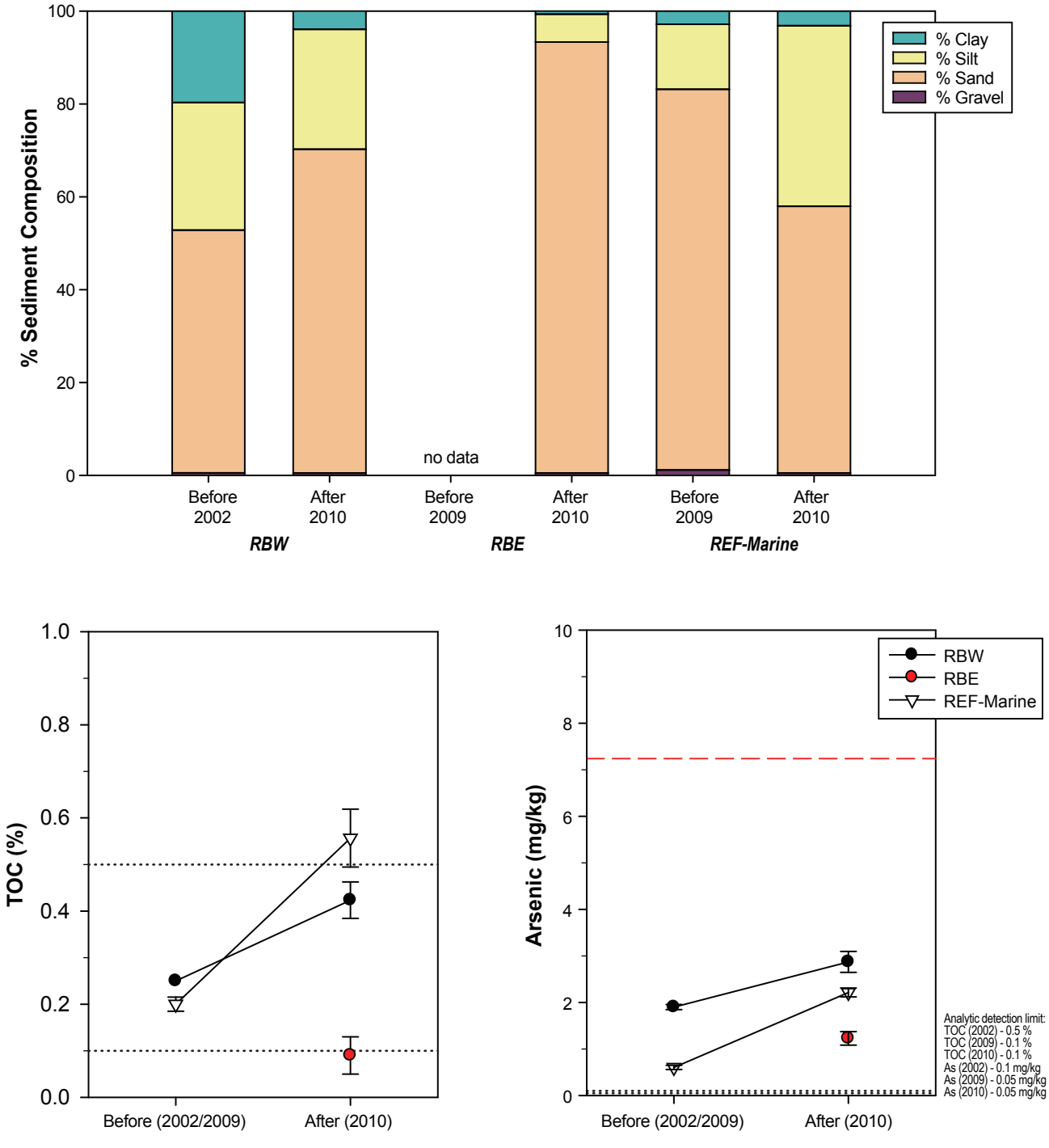

Before-After/Control-Impact Comparison

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed line represents the CCME interim marine sediment quality guideline (ISQG) for arsenic (7.24 mg/kg); the probable effects level (PEL) for arsenic (41.6 mg/kg) is not shown.

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Grain Size Composition, Total Organic Carbon, and Arsenic Concentrations in AEMP Marine Sediments, Doris North Project, 2002-2010

Figure 3.3-8

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3.3.3.2 Total Organic Carbon

The mean total organic carbon concentration at RBW appeared to increase from 2002 to 2010 (Figure 3.3-8). However, this is an artifact of the five-fold higher analytical detection limit for TOC in 2002 (0.5%) compared to 2010 (0.1%), as 2002 concentrations were all below the detection limit. The mean TOC proportion measured in 2010 (0.42%) was actually lower than the 2002 detection limit. The before-after comparison indicates that there was no significant difference in mean sediment TOC at RBW between 2002 and 2010 ($p = 0.96$); however, statistical results should be interpreted cautiously because 63% of the historical and 2010 dataset for RBW consisted of censored values. In 2010 sediment samples from the sand-dominated RBE, the proportion of TOC was near or below the detection limit of 0.1%, which was lower than the TOC content in sediments from RBW or REF-Marine (Figure 3.3-8). There is no evidence that 2010 Project activities had any effect on the proportion of TOC in the exposure site sediments.

3.3.3.3 Arsenic

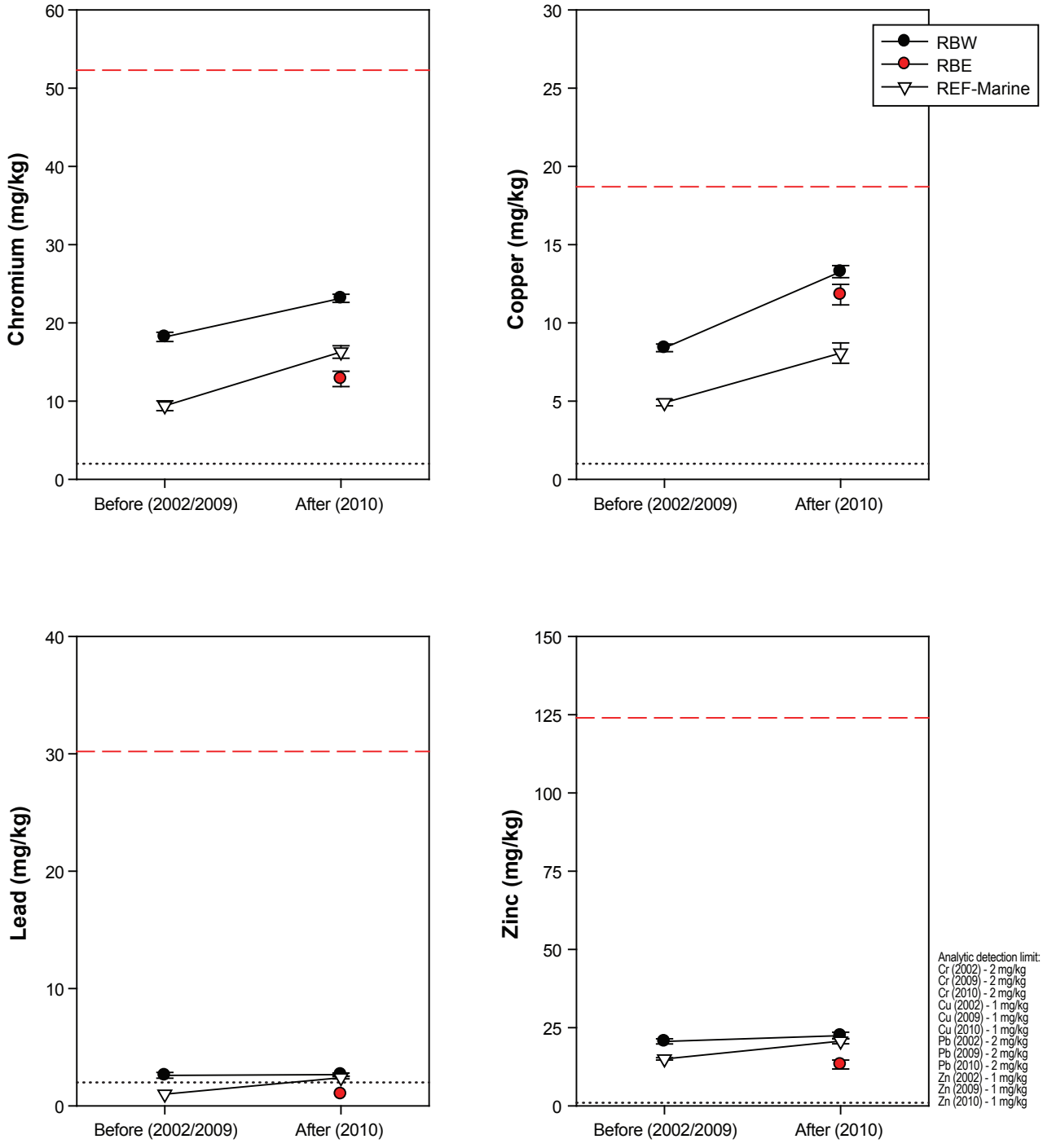
Mean arsenic concentrations in sediments from RBW increased from 1.9 mg/kg in 2002 to 2.9 mg/kg in 2010 (Figure 3.3-8). This increase was statistically significant ($p = 0.002$). Notably, mean arsenic concentrations also increased significantly at REF-Marine from 2009 (0.6 mg/kg) to 2010 (2.2 mg/kg; $p < 0.001$). The BACI interaction effect was not statistically significant ($p = 0.018$), suggesting that the change in arsenic levels that occurred in RBW sediments was within the expected range of natural variability. Therefore, it is unlikely that the observed increase in sediment arsenic levels at RBW was related to 2010 Project activities. At RBE, the mean 2010 arsenic concentration in sediments (1.2 mg/kg) was lower than concentrations in sediments from the other AEMP sites (Figure 3.3-8). All 2010 concentrations were well below the CCME ISQG of 7.24 mg/kg. There is no evidence that 2010 activities affected sediment arsenic concentrations in the marine environment.

3.3.3.4 Cadmium

Cadmium concentrations were undetectable (< 0.1 mg/kg) and well below the CCME ISQG of 0.7 mg/kg in all AEMP marine sediment samples in 2010; therefore, 2010 activities were assumed to have no effect on cadmium concentrations in marine sediments. No graphical effects assessment is presented for cadmium.

3.3.3.5 Chromium

Mean chromium concentrations in RBW sediments increased significantly from 18.2 mg/kg in 2002 to 23.1 mg/kg in 2010 ($p = 0.001$; Figure 3.3-9). The BACI analysis indicates that a similar significant increase also occurred in REF-Marine from 2009 to 2010 (before-after: $p = 0.002$; BACI: $p = 0.18$). Therefore, the increase in mean chromium concentration in RBW sediments is within the range of expected natural variability, and there was likely no effect of Project activities on sediment chromium concentrations near the jetty. The mean 2010 chromium concentration in RBE sediments (12.8 mg/kg) was slightly lower than the mean for the reference site (16.3 mg/kg; Figure 3.3-9). All 2010 chromium concentrations in marine sediments were well below the CCME ISGQ of 52.3 mg/kg. There was therefore no evidence of an effect of 2010 activities on sediment chromium concentrations in the marine environment.



Before-After/Control-Impact Comparison

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim marine sediment quality guideline (ISQG) for chromium (52.3 mg/kg), copper (18.7 mg/kg), lead (30.2 mg/kg), and zinc (124 mg/kg); probable effects levels (PEL) for chromium (160 mg/kg), copper (108 mg/kg), lead (112 mg/kg), and zinc (271 mg/kg) were not shown.

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Chromium, Copper, Lead, and Zinc Concentrations in AEMP Marine Sediments, Doris North Project, 2002-2010

Figure 3.3-9

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3.3.3.6 Copper

Like several metals in 2010, mean copper concentrations were highest in the sediments near the jetty at site RBW (13.3 mg/kg; Figure 3.3-9). The mean concentration in RBE sediments (11.8 mg/kg) was slightly lower than in RBW sediments. As was the case for arsenic and chromium, copper concentrations in RBW sediments were significantly higher in 2010 (13.3 mg/kg) than in 2002 (8.4 mg/kg; $p < 0.001$; Figure 3.3-9). At REF-Marine, mean copper concentrations were also significantly higher in 2010 compared to 2009 ($p = 0.01$). The BACI interaction was non-significant at the $p = 0.01$ level ($p = 0.05$). Given the similar increase that occurred at the reference site and the eight-year gap between sampling periods, the increase in copper between 2002 and 2010 at RBW cannot be definitively attributed to the 2010 Project activities. All 2010 copper concentrations in marine sediments were below the CCME ISQG of 18.7 mg/kg.

3.3.3.7 Lead

Mean 2010 lead concentrations were below or barely above the detection limit of 2 mg/kg in most marine samples, and all 2010 concentrations were well below the CCME ISQG of 30.2 mg/kg (Figure 3.3-9). Mean concentrations near the jetty were nearly identical between 2002 (2.6 mg/kg) and 2010 (2.7 mg/kg). The before-after analysis confirmed that there was no change in mean concentrations at RBW between 2002 and 2010 ($p = 0.85$). All 2010 lead concentrations in RBE sediments were below the detection limit. Hence, 2010 activities were assumed to have no effect on sediment lead concentrations. There was a slight increase in the mean sediment lead concentration at REF-Marine, from below detection in 2009 (< 2 mg/kg) to just above detection in 2010 (2.4 mg/kg). This increase was statistically significant according to the before-after results ($p < 0.001$), but this is an artifact of the substitution of half the detection limit for 2009 concentrations.

3.3.3.8 Mercury

Mercury concentrations were undetectable (< 0.005 mg/kg) and below the CCME ISQG of 0.13 mg/kg in all AEMP marine sediments in 2010; therefore, 2010 activities were assumed to have no effect on mercury concentrations in marine sediments. No graphical effects assessment is presented for mercury.

3.3.3.9 Zinc

Mean 2010 sediment zinc concentrations were similar between RBW (22.4 mg/kg) and REF-Marine (20.7 mg/kg), and relatively low at RBE (13.2 mg/kg; Figure 3.3-9). All zinc concentrations in marine sediments were well below the CCME ISQG of 124 mg/kg. Although mean zinc concentrations at RBW were comparable between 2002 (20.6 mg/kg) and 2010 (22.4 mg/kg), there was a statistically significant difference between years ($p < 0.001$) because of the low variability among replicates (Figure 3.3-9). A significant increase in zinc also occurred in REF-Marine sediments ($p = 0.005$) between 2009 (15.0 mg/kg) and 2010 (20.7 mg/kg), and the BACI interaction effect between sites was non-significant ($p = 0.017$). This indicates that such slight changes in sediment zinc levels occurred naturally, and were not attributable to 2010 activities.

3.4 PRIMARY PRODUCERS

3.4.1 Lake Phytoplankton Biomass

Phytoplankton biomass samples have been collected in lakes in the Doris North region since 1996, including three years of comparable historical data at the AEMP sites, Doris Lake North and Little Roberts Lake (2003, 2007. and 2008). Based on the criteria used for the baseline data, no comparable historical samples have been collected at the other AEMP sites, Doris Lake South, Reference Lake B, and Reference Lake D. The phytoplankton biomass data included in the before-after comparisons were collected in July, August, and September of each year. Under-ice samples collected in April 2010 at the

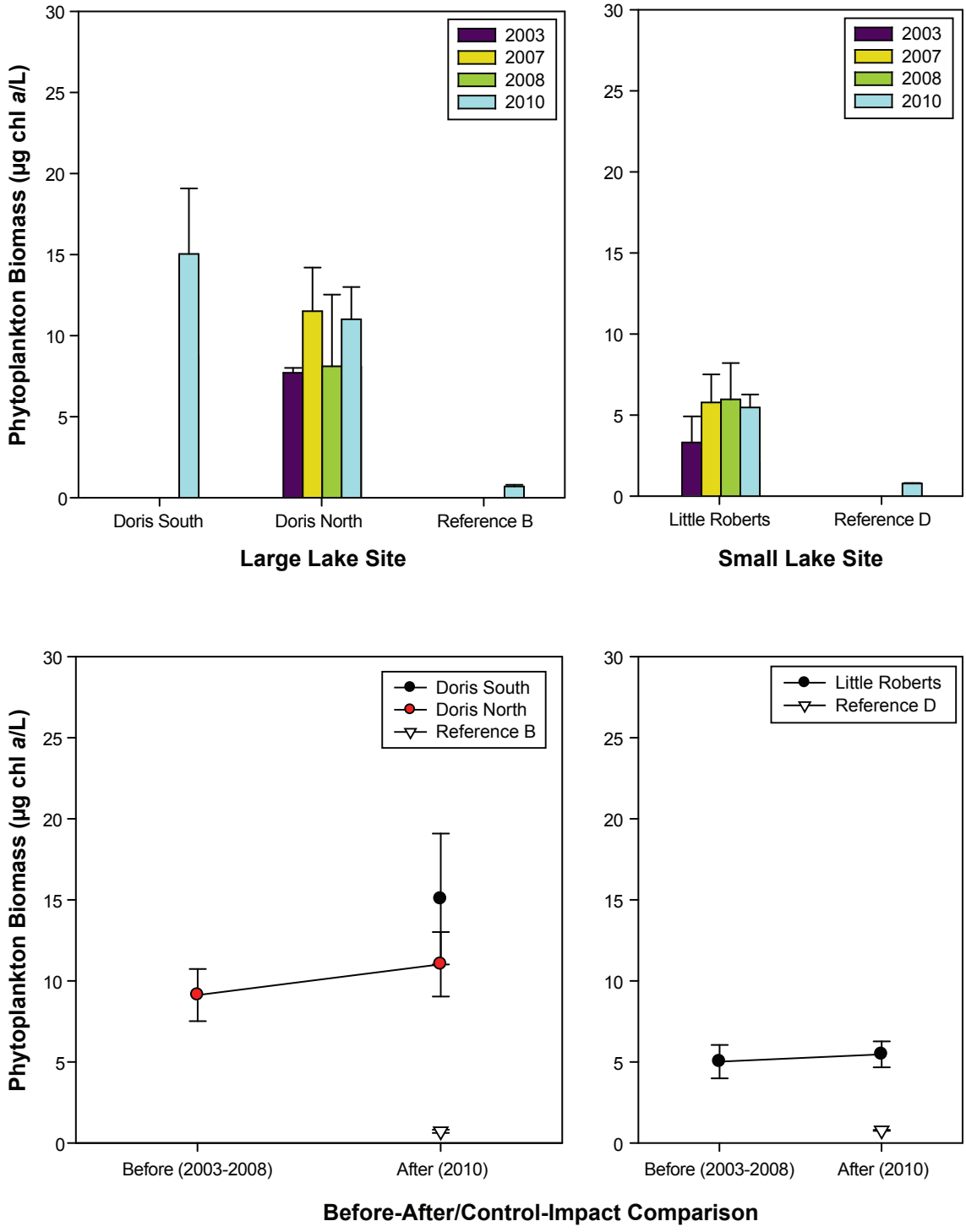
AEMP sites were not included in the 2010 dataset to facilitate comparison with pre-2010 data that did not include under-ice samples. Although phytoplankton biomass samples were collected from most AEMP lake sites in 2009, these data were not included in the evaluation of effects because 2009 samples were only collected during one month of the open-water season (August).

Overall, phytoplankton biomass levels were higher at the exposure lake sites than in the reference lake sites, but 2010 exposure lake biomass levels were within the range of historical levels (Figure 3.4-1). The higher phytoplankton biomass in the exposure lakes was likely due to the higher concentrations of phosphorus in these lakes (Appendix A). Mean 2010 chlorophyll *a* concentrations were highest in the Doris Lake sites, reaching a maximum of 15 µg chl *a*/L in Doris Lake South. Mean biomass levels were also relatively high in Little Roberts Lake in 2010 (5.5 µg chl *a*/L). Chlorophyll *a* concentrations in Doris Lake North increased slightly from a historical mean of 9.1 µg chl *a*/L to 11 µg chl *a*/L in 2010, though 2010 levels fell within the annual variability observed at this site (Figure 3.4-1). The high 2010 mean biomass level at Doris Lake South was mainly driven by a large bloom (26.1 µg chl *a*/L) that occurred in September, 2010. There is no comparable historical data available for this site. In Little Roberts Lake, the mean pre-2010 biomass level (5.0 µg chl *a*/L) was similar to the mean for 2010 (5.5 µg chl *a*/L). Accordingly, there was no apparent effect of 2010 activities on the phytoplankton biomass in the AEMP exposure lakes.

3.4.2 Marine Phytoplankton Biomass

Historical phytoplankton biomass data has been collected in Roberts Bay since 2006; however, comparable pre-2010 data for the before-after comparisons only exist for Roberts Bay East (RBE) for 2007 and 2008. Data from these years were collected near the present 2010 RBE location, and were collected in July, August, and September. While chlorophyll *a* samples were collected in April (under-ice) from the AEMP marine sites in 2010, these data were not used in the graphical analysis to facilitate comparison with 2007 and 2008 data that were collected during the open-water season only (July, August and September). There were no pre-2010 data that were collected over all three months of the open-water period near the other two AEMP marine sites, RBW and REF-Marine. Although phytoplankton biomass samples were collected near RBW and REF-Marine in 2009, these data were not included in the evaluation of effects because 2009 samples were only collected during one month of the open-water season (August).

Overall, the 2010 mean chlorophyll *a* concentration at RBE (2.6 µg chl *a*/L) was more than three times higher than the historical mean (0.67 µg chl *a*/L; Figure 3.4-2). This was entirely due to the high mean biomass level measured in August 2010 (7.0 µg chl *a*/L), which was more than an order of magnitude higher than at any other time of year at RBE, as well as at any other site. July and September chlorophyll *a* levels at RBE (mean: 0.35 µg chl *a*/L) were comparable to those observed in 2007 and 2008 at RBE, and also comparable to biomass levels at the other marine sites in 2010 (0.59 µg chl *a*/L at RBW, 0.27 µg chl *a*/L at REF-Marine; Figure 3.4-2). The high August 2010 concentrations at RBE were likely anomalous, and could have been caused by suspended episammic periphyton (periphyton attached to sand) since this area had high TSS concentrations (16 mg/L), and August sampling took place when the winds were high. Given the high seasonal variability in the biomass levels at RBE and the unknown historical trend for the reference site (REF-Marine), or the other exposure site (RBW), the increase in chlorophyll *a* concentrations at RBE should not be attributed to 2010 Project activities.



Note: Error bars represent the standard error mean.

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Phytoplankton Biomass Concentrations (as chlorophyll *a*) in AEMP Lakes, Doris North Project, 2003-2010

Figure 3.4-1

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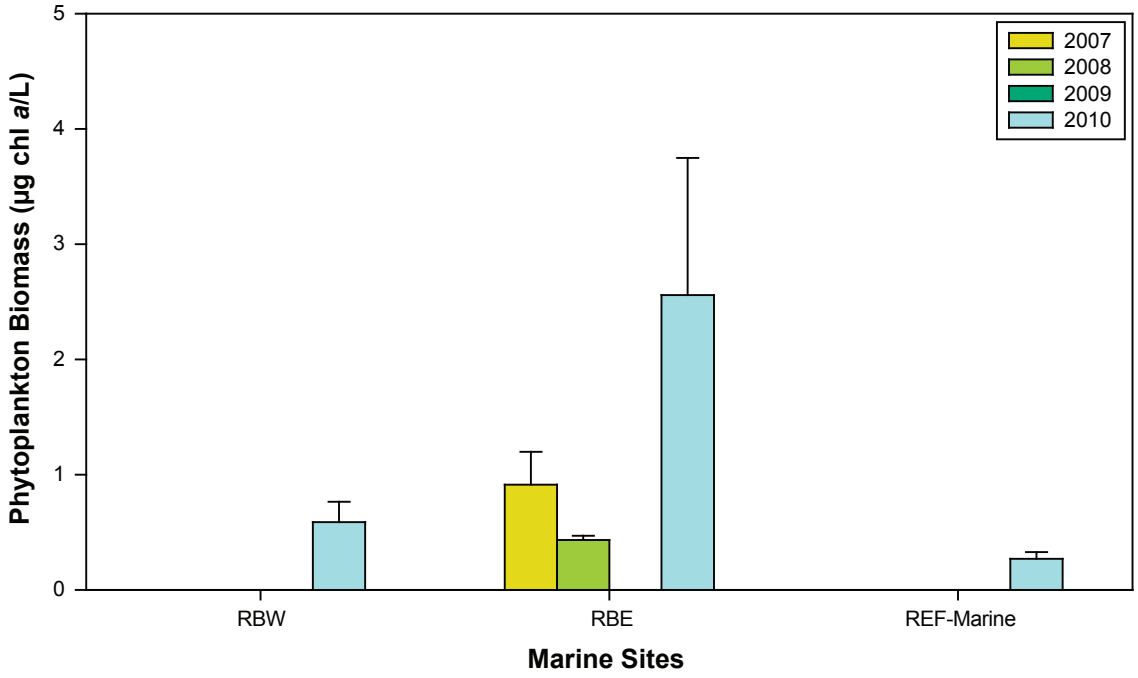

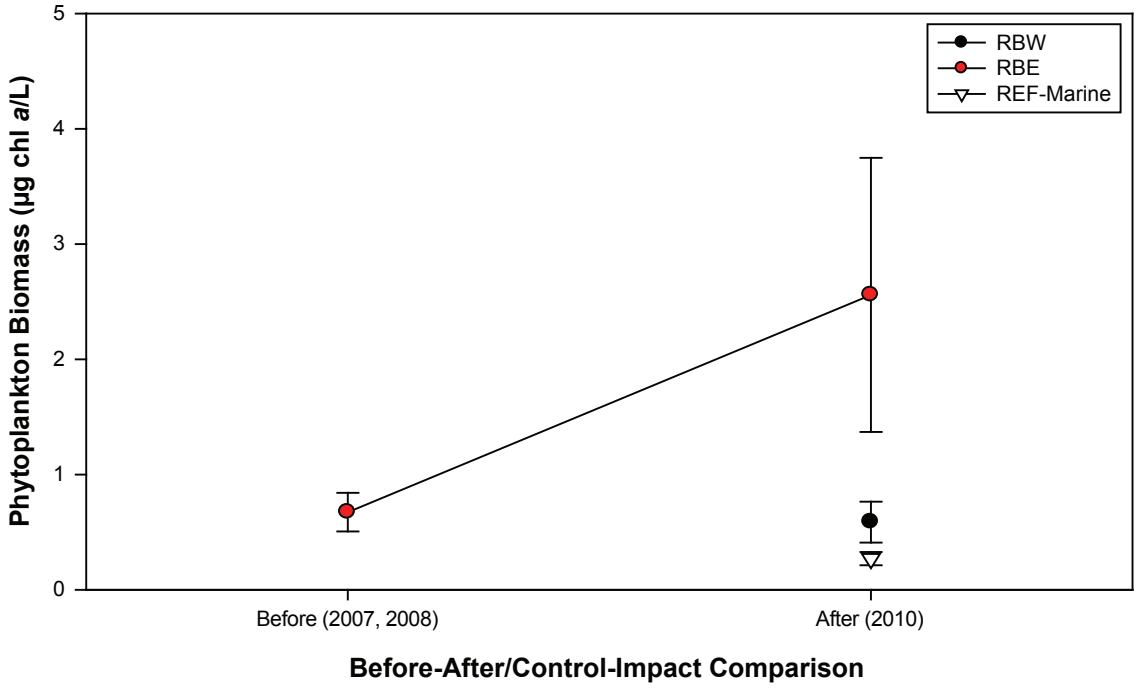

Note: Error bars represent the standard error mean.

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Phytoplankton Biomass Concentrations (as chlorophyll *a*) at AEMP Marine Sites, Doris North Project, 2007-2010

Figure 3.4-2

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4. Summary of Evaluation of Effects

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4. Summary of Evaluation of Effects

The evaluation of effects employed statistical and graphical methods to identify potential effects to the aquatic environment that may have resulted from Project activities in 2010. When historical information was available, before (baseline, pre-2010) and after (evaluation year, 2010) data for specific parameters were first compared at each of the exposure sites to establish if there was a discernible change in evaluated parameters in 2010. If there was a change, before-after trends in the exposure sites were compared to those at the reference sites (BACI design) to determine if parallel changes occurred (no effect) or if the change was only present in the exposure waterbodies (potential effect). Graphical analysis was used to supplement statistical methods and aid in the interpretation of temporal trends. Professional judgment was always employed when statistical or graphical methods indicated potential construction year effects for specific parameters to determine if the effect was likely natural or Project-related.

4.1 STREAMS

Table 4.1-1 provides a summary of the 2010 evaluation of effects for the Doris North Project streams. There was sufficient historical information to evaluate potential Project-related effects on water and sediment quality parameters. No Project effects on water or sediment quality were apparent in the AEMP streams.

Mean 2010 water quality parameter concentrations were generally below CCME guidelines, with the exception of total aluminum, total copper, and total iron, which were naturally elevated in some AEMP streams. All mean 2010 sediment quality parameter concentrations were below CCME ISQGs, with the exception of chromium in Roberts Outflow sediments.

There were increases in the concentrations of total aluminum in Doris Outflow and total iron in Roberts Outflow in 2010 compared to historical concentrations. The mean concentrations of total aluminum in Doris Outflow and total iron in Roberts Outflow were higher than applicable CCME guidelines. However, seasonal variability was high at these sites and parallel increases from historical means also occurred at the reference stream. Thus, there was no evidence that these increases were due to Project activities. Notably, 2010 was a hydrologically “wet” year, as peak flows in some AEMP streams were associated with a 1-in-100 year recurrence interval, which could have contributed to higher concentrations of certain metals in AEMP streams.

Total cyanide concentrations increased in 2010 compared to historical levels in each of the AEMP streams; however, mean 2010 total cyanide concentrations did not exceed the CCME guideline of 0.005 mg/L as free cyanide. There was no cyanide used on site or brought to site in 2010. Therefore, the increase in cyanide observed in 2010 likely resulted from a natural process (non Project-related) or some analytical error. Cyanide concentrations will be closely monitored in both exposure and reference streams in the following years to determine whether total cyanide concentrations measured in 2010 were anomalously high, or part of an increasing trend in the Project area.

4.2 LAKES

Table 4.2-1 presents the summary of the 2010 evaluation of effects for the Doris North Project lakes. There was sufficient historical information to evaluate potential Project-related effects on winter dissolved oxygen levels, water and sediment quality parameters, and phytoplankton biomass. No Project-related effects were found for these parameters in 2010.

Table 4.1-1. Summary of Evaluation of Effects for the AEMP Streams, Doris North Project, 2010

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]					Before-After Difference Relative to Reference Site (BACI analysis)[a]			Conclusion of Effect[b, c]		
		Doris OF	Roberts OF	Little Roberts OF	Reference B OF	Reference D OF	Doris OF	Roberts OF	Little Roberts OF	Doris OF	Roberts OF	Little Roberts OF
Water Quality												
pH	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Alkalinity, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Hardness	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Total Suspended Solids	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Ammonia (as N)	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Nitrate (as N)	GA, BA	-	-	-	No difference	-	-	-	-	No effect	No effect	No effect
Cyanide, Total	GA, BA	**Increase**	**Increase**	**Increase**	-		-	-	-	No effect[d]	No effect[d]	No effect[d]
Radium-226	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Aluminum, Total	GA, BA, BACI	**Increase**	No difference	No difference	No difference	-	No difference	☐	☐	No effect	No effect	No effect
Arsenic , Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Cadmium, Total	GA, BA	-	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Copper, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Iron , Total	GA, BA, BACI	No difference	**Increase**	No difference	No difference	-	☐	No difference	☐	No effect	No effect	No effect
Lead, Total	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Mercury, Total	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Molybdenum, Total	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Nickel, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Zinc, Total	GA, BA	No difference	No difference	No difference	-	-	-	-	-	No effect	No effect	No effect
Sediment Quality												
% Gravel (>2 mm)	GA, BA	No difference	-	-	No difference		☐	-	-	No effect	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA	No difference	-	No difference	No difference		☐	-	☐	No effect	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	No difference	-	No difference	No difference		☐	-	☐	No effect	No effect	No effect
% Clay (<4 µm)	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Total Organic Carbon	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Arsenic	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Cadmium	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Chromium	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Copper	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Lead	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Mercury	GA, BA	No difference	-	No difference	-	-	-	-	☐	No effect	No effect	No effect
Zinc	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis*

[a] *Statistically significant difference at p<0.01 to avoid Type I errors.*

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

[c] *For water pH, water alkalinity, water hardness, sediment total organic carbon, sediment particle size, and phytoplankton biomass, a change in any direction is considered to be an effect. For winter dissolved oxygen concentrations, only a decrease is considered to be an effect. For all remaining parameters, only an increase is considered to be an effect.*

[d] *Although there was an apparent increase, this change cannot be attributed to Project activities. There was also no historical data for the reference sites, so a BACI analysis could not be performed.*

Dash (-) indicates that statistical analysis was not possible because of missing data (i.e., no historical data available), the high proportion of nondetectable concentrations, or the lack of variation in a parameter over time (having no measure of variation causes F-statistic to be infinite).

Square (☐) indicates that BACI results are not reported because the within waterbody before-after comparison shows that there was no significant difference between historical and 2010 means.

Table 4.2-1. Summary of Evaluation of Effects for the AEMP Lakes, Doris North Project, 2010

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]					Before-After Difference Relative to Reference Site (BACI analysis)[a]			Conclusion of Effect[b, c]		
		Doris South	Doris North	Reference Lake B	Little Roberts	Reference Lake D	Doris South	Doris North	Little Roberts	Doris South	Doris North	Little Roberts
Water Quality												
pH	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Alkalinity, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Hardness	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Total Suspended Solids	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Ammonia (as N)	GA, BA	-	No difference	No difference	No difference	-	-	□	-	No effect	No effect	No effect
Nitrate (as N)	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Cyanide, Total	GA, BA	**Increase**	**Increase**	-	**Increase**	-	-	-	-	No effect[d]	No effect[d]	No effect[d]
Radium-226	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Aluminum, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Arsenic , Total	GA, BA, BACI	No difference	**Decrease**	No difference	No difference	-	□	No difference	-	No effect	No effect	No effect
Cadmium, Total	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Copper, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Iron , Total	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Lead, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Mercury, Total	GA, BA	-	No difference	-	-	-	-	-	-	No effect	No effect	No effect
Molybdenum, Total	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Nickel, Total	GA, BA	No difference	No difference	No difference	No difference	-	□	□	-	No effect	No effect	No effect
Zinc, Total	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Physical Limnology												
Winter Dissolved Oxygen	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Sediment Quality												
% Gravel (>2 mm)	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	-	**Increase**	-	**Increase**	-	-	-	-	No effect	No effect	No effect
% Clay (<4 µm)	GA, BA	-	**Decrease**	-	**Decrease**	-	-	-	-	No effect	No effect	No effect
Total Organic Carbon	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Arsenic	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Cadmium	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Chromium	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Copper	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Lead	GA, BA	-	**Decrease**	-	No difference	-	-	-	-	No effect	No effect	No effect
Mercury	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Zinc	GA, BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Phytoplankton												
Biomass	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis*

[a] *Statistically significant difference at $p<0.01$ to avoid Type I errors.*

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

[c] *For water pH, water alkalinity, water hardness, sediment total organic carbon, sediment particle size, and phytoplankton biomass, a change in any direction is considered to be an effect. For winter dissolved oxygen concentrations, only a decrease is considered to be an effect. For all remaining parameters, only an increase is considered to be an effect.*

[d] *Although there was an apparent increase, this change cannot be attributed to Project activities. There was also no historical data for the reference sites, so a BACI analysis could not be performed.*

Dash (-) indicates that statistical analysis was not possible because of missing data (i.e., no historical data available), the high proportion of nondetectable concentrations, or the lack of variation in a parameter over time (having no measure of variation causes F-statistic to be infinite).

Square (□) indicates that BACI results are not reported because the within waterbody before-after comparison shows that there was no significant difference between historical and 2010 means.

Mean 2010 water quality parameter concentrations were generally below CCME guidelines in AEMP lakes, with the exception of total cyanide (higher than the CCME guideline for free cyanide), total aluminum, and total copper in the smaller AEMP lakes, and total cadmium in Doris Lake South (driven by a single anomalously high sample concentration). All mean 2010 sediment quality parameter concentrations were below CCME ISQGs, with the exception of chromium in the sediments of most lakes, and arsenic and copper in Doris Lake North sediments.

Like streams, there were no effects to AEMP lakes that could be attributed to 2010 Project activities. Winter dissolved oxygen concentrations were within historical ranges, and there were no notable changes in sediment quality or phytoplankton biomass in any of the AEMP lakes. This was also the case for water quality, except for total cyanide concentrations, which were higher than historical levels. The mean 2010 total cyanide concentration in a single lake (Little Roberts Lake) slightly exceeded the CCME guideline of 0.005 mg/L as free cyanide. No cyanide was used or brought to site in 2010. Therefore, the increase in cyanide observed in exposure sites in 2010 likely resulted from a natural process or some analytical error. This parameter will continue to be monitored in the following years.

4.3 MARINE

The summary of the effects evaluations for the AEMP marine sites is provided in Table 4.3-1. There was sufficient historical information to evaluate potential Project-related effects on winter dissolved oxygen levels, water and sediment quality parameters, and phytoplankton biomass. No Project-related effects were found for these parameters in 2010.

All water quality and dissolved oxygen concentrations at the marine sites during 2010 remained similar to baseline conditions, indicating 2010 Project-related activities had no effects on the water chemistry in the surrounding marine habitat. The dissolved oxygen concentrations in Roberts Bay were above the CCME recommended levels for marine and estuarine waters (8 mg/L), and all water quality parameters were below CCME guidelines.

Several metals increased in RBW sediments between 2002 and 2010. However, similar or greater increases occurred at the marine reference site (REF-Marine) between 2009 and 2010, indicating that this variability was likely natural. All measured sediment quality parameters were below CCME ISQGs.

There was some indication that phytoplankton biomass increased in the southeastern section of Roberts Bay (RBE) in 2010 relative to historical levels, but this was driven by the anomalously high chlorophyll *a* concentrations found in August. This may have resulted from benthic re-suspension due to the high winds that were present during sampling. All other 2010 samples in RBE (April, July, and September) were comparable to historical levels. Therefore, it is unlikely that 2010 activities contributed to this August biomass increase in RBE.

Table 4.3-1. Summary of Evaluation of Effects for the AEMP Marine Sites, Doris North Project, 2010

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]			Before-After Difference Relative to Reference Site (BACI analysis)[a]		Conclusion of Effect[b, c]	
		Roberts Bay West (RBW)	Roberts Bay East (RBE)	Reference Bay (REF-AEMP)	Roberts Bay West (RBW)	Roberts Bay East (RBE)	Roberts Bay West (RBW)	Roberts Bay East (RBE)
Water Quality								
pH	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Alkalinity, Total	GA, BA	-	No difference	-	-	-	No effect	No effect
Hardness	GA, BA	No difference	No difference	-	-	-	No effect	No effect
Total Suspended Solids	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Ammonia (as N)	GA, BA	-	No difference	No difference	-	☐	No effect	No effect
Nitrate (as N)	GA, BA	No difference	-	-	-	-	No effect	No effect
Cyanide, Total	GA, BA	-	No difference	-	-	-	No effect	No effect
Radium-226	GA	-	-	-	-	-	No effect	No effect
Aluminum, Total	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Arsenic , Total	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Cadmium, Total	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Copper, Total	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Iron , Total	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Lead, Total	GA, BA	-	Increase[d]	-	-	-	No effect	No effect
Mercury, Total	GA	-	-	-	-	-	No effect	No effect
Molybdenum, Total	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Nickel, Total	GA, BA	No difference	No difference	No difference	☐	☐	No effect	No effect
Zinc, Total	GA, BA	No difference	No difference	-	-	-	No effect	No effect
Physical Oceanography								
Winter Dissolved Oxygen	GA	-	-	-	-	-	No effect	No effect
Sediment Quality								
% Gravel (>2 mm)	GA, BA	-	-	No difference	-	-	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA, BACI	Increase	-	Decrease	Increase	-	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	No difference	-	Increase	☐	-	No effect	No effect
% Clay (<4 µm)	GA, BA, BACI	Decrease	-	No difference	Decrease	-	No effect	No effect
Total Organic Carbon	GA, BA	No difference	-	No difference	☐	-	No effect	No effect
Arsenic	GA, BA, BACI	Increase	-	Increase	No difference	-	No effect	No effect
Cadmium	GA	-	-	-	-	-	No effect	No effect
Chromium	GA, BA, BACI	Increase	-	Increase	No difference	-	No effect	No effect
Copper	GA, BA, BACI	Increase	-	Increase	No difference	-	No effect	No effect
Lead	GA, BA	No difference	-	Increase	☐	-	No effect	No effect
Mercury	GA	-	-	-	-	-	No effect	No effect
Zinc	GA, BA, BACI	Increase	-	Increase	No difference	-	No effect	No effect
Phytoplankton								
Biomass	GA	-	-	-	-	-	No effect	No effect

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis*

[a] *Statistically significant difference at p<0.01 to avoid Type I errors.*

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

[c] *For water pH, water alkalinity, water hardness, sediment total organic carbon, sediment particle size, and phytoplankton biomass, a change in any direction is considered to be an effect. For winter dissolved oxygen concentrations, only a decrease is considered to be an effect. For all remaining parameters, only an increase is considered to be an effect.*

[d] *Increase in mean total lead concentration at RBW is an artifact of the high 2010 detection limit compared to historical detection limits. All 2010 total lead concentrations at RBW were below the detection limit.*

Dash (-) indicates that statistical analysis was not possible because of missing data (i.e., no historical data available), the high proportion of nondetectable concentrations, or the lack of variation in a parameter over time (having no measure of variation causes F-statistic to be infinite).

Square (☐) indicates that BACI results are not reported because the within waterbody before-after comparison shows that there was no significant difference between historical and 2010 means.

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Appendix A

2010 Aquatic Resources Results

Appendix A1. 2010 Aquatic Resources Data Report, Doris North Project

Appendix A2. 2010 Aquatic Resources Raw Data, Doris North Project

Appendix A3. 2010 Aquatic Resources Summary Statistics, Doris North Project

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Appendix A1

2010 Aquatic Resources Data Report, Doris North Project

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APPENDIX A1
2010 AQUATIC RESOURCES DATA REPORT, DORIS NORTH PROJECT

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A1. 2010 Aquatic Resources Data Report, Doris North Project

The 2010 Aquatic Effects Monitoring Program (AEMP) was comprised of two main components: 1) aquatic resources and 2) the fish community. 2010 was the first year of post-baseline monitoring of the freshwater and marine aquatic resources. This report presents the data from the 2010 aquatic resources (including water quality and water column structure, sediment quality, primary producers, and benthic invertebrates). Appendix B1 presents the results of the 2010 fish data.

A1.1 PHYSICAL LIMNOLOGY AND OCEANOGRAPHY

Temperature and dissolved oxygen profiles were collected from the lakes and marine sites four times between April (under-ice) and September (open water), 2010. The profiles are shown in Figures A1.1-1 through A1.1-8 and the data are included in Appendices A2-1 to A2-3. The dissolved oxygen data were compared to the CCME guideline for early and late aquatic life stages (CCME 2011b).

A1.1.1 Lakes

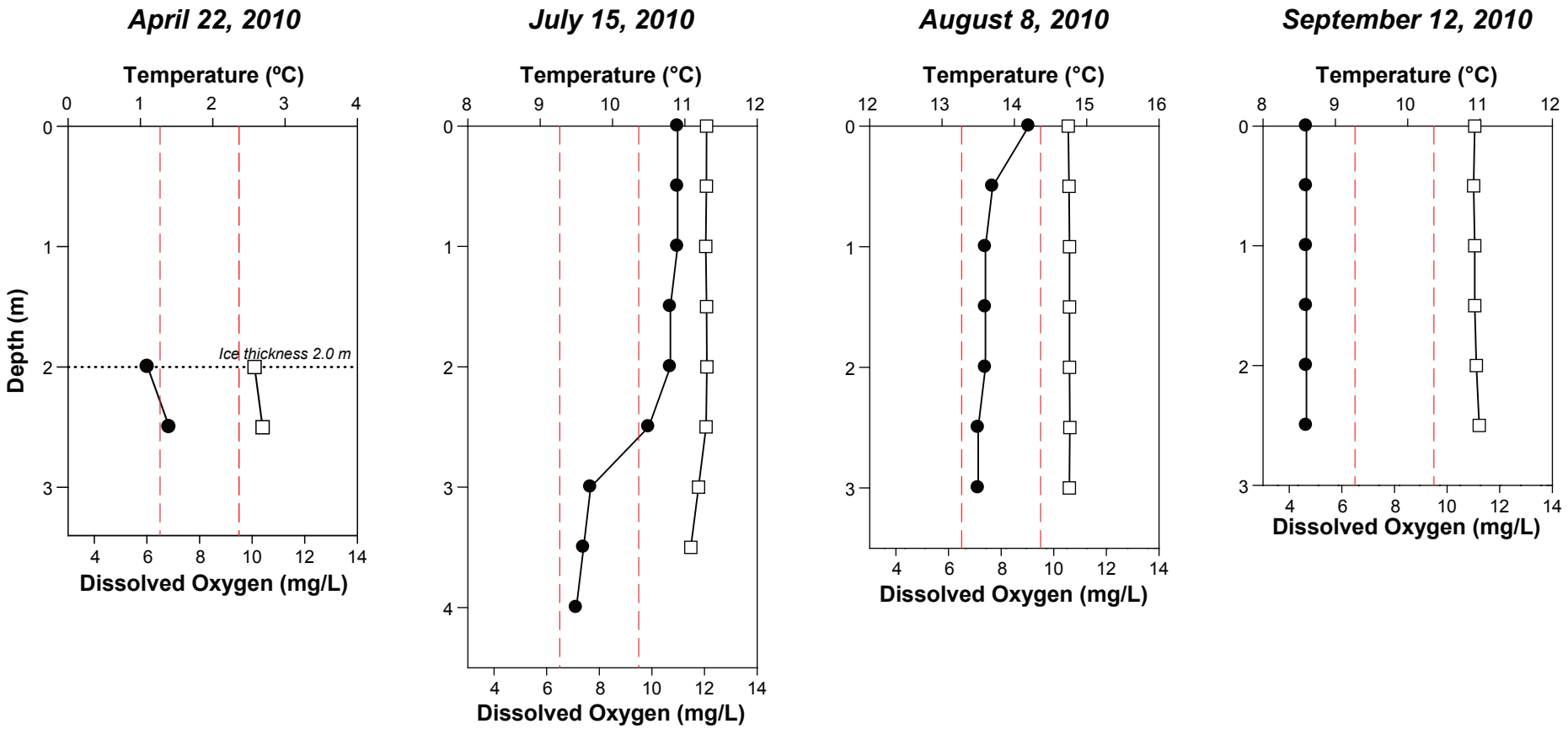
A1.1.1.1 Under-Ice

During April, the thickness of the ice cover on AEMP lakes ranged from 1.7 m (Reference Lake B) to 2 m (Doris Lake South). In the shallower lake sites such as Doris Lake South, Little Roberts Lake, and Reference Lake D, approximately 1 m of water was present between the bottom of the ice and the sediment layer. Water temperatures ranged from 0.4°C to 1.4°C just below the ice, and increased with depth at the deeper sites (to 2.3°C at Reference Lake B and 1.9°C in Doris Lake North).

The under-ice dissolved oxygen concentrations differed depending on the depth of the lake. At the shallower sites, dissolved oxygen was always above 10 mg/L and 90% saturation, with a maximum of 11.4 mg/L and 104% at Reference Lake D (2.5 m depth). These lakes were likely well-oxygenated due to epontic and benthic photosynthesis, and the oxygen levels were above the 9.5 mg/L CCME guideline for the protection of early life stages of fish. In the deeper lakes, there was a noticeable oxygen decrease at depth due to benthic respiration and the absence of vertical mixing. In Doris Lake North, oxygen levels declined sharply from 9.1 mg/L at 9.5 m to 6.1 mg/L at 10 m, and reached a minimum of 5.2 mg/L at 12 m (Figure A1.1-2). Below 10 m, saturation levels were near 50% and the dissolved oxygen concentrations were lower than the CCME guideline for later aquatic life stages (6.5 mg/L). At Reference Lake B, this oxygen decline occurred at a shallower depth, as surface concentrations of approximately 12 mg/L and 110% saturation decreased sharply to 4 mg/L and 37% at 5.5 m depth (Figure A1.1-3). This was the lowest dissolved oxygen concentration measured in any AEMP lake during 2010.

A1.1.1.2 Open Water

During the open-water season, the AEMP lakes were generally well-mixed, with the warmest temperatures occurring in August (Figures A1.1-1 to A1.1-5). No vertical stratification was evident in the shallow lake sites (Doris Lake South, Little Roberts Lake, and Reference Lake D) during any of the sampled open-water months, except Doris Lake South in July where there was mild stratification present (change in temperature (ΔT) = 1.3°C). Reference Lake D and Little Roberts Lake were the warmest AEMP lakes, with surface temperatures of 16.6°C and 15.4°C in August.



Note: Vertical dashed lines represent CCME 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.
Scale used to plot temperature changes from month to month

Figure A1.1-1

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Doris Lake South, Doris North Project 2010

Figure A1.1-1

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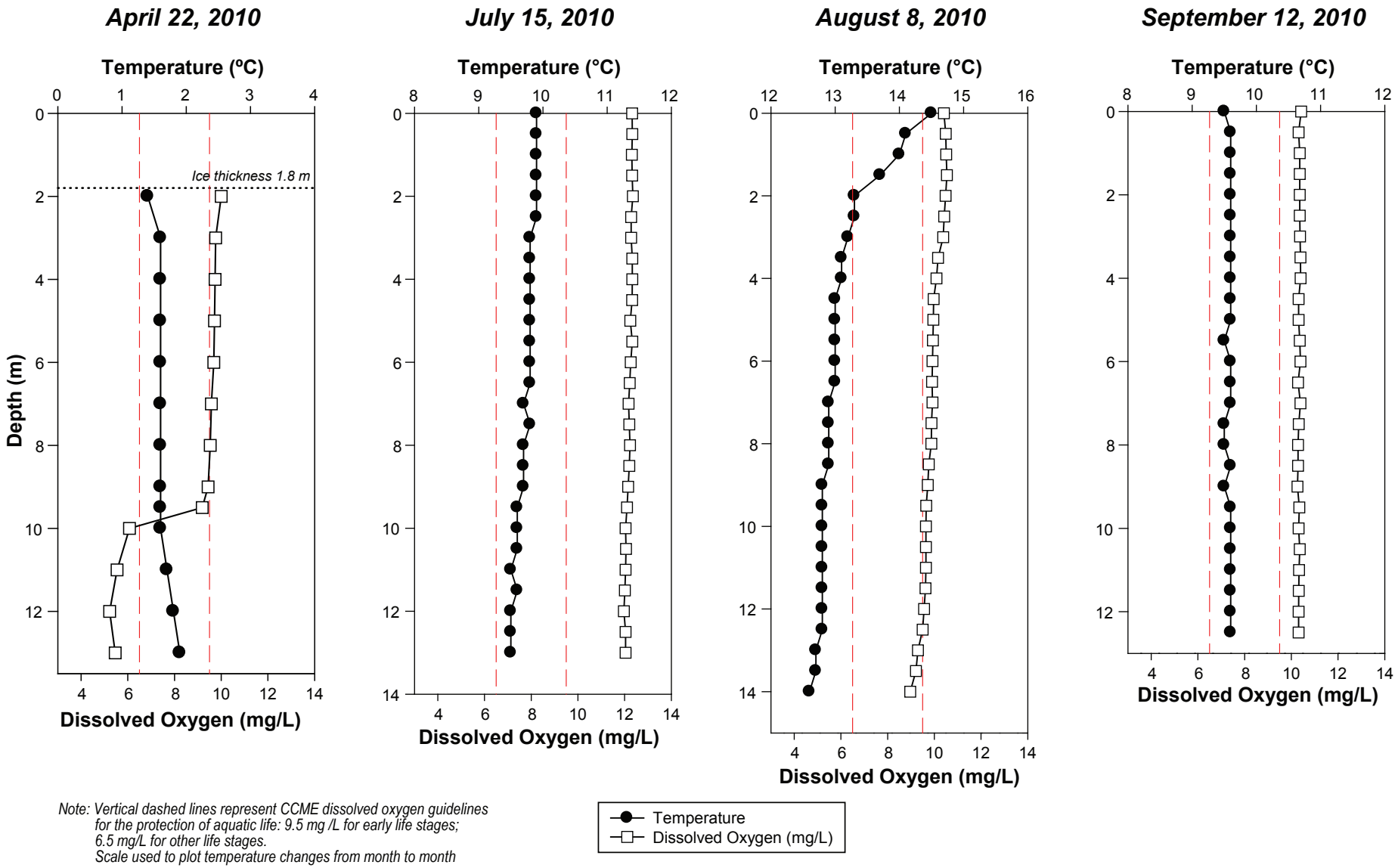

Note: Vertical dashed lines represent CCME dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages.
Scale used to plot temperature changes from month to month

Figure A1.1-2

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Doris Lake North, Doris North Project, 2010

Figure A1.1-2

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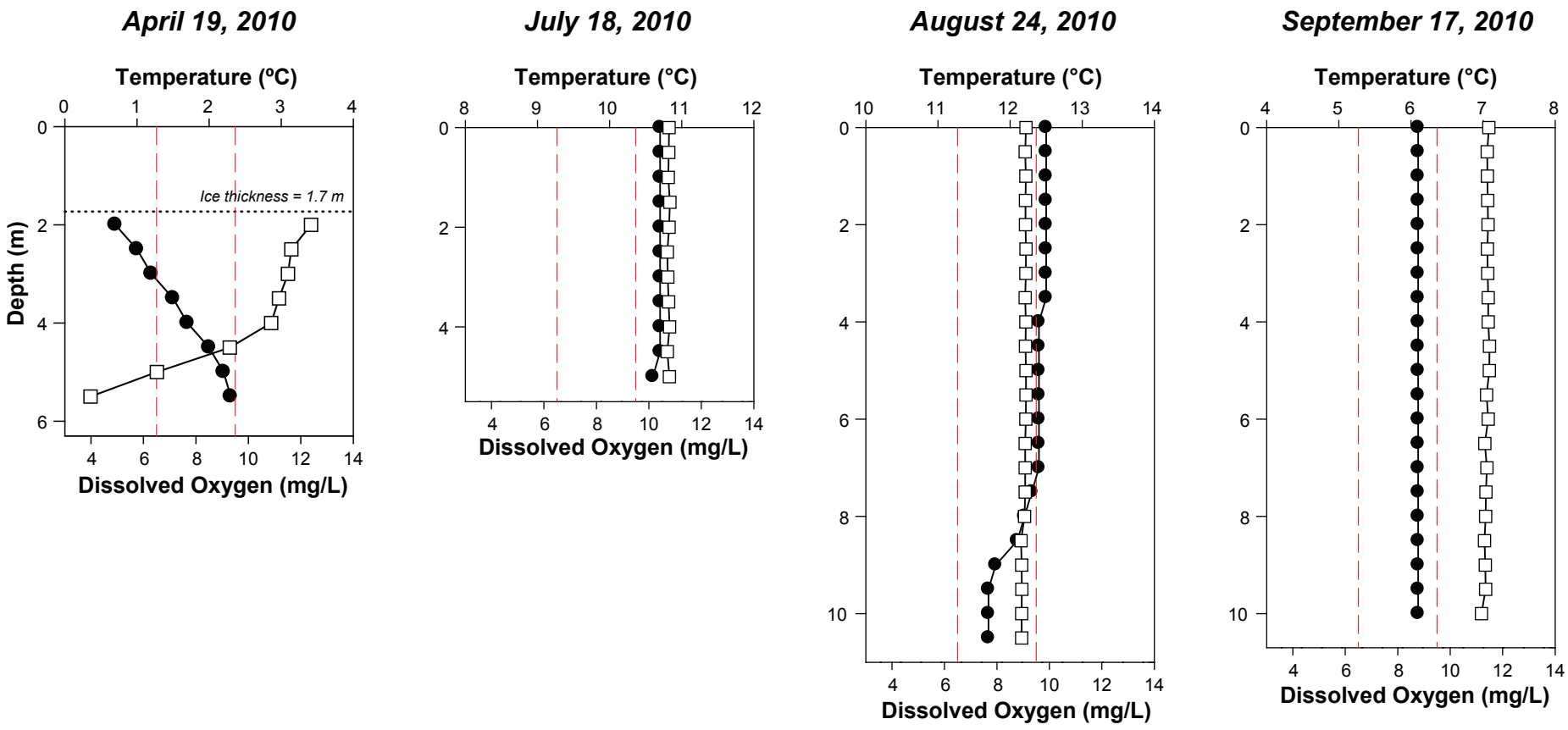

Note: Vertical dashed lines represent CCME dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages.
Scale used to plot temperature changes from month to month

Figure A1.1-3

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Reference Lake B, Doris North Project, 2010

Figure A1.1-3

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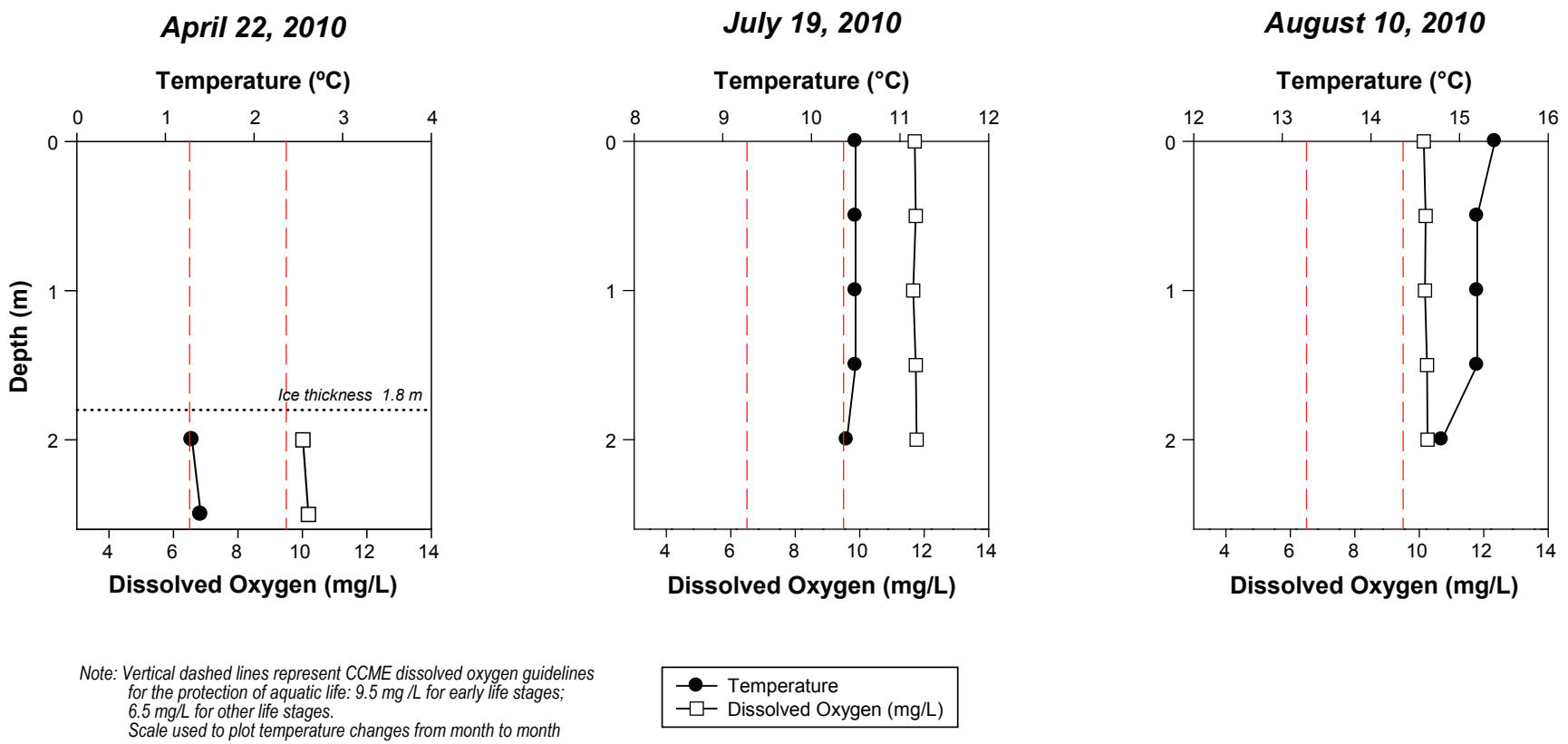


Note: Vertical dashed lines represent CCME dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages.
Scale used to plot temperature changes from month to month

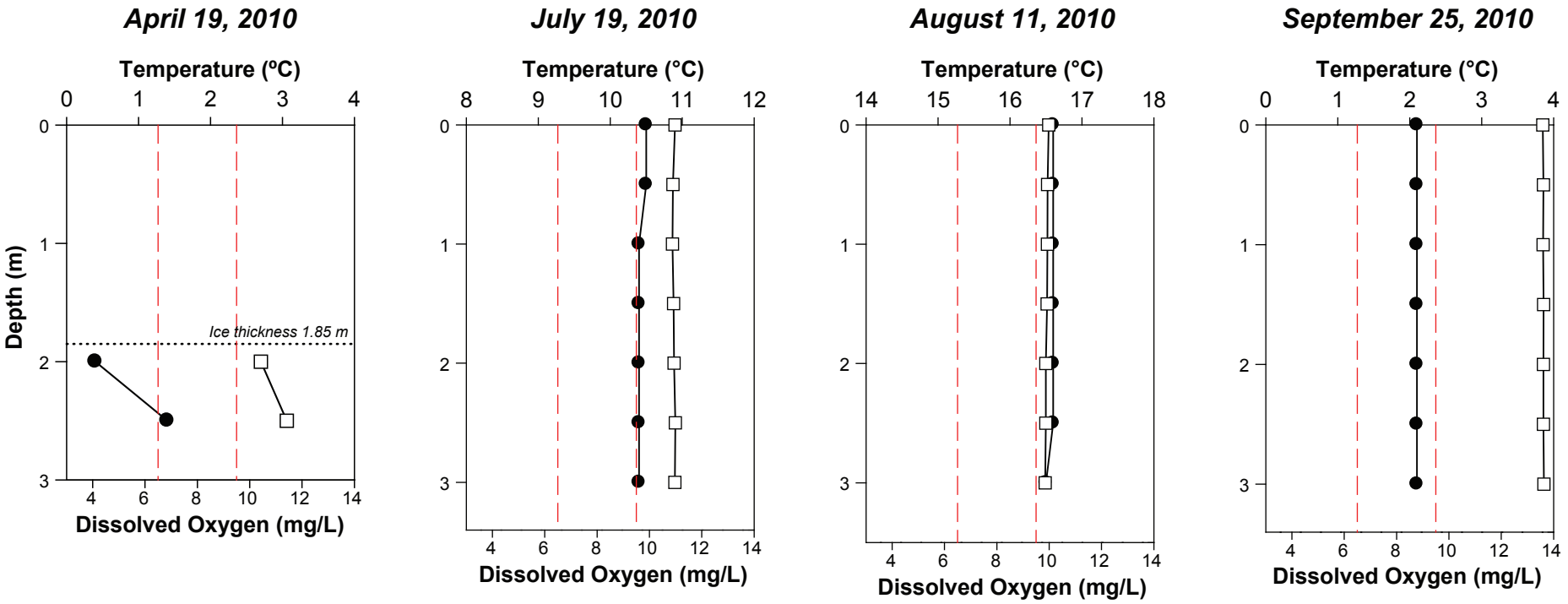
Figure A1.1-4

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Little Roberts Lake, Doris North Project, 2010

Figure A1.1-4

Rescan Engineers & Scientists



Note: Vertical dashed lines represent CCME 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.
Scale used to plot temperature changes from month to month

Figure A1.1-5

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Reference Lake D, Doris North Project, 2010

Figure A1.1-5

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At the deeper lake sites, the water column was well-mixed in July and September, and weakly stratified in August. In Doris Lake North, a slight temperature gradient was present at the surface ($\Delta T = 1.2^{\circ}C$); however, deep water temperatures were approximately 3°C warmer in August than July, suggesting that this stratification was ephemeral and heat was being transferred effectively into the bottom layer by wind-driven mixing. In Reference Lake B, stratification was present, but weak ($\Delta T = 0.8^{\circ}C$), with an upper mixed layer depth of 7 m.

In general, temperatures were similar among the AEMP lakes in July (surface range: 9.9–10.9°C), more variable in August (surface range: 12.5–16.6°C; lowest at Reference Lake B), and most variable in September (surface range: 2.1–9.6°C). Sampling in September was carried out over a two-week period, allowing observation of the rapid seasonal decline in temperatures during that month.

Overall, the AEMP lakes were well-oxygenated during the open-water period. Dissolved oxygen concentrations were largely uniform throughout the water column and surface oxygen was usually very near saturation or supersaturated (range: 91–110%; Appendix A2-1). During August, dissolved oxygen concentrations in Reference Lake B were always below the CCME guideline for early aquatic life stages (9.5 mg/L; Figure A1.1-3), although saturation levels ranged between 96 and 100%. August dissolved oxygen levels at Doris Lake North were also lower than this guideline at depth (below 13 m) with slightly lower saturation levels than at Reference Lake B (84–88%). No other open-water measurements were below this threshold.

A1.1.2 Marine

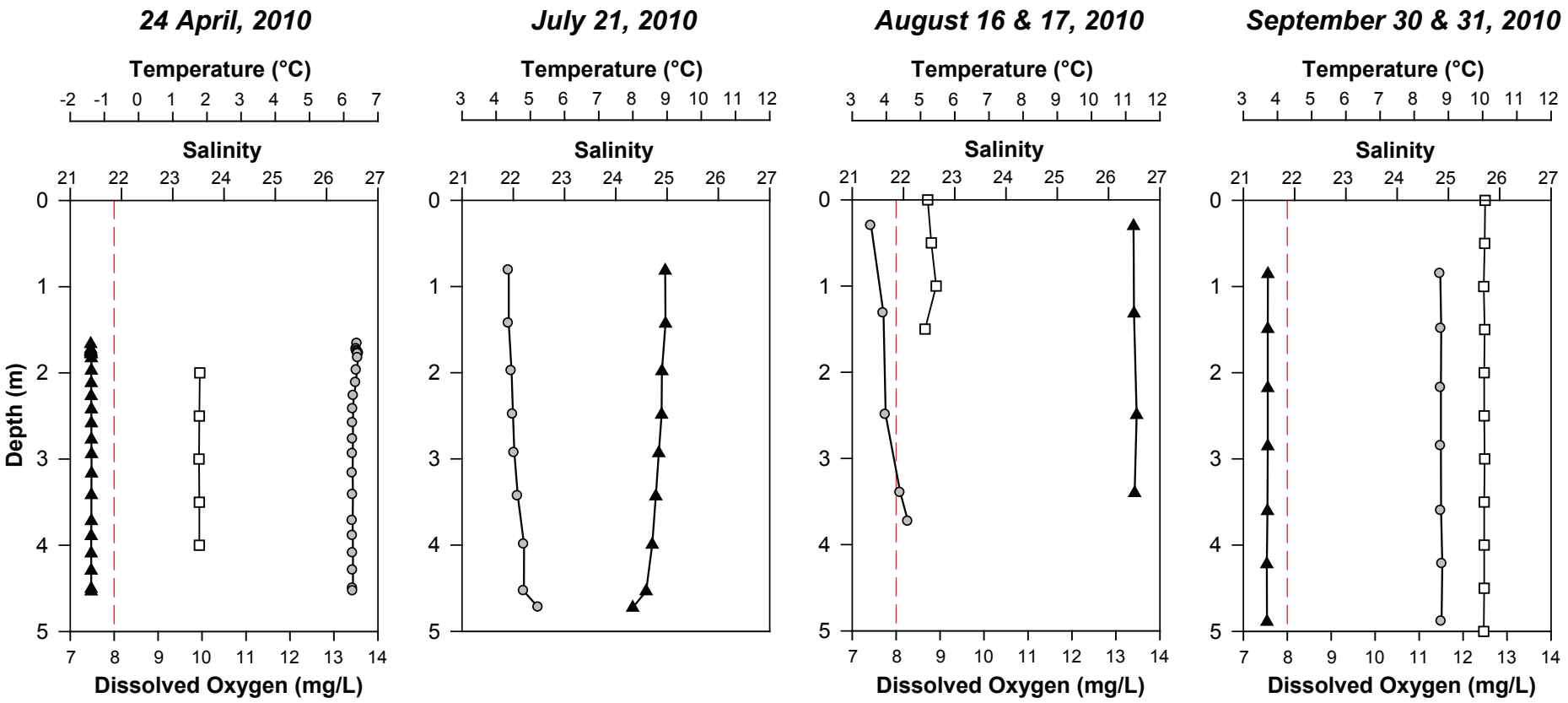
A1.1.2.1 Under-Ice

Thermohaline profiles were collected in April at the two marine sites in Roberts Bay, RBE and RBW, but not at the reference site, REF-Marine, because surface melting made sampling unsafe. In Roberts Bay, uniform temperatures and salinities were present from the base of the ice layer to the sediment surface. At both RBE and RBW, temperatures were -1.4°C and salinities were near 26.5 (Figures A1.1-6 and A1.1-7). Based on the observed salinities at these sites, the temperatures were very close to the freezing point of seawater (-1.45°C). The slightly higher salinity found at the surface of RBW than at depth suggests that some salt extrusion was occurring. Thus, the seawater was freezing and the ice layer was possibly expanding during this time.

Like temperature and salinity, the dissolved oxygen concentrations at RBW and RBE were similar throughout the depth profile, with concentrations near 10 mg/L and saturation levels between 83 and 86%. These concentrations were well above the recommended CCME minimum concentration for estuarine waters (8 mg/L).

A1.1.2.2 Open Water

Temperatures at the marine sites increased quickly after ice-off (late June), with the waters warming from July (maximum: 8.9°C) into August (maximum: 11.2°C) before cooling substantially in late September (maximum: 4°C; Figures A1.1-6 to A1.1-8). The marine sites were generally well-mixed because of their shallow nature, their position in the southern near-shore environment, and the persistence of the north to northwest winds in the Doris North region. Stratification was only present at REF-Marine in August where there was a shallow pycnocline at approximately 2 m. Salinities were usually between 20 and 22 in July and 24 and 25 in September, but were more spatially variable in August. For example, RBE was much more brackish in August (salinity: 4.5) due to freshwater inputs from Little Roberts Outflow, REF-Marine had a less saline surface layer (salinity: 17), while RBW showed little freshwater influence with a surface salinity near 22.



Note: Temperature and salinity scales vary between graphs.
The dashed line shows the recommended minimum concentration of DO in estuarine waters (8.0 mg/L).
Dissolved oxygen data was not collected in July.

Figure A1.1-6

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Temperature, Salinity and Dissolved Oxygen Profiles at Marine Site RBW, Doris North Project, 2010

Figure A1.1-6

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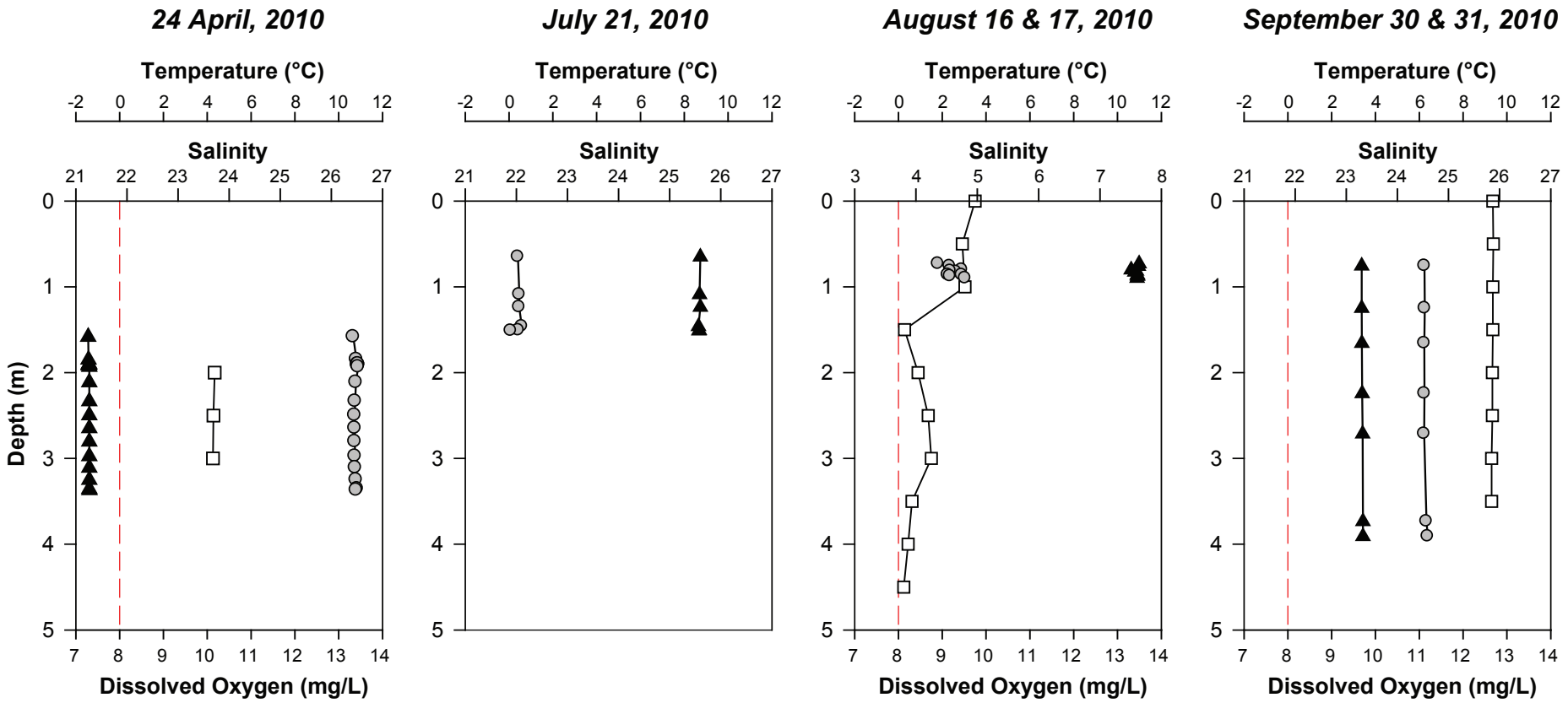

Note: Temperature and salinity scales vary between graphs.
The dashed line shows the recommended minimum concentration of DO in estuarine waters (8.0 mg/L).
Dissolved oxygen data was not collected in July.

Figure A1.1-7

NEWMONT NORTH AMERICA

Temperature, Salinity and Dissolved Oxygen Profiles at Marine Site RBE, Doris North Project, 2010

Figure A1.1-7

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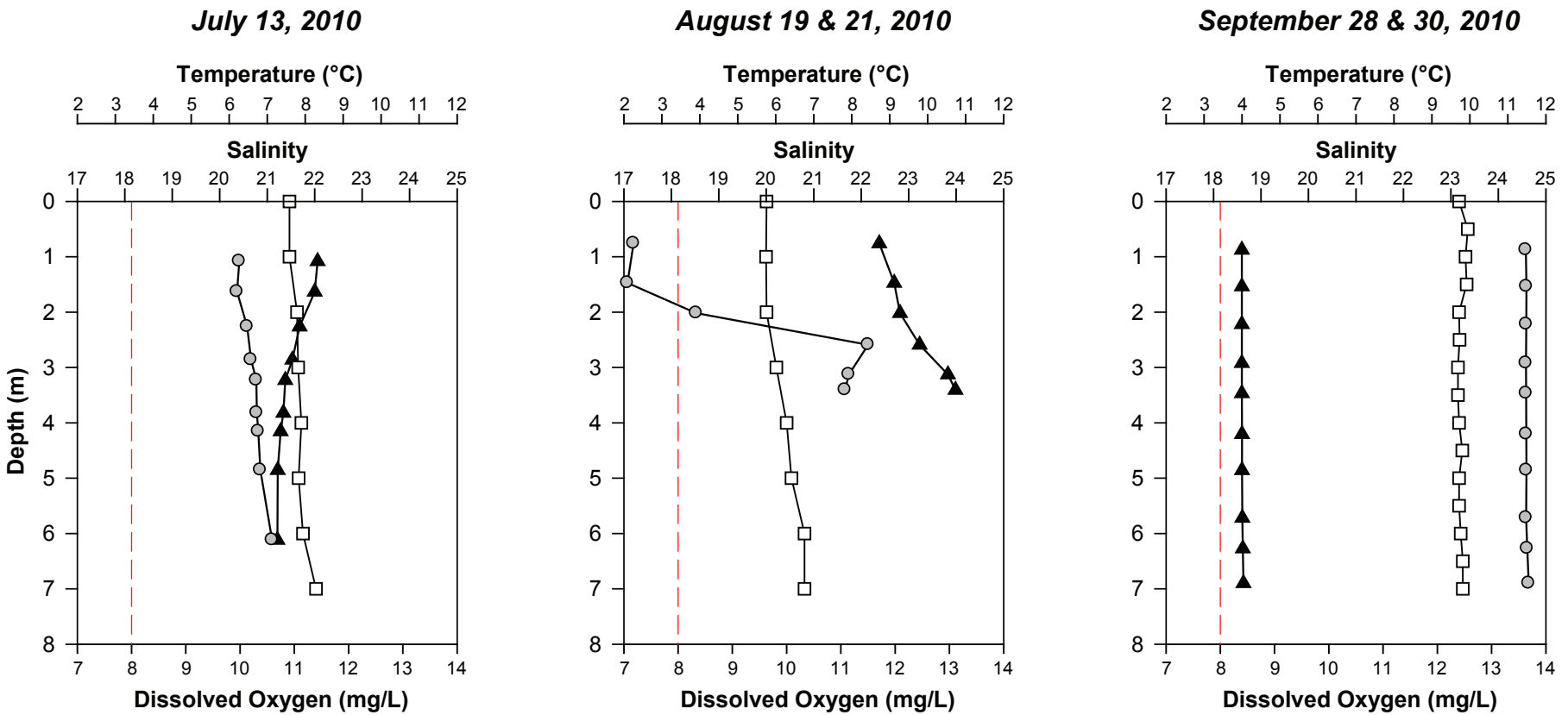

Note: The dashed line shows the recommended minimum concentration of DO in estuarine waters (8.0 mg/L). No winter data was collected from Site REF-Marine.

Figure A1.1-8

NEWMONT NORTH AMERICA

Temperature, Salinity and Dissolved Oxygen Profiles at Marine Site REF-Marine, Doris North Project, 2010

Figure A1.1-8

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Dissolved oxygen concentrations and saturation levels at the marine AEMP sites were generally well distributed through the water column and were higher in July and September than in August, largely because of the inverse relationship between oxygen solubility and temperature (Figures A1.1-6 to A1.1-8; Appendix A2-3). Surface oxygen levels usually approached saturation (90–100%) at most depth intervals throughout the open-water season and were supersaturated at REF-Marine in July (maximum: 114%; Appendix A2-3). While no dissolved oxygen measurements were below the recommended CCME minimum concentration for estuarine waters of 8.0 mg/L, this value was approached at RBE in August (8.1 mg/L; saturation of 85.3%).

A1.2 WATER QUALITY

Water quality samples were collected from streams, lakes, and marine sites between April and September, 2010. All raw water quality data are provided in Appendix A2-4 and select water quality parameters are described below. For graphing purposes, half the detection limit was substituted for water quality variables that were below analytical detection limits. Parameter concentrations were compared against applicable CCME water quality guidelines for the protection of freshwater aquatic life (CCME 2011b).

A1.2.1 Streams

Water quality samples from streams were collected during freshet (June) and three times during the open-water season (July, August, and September). Samples were collected from three exposure streams (Doris Outflow, Roberts Outflow, and Little Roberts Outflow) and two reference streams (Reference B Outflow and Reference D Outflow).

A1.2.1.1 pH

pH levels were generally similar among stream sites and seasons, ranging from 7.1 (Reference B Outflow in August) to 7.8 (Doris Outflow in July; Figure A1.2-1).

A1.2.1.2 Total Alkalinity

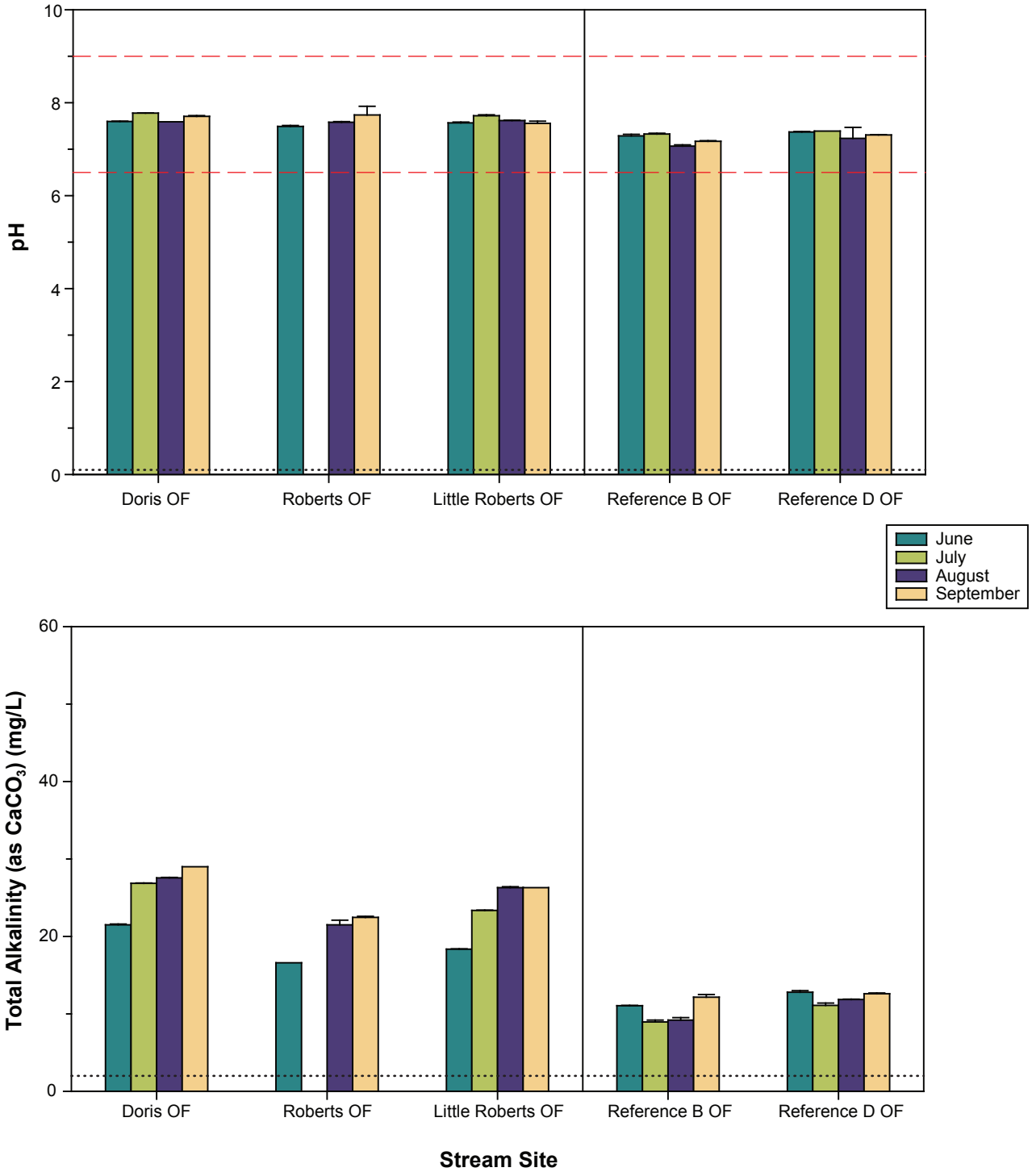
Total alkalinity is a measure of the acid-neutralizing capacity of water, and is therefore used as an index of the acid-sensitivity of a waterbody. Table A1.2-1 summarizes the classification system used by Saffran and Trew (1996) for the acid-sensitivity of lakes in Alberta based on total alkalinity.

Table A1.2-1. Acid Sensitivity Classification of Lakes based on Total Alkalinity (as $CaCO_3$)

Acid Sensitivity	Total Alkalinity (as $CaCO_3$)
High	< 10 mg/L
Moderate	11–20 mg/L
Low	21–40 mg/L
Least	> 40 mg/L

Source: Saffran and Trew, 1996

Total alkalinity (as $CaCO_3$) was consistently higher in the exposure streams than in the reference streams (Figure A1.2-1). Mean total alkalinity levels in the exposure streams ranged from 16.6 mg/L (Roberts Outflow in June) to 29.0 mg/L (Doris Outflow in September). Based on the classification system outlined by Saffran and Trew (1996), Roberts and Little Roberts outflows had moderate sensitivity to acid deposition during the ice-covered season and low-sensitivity during the open-water season, while Doris Outflow had low sensitivity to acid deposition during all sampling periods. Mean total alkalinity in the reference streams ranged from 8.95 mg/L (Reference B Outflow in July) to 12.8 mg/L (Reference D Outflow in June). Reference D Outflow was moderately sensitive to acid during all sampling periods, and Reference B Outflow ranged from moderately to highly sensitive.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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pH and Total Alkalinity in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-1

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A1.2.1.3 Hardness

Similar to total alkalinity, hardness (as $CaCO_3$) was consistently higher in the exposure streams than in the reference streams (Figure A1.2-2). Mean hardness in exposure streams ranged from 30.1 mg/L (Roberts Outflow in June) to 56.4 mg/L (Doris Outflow in September) and tended to increase from June to September. Mean hardness in reference streams ranged from 12.2 mg/L (Reference B Outflow in July) to 20.3 mg/L (Reference B Outflow in August), with no apparent seasonal trends. According to the water hardness classification system used by the United States Geological Survey (USGS 2009; Table A1.2-2), all exposure and reference streams would be characterized as soft.

Table A1.2-2. USGS Water Hardness Classification

Classification	Hardness (as $CaCO_3$)
Soft	< 60 mg/L
Moderately Hard	61–120 mg/L
Hard	121–180 mg/L
Very Hard	> 180 mg/L

Source: http://water.usgs.gov/owq/hardness-alkalinity.html

A1.2.1.4 Total Suspended Solids

Concentrations of total suspended solids (TSS) were highly variable among sites and sampling months, and no consistent spatial or seasonal trends were apparent. TSS concentrations were below the analytical detection limit of 3 mg/L in most samples collected from the reference streams. The highest mean TSS concentration of 20 mg/L was measured at Doris Outflow in August (Figure A1.2-2).

A1.2.1.5 Total Ammonia

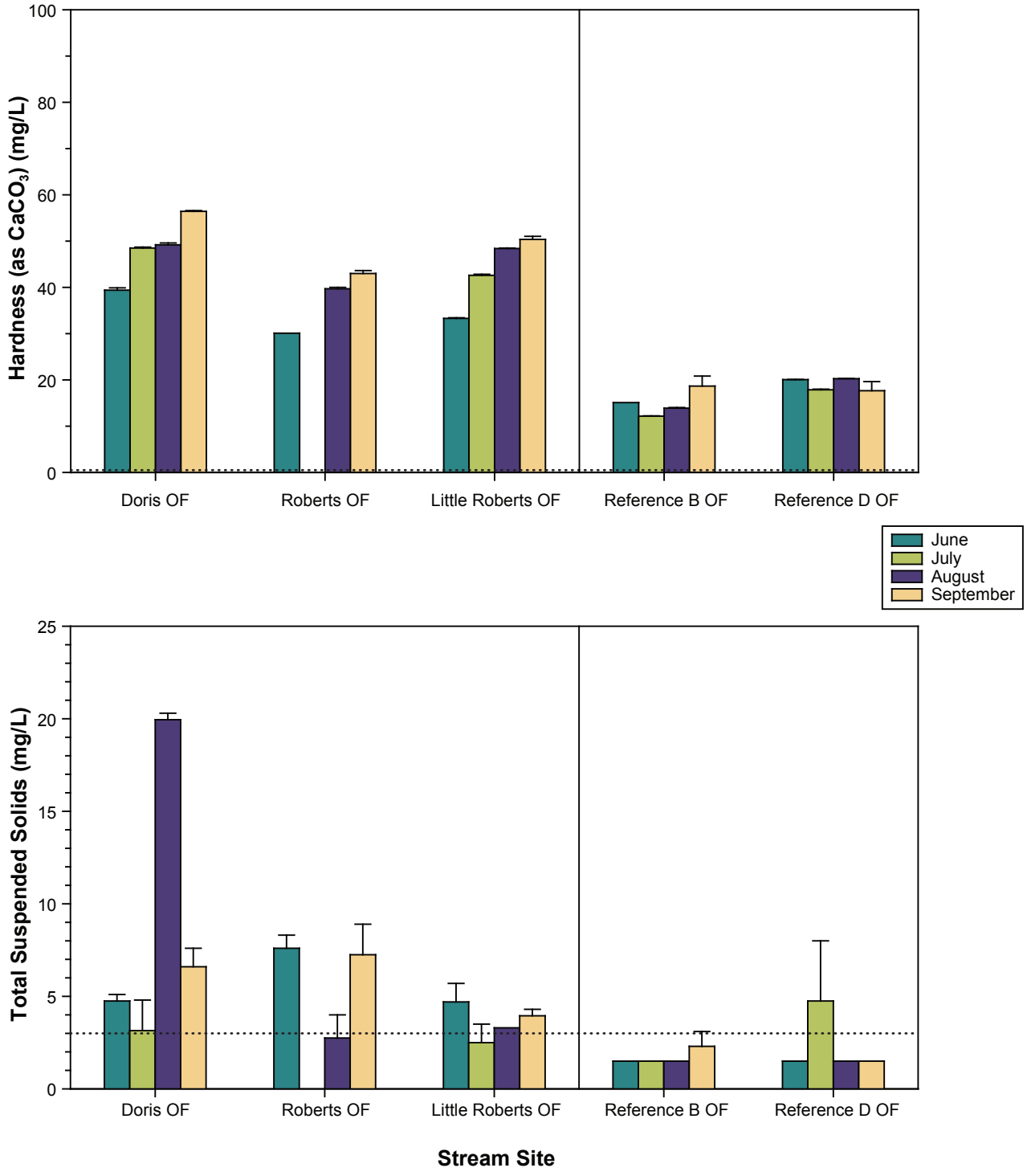
Total ammonia concentrations in streams were highly variable among sites and sampling months, and no consistent spatial or seasonal trends were apparent. At all sites, concentrations of total ammonia were below the analytical detection limit of 0.005 mg ammonia-N/L during at least one sampling period. The highest mean total ammonia concentration of 0.039 mg ammonia-N/L was measured at Reference D Outflow in September (Figure A1.2-3). August and September total ammonia concentrations should be interpreted with caution because of potential ambient contamination evident in field blanks (see Section A1.2.2.4).

A1.2.1.6 Nitrate

Concentrations of nitrate were below the analytical detection limit of 0.005 mg nitrate-N/L in all samples collected from the exposure streams and in the majority of samples collected from the reference streams. Overall, nitrate concentrations in 87% of stream samples were below the detection limit. The maximum mean concentration of nitrate of 0.011 mg nitrate-N/L occurred at Reference B Outflow in September (Figure A1.2-3).

A1.2.1.7 Total Cyanide

The mean concentration of total cyanide ranged from 0.0016 mg/L (Reference B Outflow in September) to 0.0063 mg/L (Roberts Outflow in June). A seasonal trend was apparent in all streams as mean total cyanide concentrations were highest during June freshet and lowest in September. Total cyanide concentrations tended to be slightly higher in exposure streams than in reference streams from June to August, but September concentrations were similar in all monitored streams (Figure A1.2-4).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
The CCME guideline for total suspended solids is dependent upon background levels.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Hardness and Total Suspended Solids in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-2

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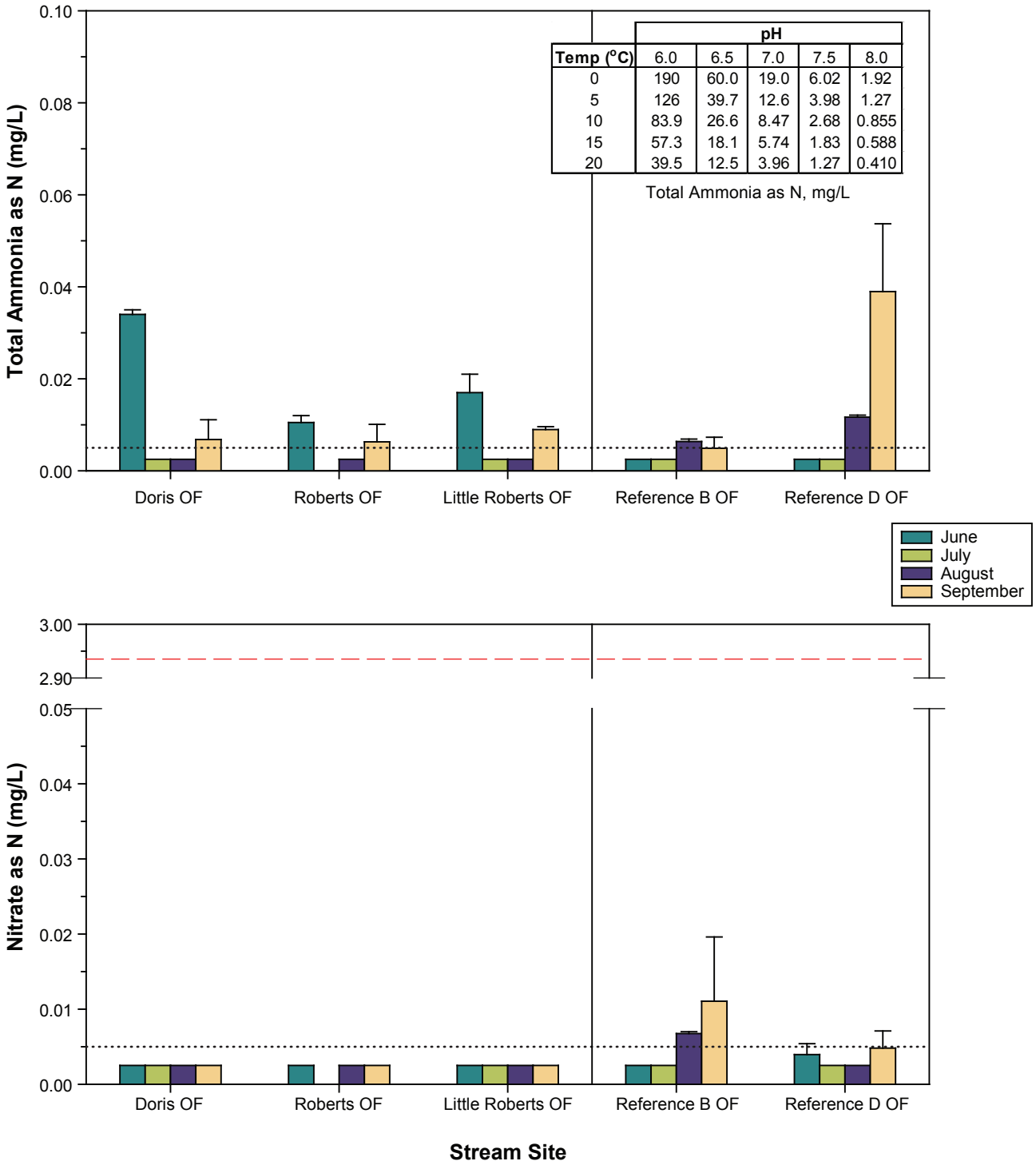

Temp (°C)	pH 6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Total Ammonia as N, mg/L

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Inset table shows the pH- and temperature-dependent CCME guideline for total ammonia.
Red dashed line represents the interim CCME guideline for nitrate as N (2.935 mg/L).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia and Nitrate Concentrations in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-3

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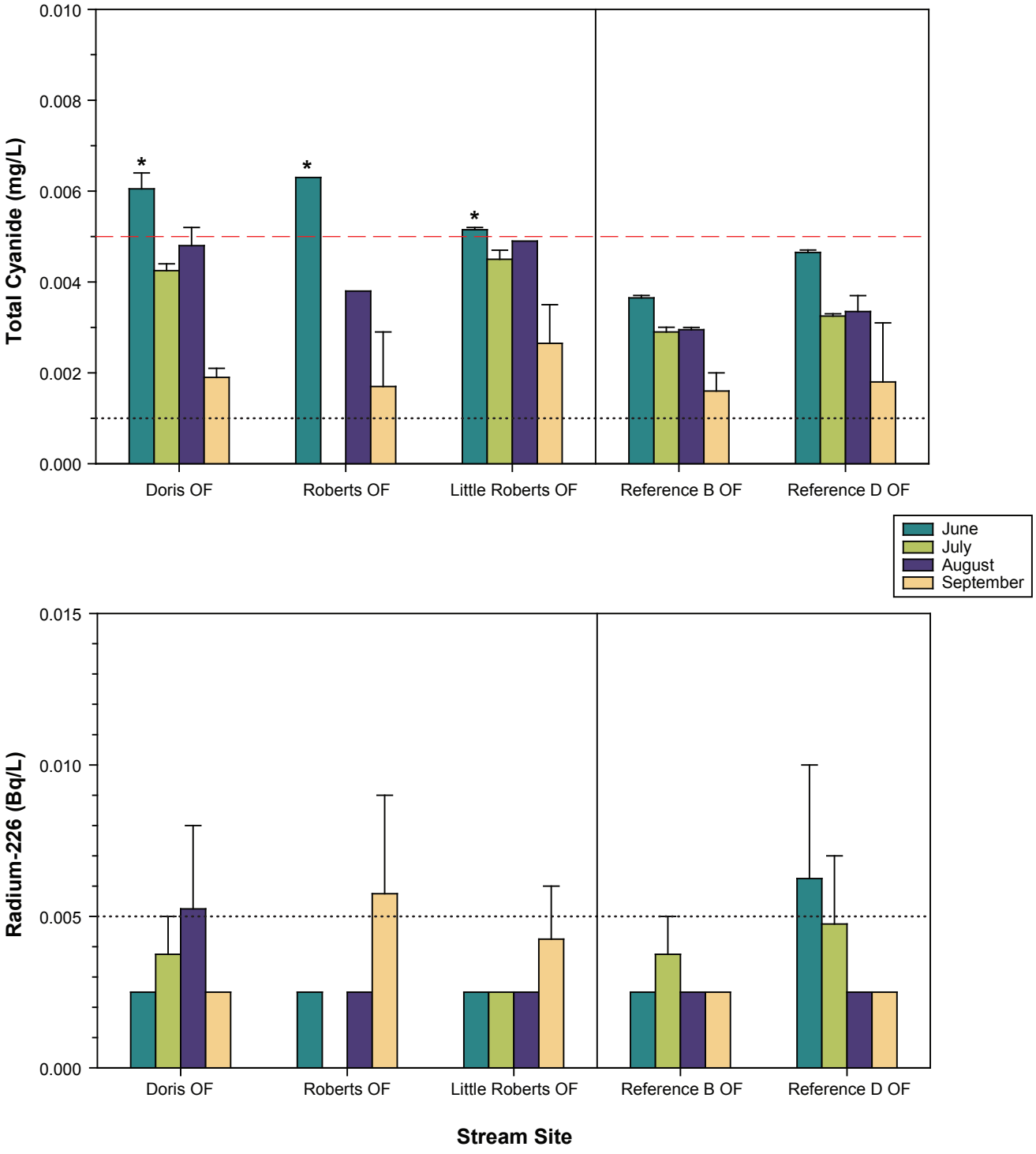

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed line represents the CCME guideline for cyanide (0.005 mg/L as free cyanide).
** Indicates mean total cyanide concentrations that are higher than the CCME guideline.*
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Cyanide and Radium-226 Concentrations in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-4

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A1.2.1.8 Radium-226

Mean radium-226 concentrations in all stream samples were near or below the analytical detection limit of 0.005 mg/L, and no spatial or seasonal trends were apparent. Overall, radium-226 concentrations were below the analytical detection limit in 82% of samples collected from streams (Figure A1.2-4). Any measurable concentrations of radium-226 may be due to ambient contamination, as the radium-226 concentration in the April field blank was 0.008 mg/L (see Section A1.2.2.4).

A1.2.1.9 Total Aluminum

Mean total aluminum concentrations were highly variable spatially and seasonally, and ranged from 0.011 mg/L (Reference B Outflow in August) to 0.65 mg/L (Roberts Outflow in June). There were no obvious seasonal trends. Total aluminum concentrations tended to be lowest at Reference B Outflow, but varied over a similar range in the other monitored streams (Figure A1.2-5).

A1.2.1.10 Total Arsenic

There was some spatial, but little seasonal variability in mean total arsenic concentrations. Total arsenic concentrations tended to be lowest at Reference B Outflow (averaging 0.000088 mg/L across all months), followed by Reference D Outflow (averaging 0.00013 mg/L). Concentrations were similar among exposure sites, averaging 0.00027 mg/L at Doris Outflow, 0.00028 at mg/L at Little Roberts Outflow, and 0.00032 mg/L at Roberts Outflow (Figure A1.2-5).

A1.2.1.11 Total Cadmium

Total cadmium concentrations in all stream samples were below the analytical detection limit of 0.000005 mg/L (Figure A1.2-6).

A1.2.1.12 Total Copper

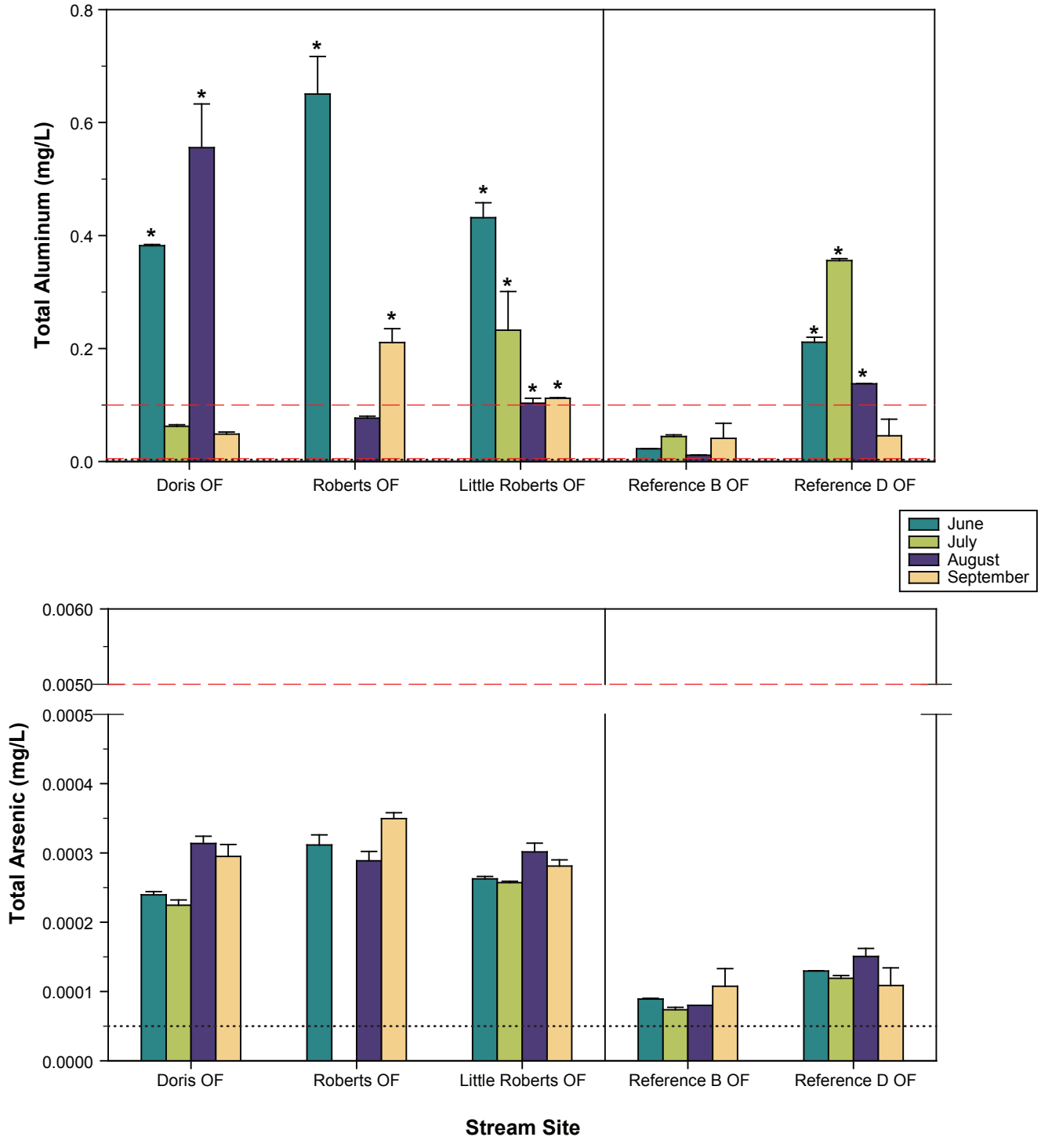
Mean total copper concentrations ranged from 0.00086 mg/L (Reference B Outflow in August) to 0.0032 mg/L (Little Roberts Outflow in July), and there were no consistent seasonal trends. Total copper concentrations tended to be lowest in the reference streams. With the exception of several elevated concentrations in Doris Outflow and Little Roberts Outflow during July, total copper concentrations were generally similar among the exposure streams, (Figure A1.2-6).

A1.2.1.13 Total Iron

Mean total iron concentrations were highly variable spatially and seasonally, and ranged from 0.039 mg/L (Reference B Outflow in August) to 0.79 mg/L (Roberts Outflow in June). Patterns in total iron concentration closely mirrored the patterns observed for total aluminum. Total iron concentrations tended to be lowest at Reference B Outflow, and concentrations were generally similar among the remaining streams, with the exception of sporadically elevated total iron concentrations measured in all three exposure streams (Figure A1.2-7).

A1.2.1.14 Total Lead

Mean total lead concentrations ranged from below the analytical detection limit of 0.00005 mg/L at all sites during at least one sampling month to a maximum of 0.00023 mg/L at Roberts Outflow in June. There were no apparent spatial or seasonal trends, though Reference B Outflow was the only site at which total lead concentrations were below the detection limit in all samples (Figure A1.2-7).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the pH-dependent CCME guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5) and the CCME guideline for arsenic (0.005 mg/L).
** Indicates mean concentrations that are higher than the CCME guideline.*
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Aluminum and Total Arsenic Concentrations in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-5

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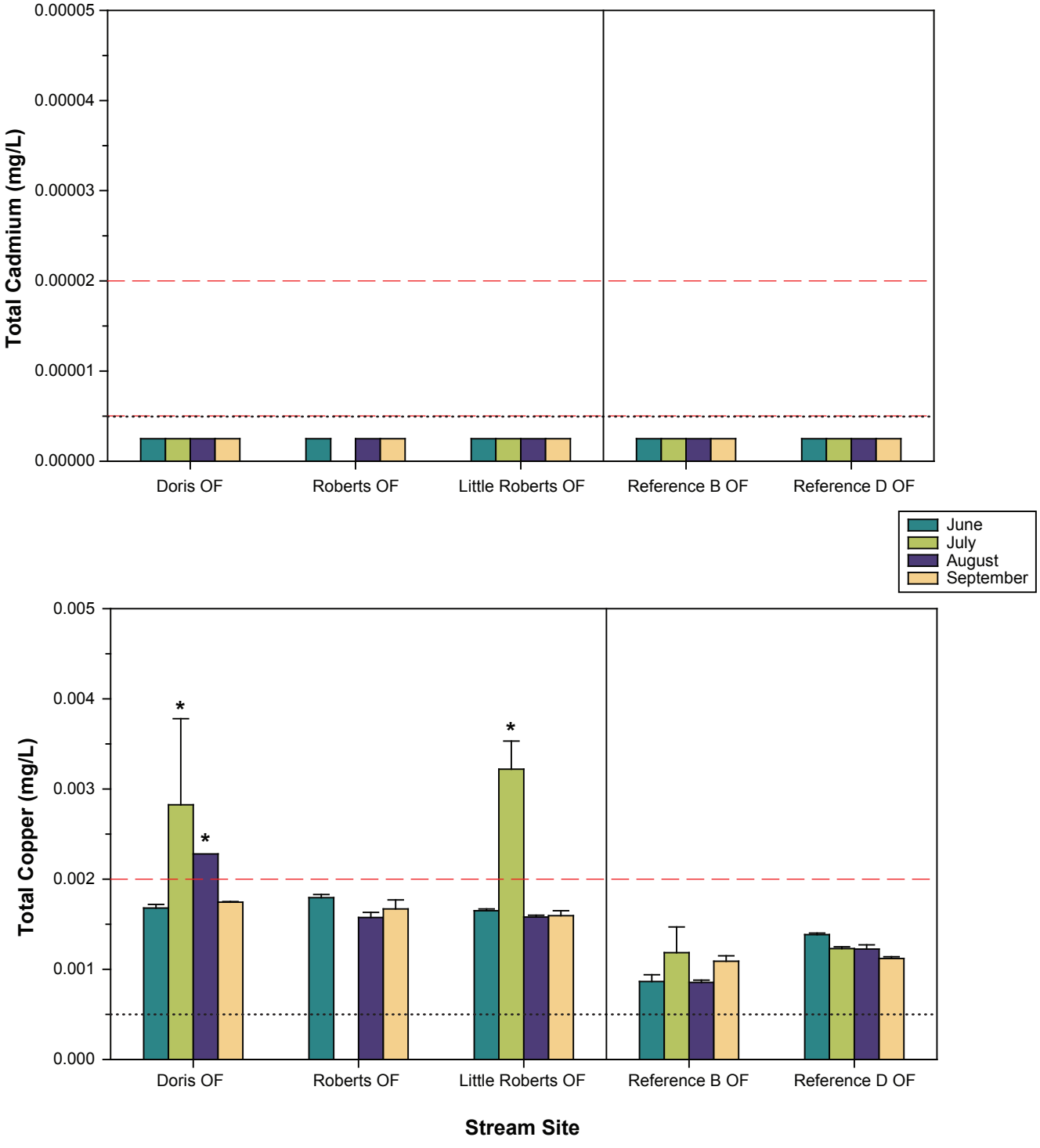

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
The CCME guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum site-specific CCME guidelines for cadmium (0.000005 and 0.000020 mg/L) and for copper (0.002 mg/L) based on the hardness (as $CaCO_3$) range in streams of 12 to 57 mg/L.
** Indicates mean concentrations that are higher than the CCME guideline.*
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cadmium and Total Copper Concentrations in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-6

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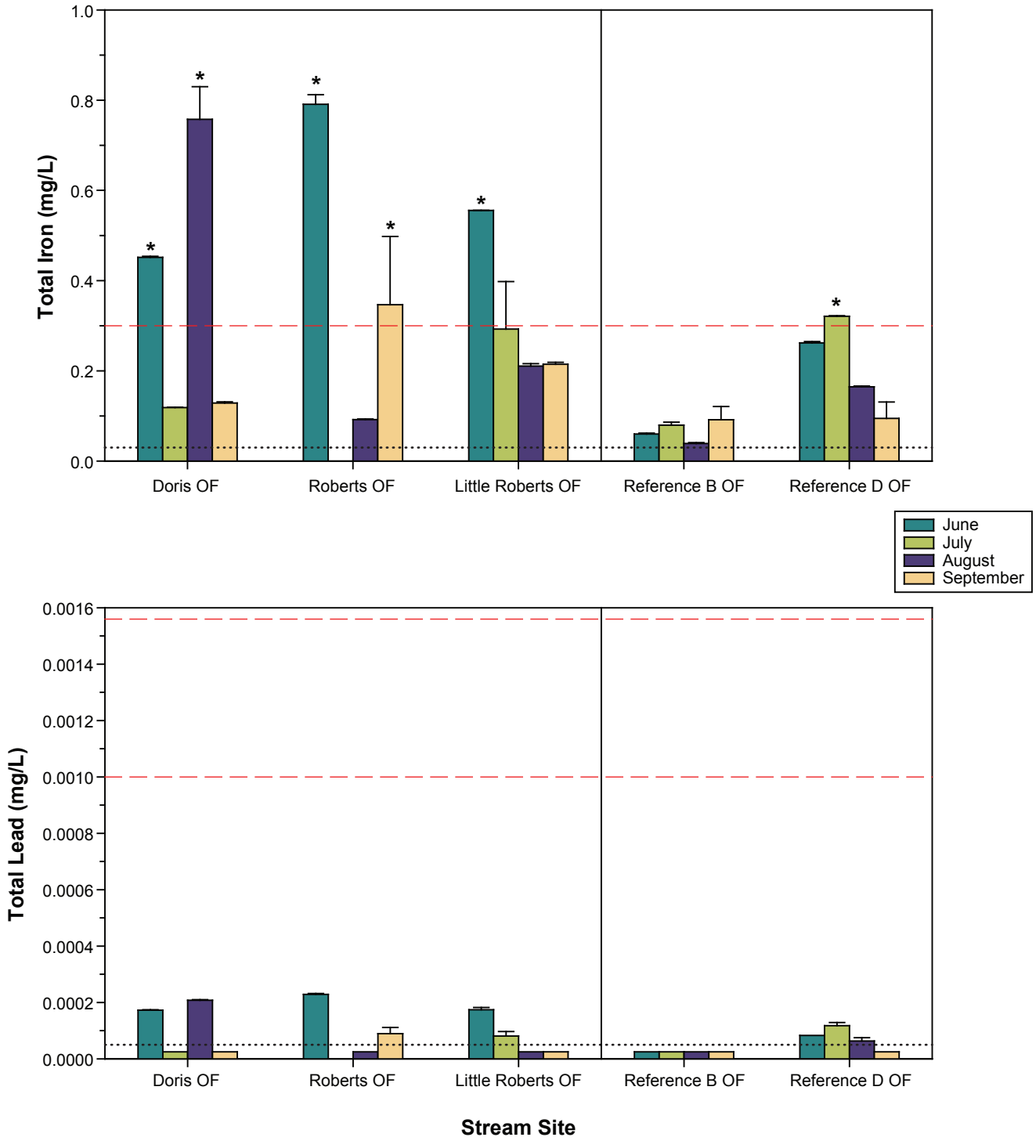

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
The CCME guideline for lead is hardness dependent.
Red dashed lines represent the CCME guideline for iron (0.3 mg/L) and the minimum and maximum site-specific CCME guideline for lead (0.001 and 0.00156 mg/L) based on the hardness (as $CaCO_3$) range in streams of 12 to 57 mg/L.
** Indicates mean concentrations that are higher than the CCME guideline.*
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Iron and Total Lead Concentrations in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-7

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A1.2.1.15 Total Mercury

Total mercury concentrations in all stream samples were below the analytical detection limit of 0.00001 mg/L or 0.00005 mg/L (the detection limit was raised from 0.00001 mg/L to 0.00005 mg/L for June stream samples collected from the reference streams and Roberts Outflow; Figure A1.2-8).

A1.2.1.16 Total Molybdenum

Some spatial and seasonal trends were apparent for total molybdenum concentrations. The reference streams tended to have the lowest concentrations of total molybdenum (ranging from below the analytical detection limit of 0.00005 mg/L to 0.000081 mg/L). Total molybdenum in the exposure streams ranged from 0.00015 mg/L (Roberts Outflow in June) to 0.00021 mg/L (Little Roberts Outflow in September). Concentrations generally increased from June to September at all sites (Figure A1.2-8).

A1.2.1.17 Total Nickel

Total nickel concentrations were spatially and seasonally variable, ranging from below the detection limit of 0.0002 mg/L (Reference B Outflow in August) to 0.0011 mg/L (Roberts Outflow in June). Nickel concentrations were usually lowest at Reference B Outflow, and were generally similar among the remaining streams (Figure A1.2-9).

A1.2.1.18 Total Zinc

Total zinc concentrations were below the analytical detection limit of 0.003 mg/L at all sites and during all sampling months, with the exception of a single replicate collected at Roberts Outflow in June (which had a total zinc concentration of 0.004 mg/L; Figure A1.2-9).

A1.2.1.19 Comparison with CCME Guidelines

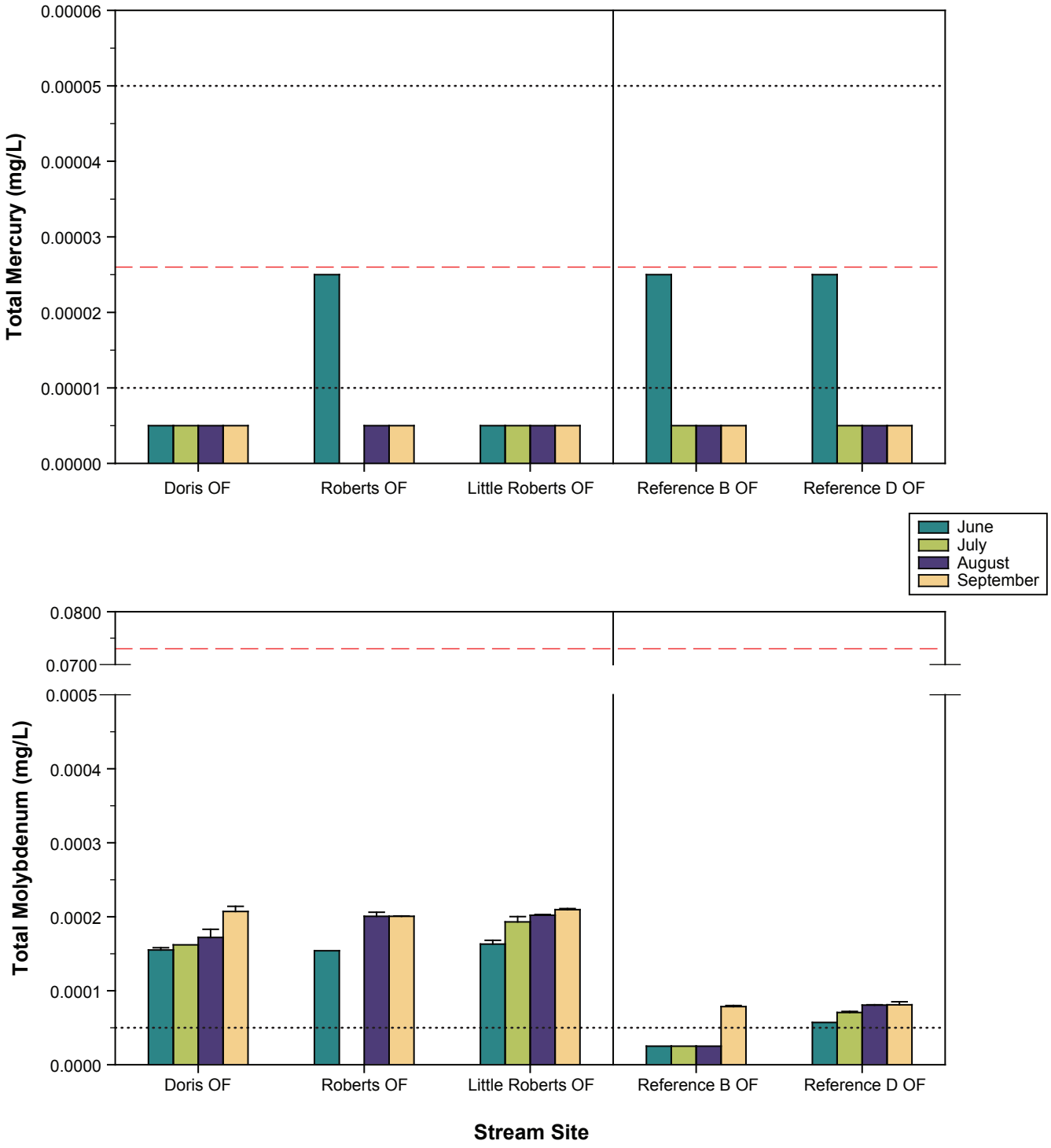
Stream water quality parameters were compared against CCME water quality guidelines for the protection of freshwater aquatic life (CCME 2011b). Table A1.2-3 presents the percentage of samples collected from each stream in which parameter concentrations were higher than CCME guidelines, and Table A1.2-4 presents the factor by which average parameter concentrations were higher than CCME guidelines.

Based on the CCME guidance framework for total phosphorus, Doris Outflow would be categorized as a meso-eutrophic to eutrophic system (depending on the month of sampling), Roberts and Little Roberts outflows would be categorized as mesotrophic to meso-eutrophic, Reference D Outflow would be categorized as ultra-oligotrophic to mesotrophic, and Reference B Outflow would be categorized as oligotrophic.

Reference B Outflow was the only stream in which parameter concentrations in all samples were consistently below CCME guidelines.

In all three exposure streams, mean June concentrations of total cyanide were slightly higher than the CCME guideline; however, the CCME guideline of 0.005 mg/L as free cyanide (cyanide existing in the form of HCN and CN^-) is not directly comparable to total cyanide, which includes all forms of cyanide (free cyanides, metallocyanides, organocyanides, etc. (Singleton 1986)).

In all exposure streams and in Reference D Outflow, concentrations of total aluminum and total iron were higher than CCME guidelines during at least one sampling month. Annual averages of total aluminum in these streams were approximately two to three times higher than the CCME guideline. Annual averages of total iron were slightly higher than the CCME guideline in the exposure streams, and slightly below the CCME guideline in Reference D Outflow.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
All total mercury concentrations in streams were below analytical detection limits.
Red dashed lines represent the CCME guidelines for inorganic mercury (0.000026 mg/L) and molybdenum (0.073 mg/L).
Total mercury and total molybdenum are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Mercury and Total Molybdenum Concentrations in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-8

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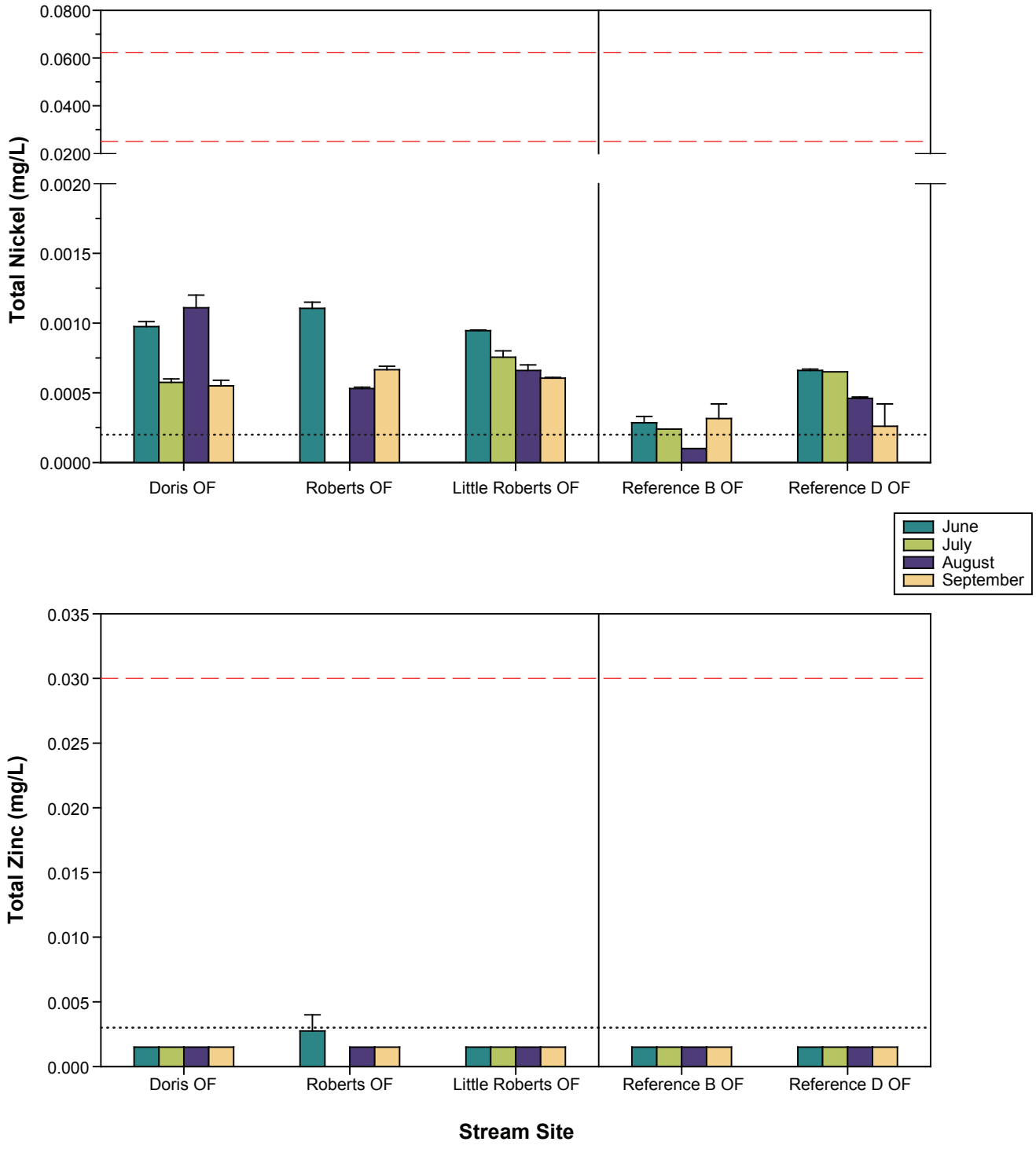

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the CCME guideline for zinc (0.03 mg/L) and the minimum and maximum site-specific CCME guideline for nickel (0.025 and 0.062mg/L) based on the hardness (as $CaCO_3$) range in streams of 12 to 57 mg/L.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Nickel and Total Zinc Concentrations in AEMP Stream Sites, Doris North Project, 2010

Figure A1.2-9

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Table A1.2-3. Water Quality in AEMP Stream Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Stream	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Total Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Chromium (Cr)-Total
			6.5-9.0	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L (as free CN)	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]	Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]
Doris Outflow	8		0	0	0	0	Meso-eutrophic to Eutrophic	37.5	50	0	0	0	25[h]
Roberts Outflow	6		0	0	0	0	Mesotrophic to Meso-eutrophic	33.3	66.7	0	0	0	33.3[h]
Little Roberts Outflow	8		0	0	0	0	Mesotrophic to Meso-eutrophic	25	87.5	0	0	0	0
Reference B Outflow	8		0	0	0	0	Oligotrophic	0	0	0	0	0	0
Reference D Outflow	8		0	0	0	0	Ulta-oligotrophic to Mesotrophic	0	75	0	0	0	0

Stream	Total Number of Samples Collected	CCME Guideline Value[a]:	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)-Total	Zinc (Zn)-Total
			≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Doris Outflow	8		37.5	50	0	0	0	0	0	0	0	0	0
Roberts Outflow	6		0	50	0	0	0	0	0	0	0	0	0
Little Roberts Outflow	8		25	37.5	0	0	0	0	0	0	0	0	0
Reference B Outflow	8		0	0	0	0	0	0	0	0	0	0	0
Reference D Outflow	8		0	25	0	0	0	0	0	0	0	0	0

Values represent the percentages of 2010 samples that are both above detection limits and higher than CCME guidelines

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) Interim guideline

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

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{[0.86[\log(\text{hardness})]-3.2]}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{[0.8545[\ln(\text{hardness})]-1.465]}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ / 1000. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

h) In these instances, total chromium concentrations were higher than the CCME guideline for hexavalent chromium (Cr(VI)) of 0.001 mg/L.

Table A1.2-4. Water Quality in AEMP Stream Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Stream	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Total Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Chromium (Cr)-Total
			6.5-9.0	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L (as free CN)	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]	Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]
Doris Outflow	8		-	-	-	-	Meso-eutrophic to Eutrophic	-	2.62	-	-	-	-
Roberts Outflow	6		-	-	-	-	Mesotrophic to Meso-eutrophic	-	3.13	-	-	-	-
Little Roberts Outflow	8		-	-	-	-	Mesotrophic to Meso-eutrophic	-	2.20	-	-	-	-
Reference B Outflow	8		-	-	-	-	Oligotrophic	-	-	-	-	-	-
Reference D Outflow	8		-	-	-	-	Ulta-oligotrophic to Mesotrophic	-	1.87	-	-	-	-

Stream	Total Number of Samples Collected	CCME Guideline Value[a]:	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)-Total	Zinc (Zn)-Total
			≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Doris Outflow	8		1.07	1.21	-	-	-	-	-	-	-	-	-
Roberts Outflow	6		-	1.37	-	-	-	-	-	-	-	-	-
Little Roberts Outflow	8		-	1.06	-	-	-	-	-	-	-	-	-
Reference B Outflow	8		-	-	-	-	-	-	-	-	-	-	-
Reference D Outflow	8		-	-	-	-	-	-	-	-	-	-	-

Values represent the factor by which average 2010 concentrations are higher than CCME guidelines; dashes represent average 2010 concentrations that are below CCME guidelines

The average 2010 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration

For hardness-dependent guidelines, the average 2010 hardness was used to determine the applicable CCME guideline

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) Interim guideline

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 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) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{[0.86[\log(\text{hardness})]-3.2]}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{[0.8545[\ln(\text{hardness})]-1.465]}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{[1.273[\ln(\text{hardness})]-4.705]}$ / 1000. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{[0.76[\ln(\text{hardness})]+1.06]}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

In Doris Outflow in August and Roberts Outflow in June, total chromium concentrations were slightly higher than the CCME guideline for hexavalent chromium of 0.001 mg/L. However, the CCME guideline for chromium is dependent on its oxidation state (the guideline for hexavalent chromium (Cr(VI)) is 0.001 mg/L and the interim guideline for trivalent chromium (Cr(III)) is 0.0089 mg/L), and is therefore not directly comparable to total chromium concentrations.

In Doris Outflow in July and August, and Little Roberts Outflow in July, total copper concentrations were higher than the hardness-dependent CCME guideline for copper.

A1.2.2 Lakes

Water quality samples from lake sites were collected once during the ice-covered season (April) and three times during the open-water season (July, August, and September). Samples were collected from three exposure lakes (Doris Lake South, Doris Lake North, and Little Roberts lakes) and two reference lakes (Reference Lake B and Reference Lake D). Because of comparability in lake sizes, Reference Lake B was used as a reference site for Doris Lake (these larger lakes are both > 3 km^2 in surface area) and Reference Lake D was used as a reference site for Little Roberts Lake (these smaller lakes are both < 0.1 km^2 in surface area). Surface water quality samples were collected at all sites, and deep water samples were occasionally collected at some sites. Because there was little evidence of vertical chemical stratification, sample results from each site were combined regardless of sampling depth for graphs of monthly means.

A1.2.2.1 pH

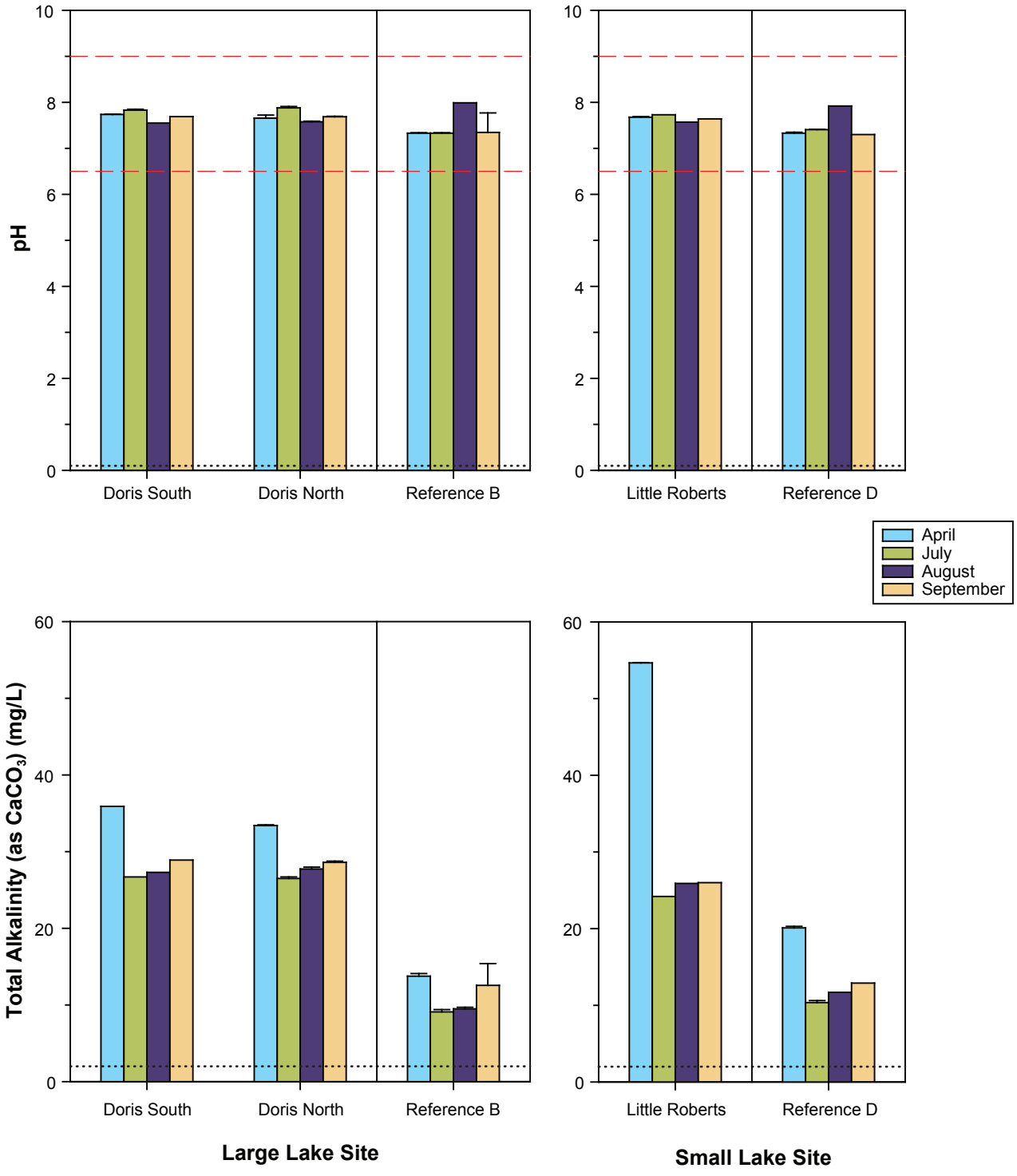
pH levels were generally similar among lake sites and seasons. In both the large and the small lakes, pH ranged from approximately 7.3 to 8.0, and the pH in the exposure lakes was within the pH range observed in the reference lakes (Figure A1.2-10).

A1.2.2.2 Total Alkalinity

Total alkalinity (as $CaCO_3$) was consistently higher in the exposure lakes than in the reference lakes (Figure A1.2-10). As well, total alkalinity levels within each lake tended to be highest in April and lowest in July (though open-water season concentrations were relatively similar). In Little Roberts Lake in particular, total alkalinity in April was more than double the alkalinity measured during the open water season. Mean total alkalinity levels in Doris Lake ranged from 26.5 mg/L (Doris Lake North in July) to 35.9 mg/L (Doris Lake South in April). Based on the classification system outlined by Saffran and Trew (1996), Doris Lake North and South had low sensitivity to acid deposition during all sampling periods (Table A1.2-1). Mean total alkalinity in Little Roberts Lake ranged from 24.2 mg/L in July to 54.7 mg/L in April, indicating that this waterbody was not sensitive to acid deposition during the ice-covered season, and had low sensitivity during the open-water season. In the reference lakes, mean total alkalinity ranged from 9.1 to 13.8 mg/L in Reference B and from 10.4 to 20.1 mg/L in Reference D, indicating that these waterbodies had high to moderate sensitivity to acid deposition.

A1.2.2.3 Hardness

Similar to total alkalinity, hardness (as $CaCO_3$) was consistently higher in the exposure lakes than in the reference lakes (Figure A1.2-11). Within each lake, hardness was also highest in April and lowest in July (though open-water season concentrations were relatively similar). Mean hardness in Doris Lake ranged from 47.5 to 60.7 mg/L, which is indicative of soft water (Table A1.2-2). In Little Roberts Lake, hardness ranged from 42.7 to 95.4 mg/L, which is indicative of soft to moderately hard water (Table A1.2-2). The reference lakes had the softest water, as hardness ranged from 12.1 to 18.4 mg/L in Reference B and from 17.6 to 30.4 mg/L in Reference D.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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pH and Total Alkalinity in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-10

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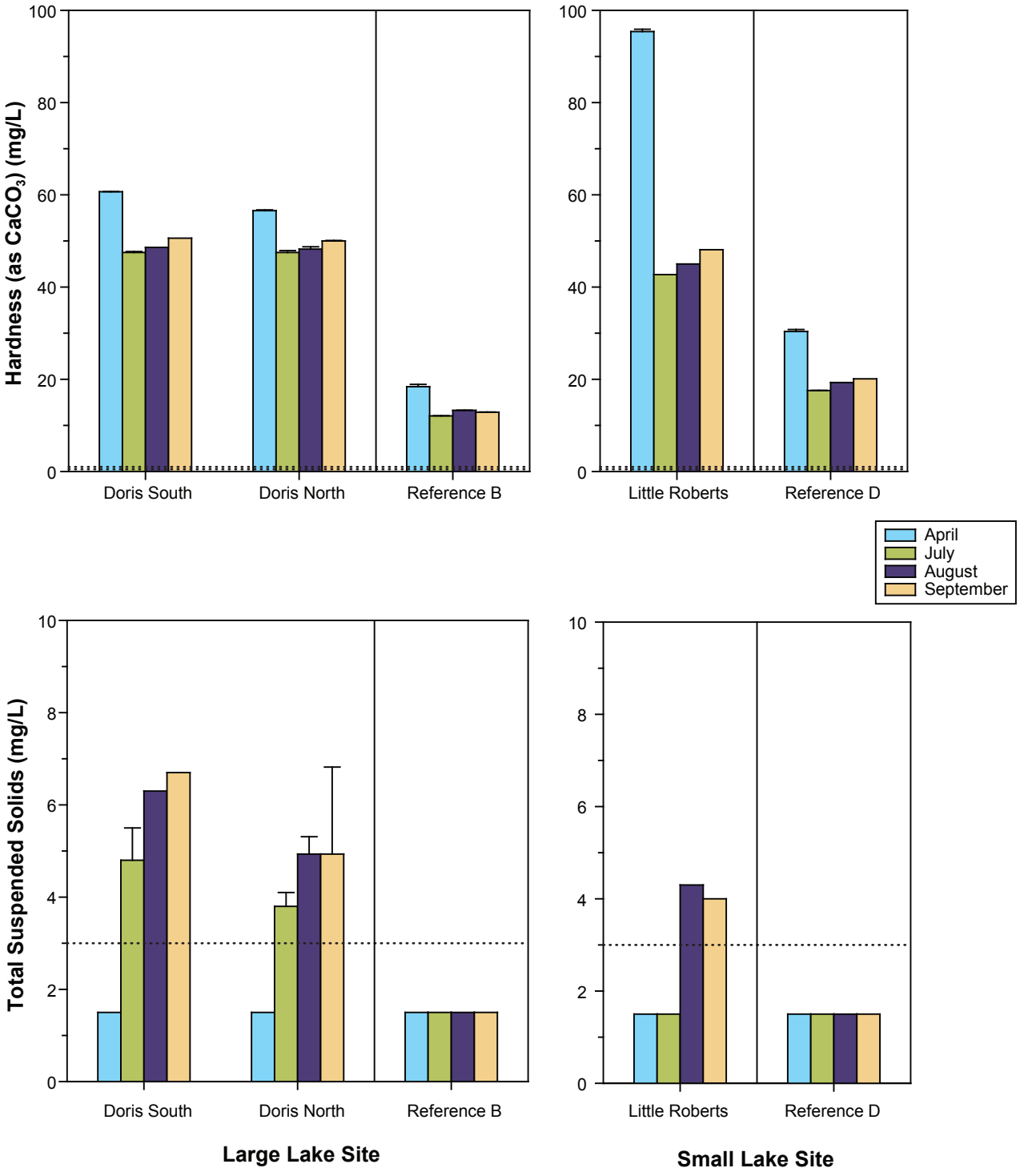

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit(s); values below the detection limit are plotted at half the detection limit.
The CCME guideline for total suspended solids is dependent upon background levels.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Hardness and Total Suspended Solids in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-11

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A1.2.2.4 Total Suspended Solids

Total suspended solid concentrations were below the detection limit of 3 mg/L at all sites during the April sampling period. During the open-water season, mean concentrations of TSS remained below the detection limit in the reference lakes, but increased in the exposure sites to a maximum of 6.9 mg/L in Doris Lake South, 4.9 mg/L in Doris Lake North, and 4.3 mg/L in Little Roberts lakes (Figure A1.2-11).

A1.2.2.5 Total Ammonia

Total ammonia concentrations were below the detection limit of 0.005 mg ammonia-N/L during at least one sampling period in all lakes. The highest concentrations of total ammonia were measured in the reference lakes (0.025 mg ammonia-N/L in Reference B in April and 0.023 mg ammonia-N/L in Reference D in September); therefore, concentrations in the exposure sites were always within the range observed in the reference sites (Figure A1.2-12). August and September total ammonia concentrations should be interpreted with caution because of potential ambient contamination evident in field blanks (see Section A1.2.2.4).

A1.2.2.6 Nitrate

Concentrations of nitrate were below the analytical detection limit of 0.005 mg nitrate-N/L in all open-water season lake samples. In April, mean concentrations of nitrate were above the detection limit in three of the five lake sites: Doris Lake North (0.055 mg nitrate-N/L), Reference B (0.011 mg nitrate-N/L), and Reference D (0.045 mg nitrate-N/L). Overall, 86% of nitrate concentrations in lake samples were below the detection limit (Figure A1.2-12).

A1.2.2.7 Total Cyanide

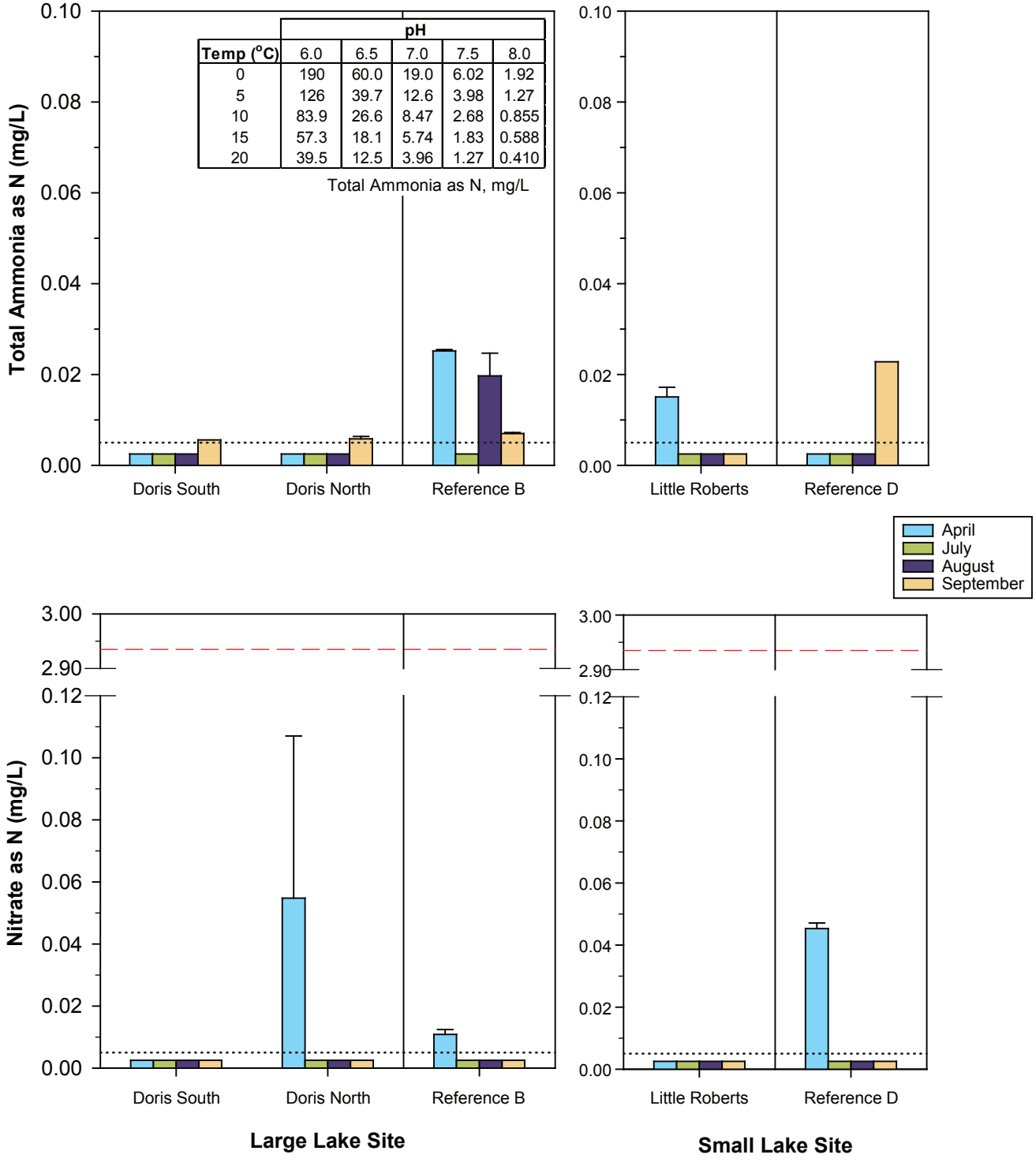
With the exception of Little Roberts Lake in April, where the mean total cyanide concentration reached 0.0075 mg/L, total cyanide concentrations were generally similar among the exposure sites, ranging narrowly from 0.0040 to 0.0050 mg/L across all sampling months. Concentrations were typically lower in the reference lakes, ranging from 0.0022 to 0.0029 mg/L in Reference B and from 0.0033 to 0.0042 mg/L in Reference D (Figure A1.2-13).

A1.2.2.8 Radium-226

Mean radium-226 concentrations in all lake samples were near or below the analytical detection limit of 0.005 mg/L, and no spatial or seasonal trends were apparent. Overall, radium-226 concentrations were below the analytical detection limit in 86% of samples collected from lakes (Figure A1.2-13). Any measurable concentrations of radium-226 may be due to ambient contamination, as the radium-226 concentration in the April field blank was 0.008 mg/L (see Section A1.2.2.4).

A1.2.2.9 Total Aluminum

Mean total aluminum concentrations were highly variable spatially and seasonally. Among the large lake sites, concentrations were lowest in Reference B (ranging from 0.0057 to 0.016 mg/L) and highest in Doris Lake South (ranging from 0.034 to 0.09 mg/L). Higher maximum concentrations were reached in the small lakes sites (0.16 mg/L in Little Roberts in July, and 0.30 mg/L in Reference D in July; Figure A1.2-14). July total aluminum concentrations should be interpreted with caution because of potential contamination introduced by the GO-FLO sampler (see Section A1.2.2.4).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Inset table shows the pH- and temperature-dependent CCME guideline for total ammonia.
Red dashed lines represent the interim CCME guideline for nitrate as N (2.935 mg/L).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia and Nitrate Concentrations in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-12

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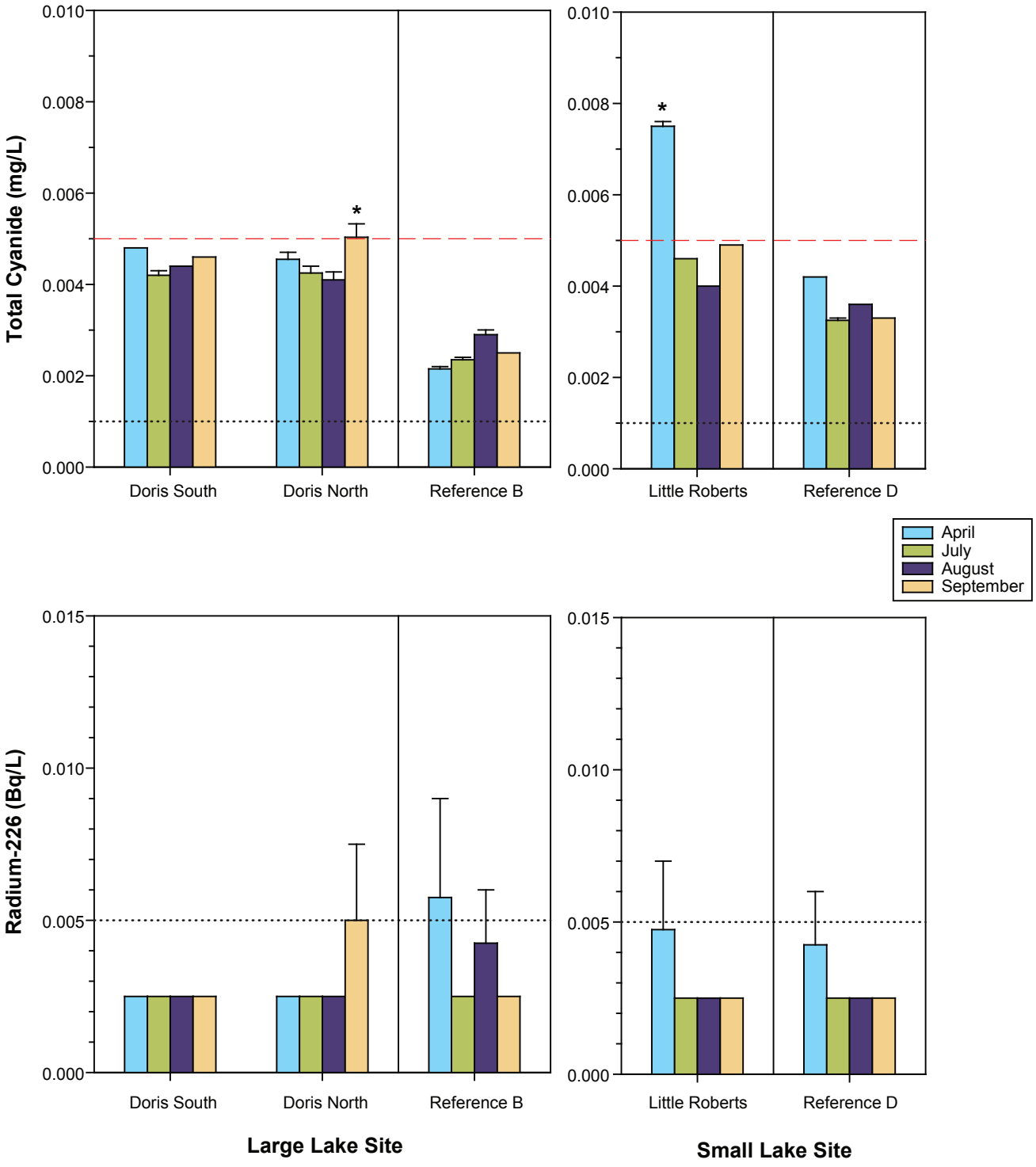

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME guideline for cyanide (0.005 mg/L as free cyanide).
** Indicates mean total cyanide concentrations that are higher than the CCME guideline.*
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Cyanide and Radium-226 Concentrations in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-13

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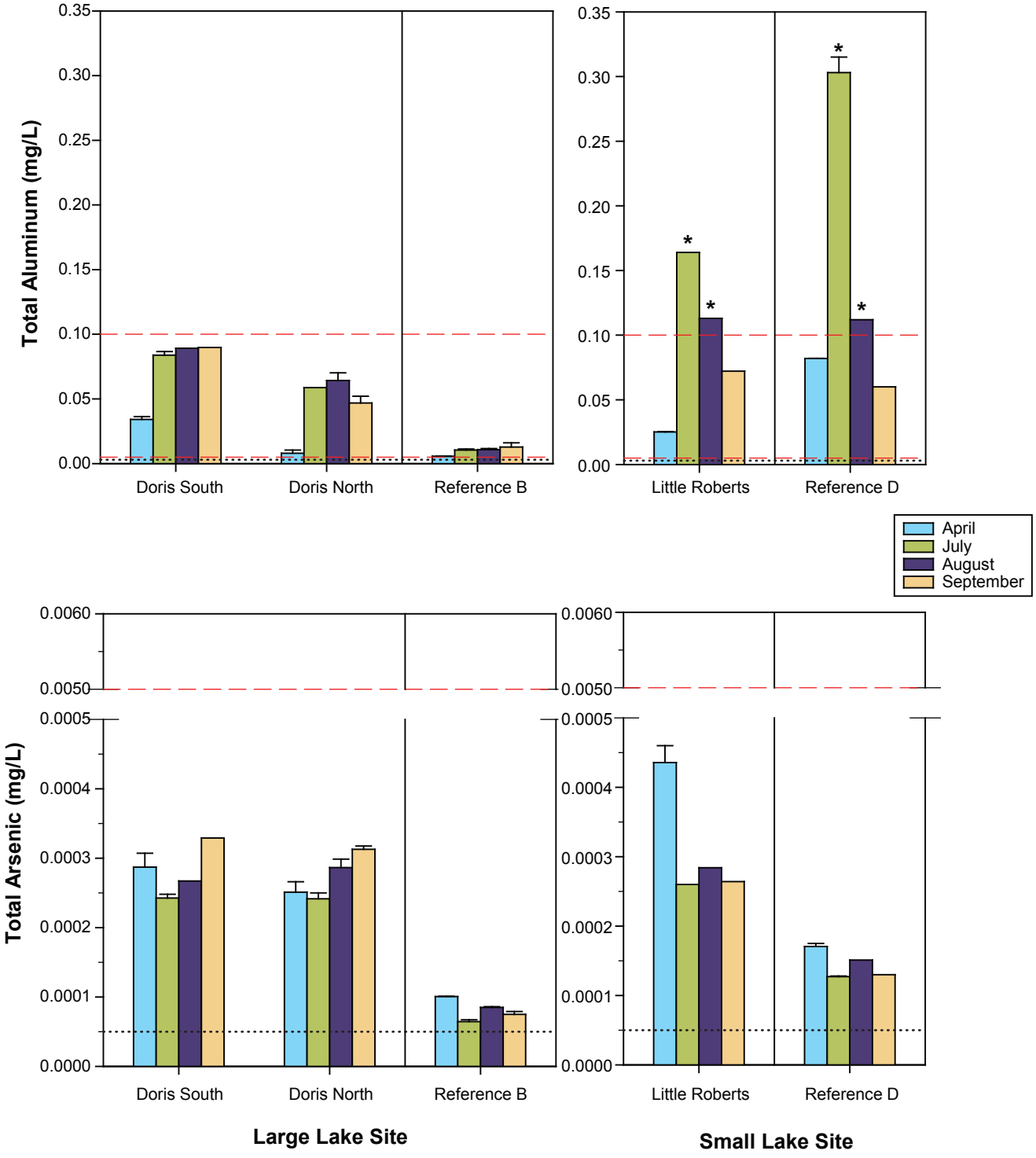

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the pH-dependent CCME guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5) and the CCME guideline for arsenic (0.005 mg/L).
** Indicates mean concentrations that are higher than the CCME guideline.*
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Aluminum and Total Arsenic Concentrations in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-14

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A1.2.2.10 Total Arsenic

With the exception of Little Roberts Lake in April where the mean total arsenic concentration reached 0.00044 mg/L, total arsenic concentrations were generally similar among the exposure sites, ranging narrowly from 0.00024 to 0.00033 mg/L across all sampling months. Concentrations were typically lower in the reference lakes, ranging from 0.000065 to 0.00010 mg/L in Reference B and from 0.00013 to 0.00017 mg/L in Reference D (Figure A1.2-14).

A1.2.2.11 Total Cadmium

Total cadmium concentrations were below the analytical detection limit of 0.000005 mg/L in 89% of lake samples collected. An anomalously high concentration of total cadmium was measured at Doris Lake South in August (0.00019 mg/L); however, since no replicates were collected, it is unclear whether this was the actual concentration or whether this high value was the result of contamination or analytical error (Figure A1.2-15).

A1.2.2.12 Total Copper

Among large lake sites, mean total copper concentrations were lower in Reference B than Doris Lake North or Doris Lake South. Concentrations ranged from 0.0007 mg/L (Reference B in July) to 0.0026 mg/L (Doris Lake South in April). Among small lake sites, copper concentrations were similar in April, but concentrations were higher in Little Roberts than in Reference D during the open-water season. Concentrations ranged from 0.0012 mg/L (Reference D in July and August) to 0.0059 mg/L (Little Roberts in July; Figure A1.2-15).

A1.2.2.13 Total Iron

In large lake sites, total iron concentrations were always below the analytical detection limit of 0.03 mg/L in Reference B, and ranged from below detection to 0.16 mg/L in Doris Lake sites. Total iron concentrations tended to be higher in the small lakes than in the large lakes. Total iron concentrations in the small lakes ranged from 0.085 mg/L (Reference D in September) to 0.54 mg/L (Little Roberts in April; Figure A1.2-16).

A1.2.2.14 Total Lead

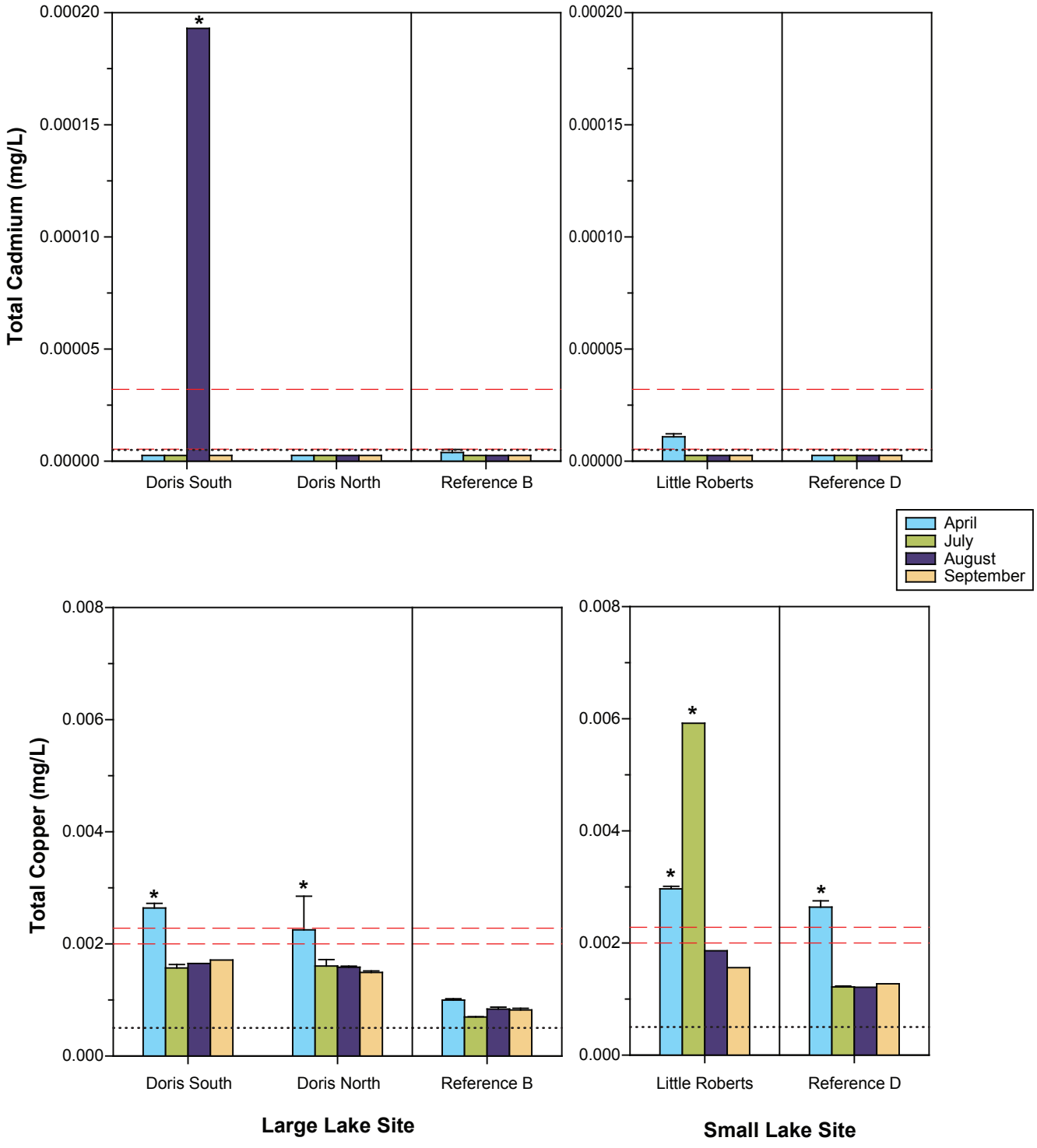
Mean total lead concentrations at all sites were generally low (< 0.0006 mg/L), but elevated mean concentrations were reached in August at two sites: 0.0014 mg/L in Reference B and 0.0015 mg/L in Little Roberts (Figure A1.2-16). July total lead concentrations should be interpreted with caution because of potential contamination introduced by the GO-FLO sampler (see Section A1.2.2.4).

A1.2.2.15 Total Mercury

Total mercury concentrations in all lake samples were below the analytical detection limit of 0.00001 mg/L (Figure A1.2-17).

A1.2.2.16 Total Molybdenum

Mean total molybdenum concentrations were similar among the exposure lake sites, ranging from 0.00016 mg/L (Doris Lake North and South in July) to 0.00029 mg/L (Little Roberts in April). Concentrations were relatively low in the reference lakes, as concentrations were near or below the detection limit of 0.00005 mg/L in Reference B, and ranged from 0.000074 to 0.000086 mg/L in Reference D (Figure A1.2-17).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
The CCME guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum site-specific CCME guidelines for cadmium (0.000005 and 0.000032 mg/L) and for copper (0.002 and 0.00228 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 12 to 96 mg/L.
** Indicates mean concentrations that are higher than the CCME guideline.*
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cadmium and Total Copper Concentrations in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-15

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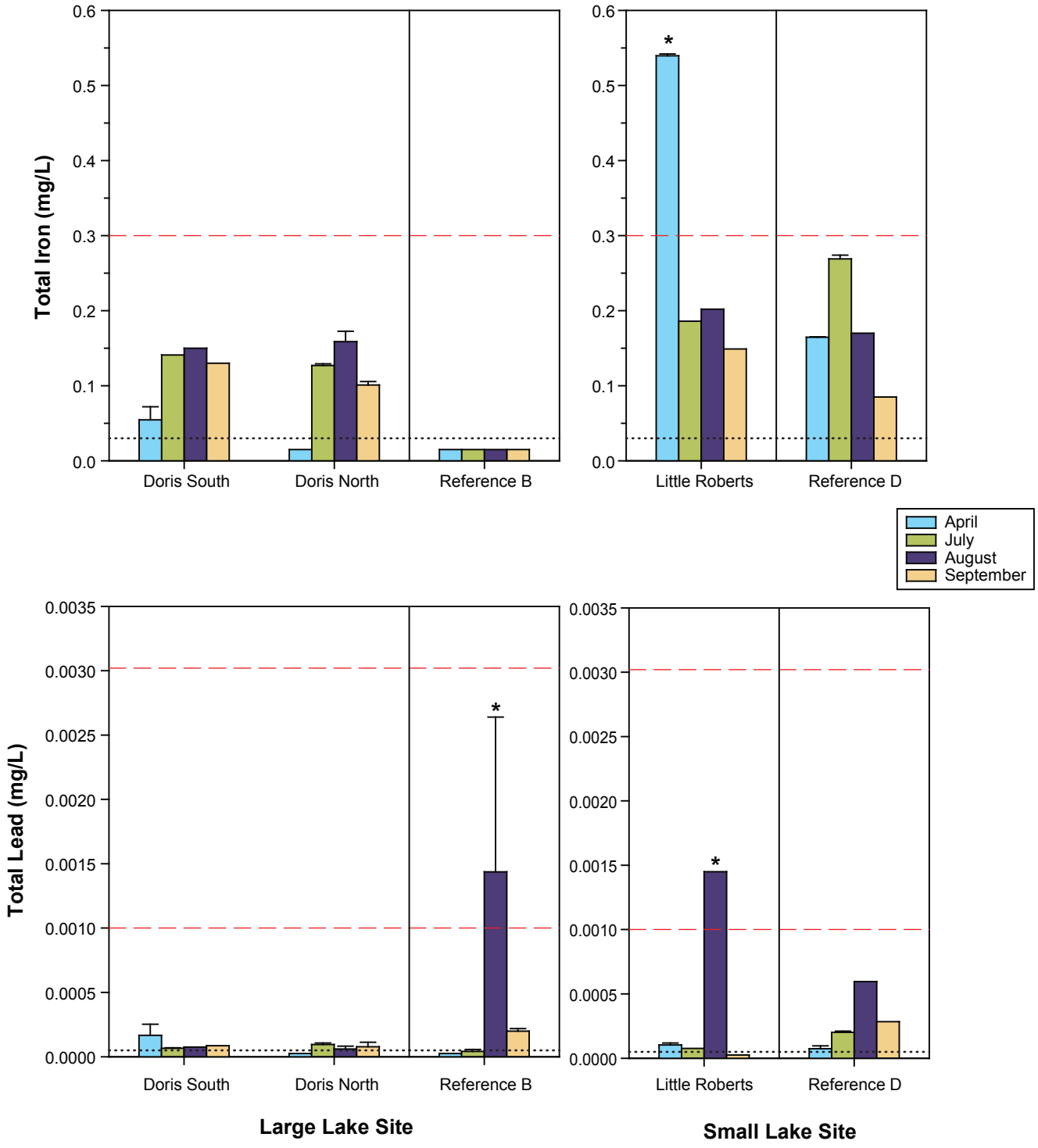

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
The CCME guideline for lead is hardness dependent.
Red dashed lines represent the CCME guideline for iron (0.3 mg/L) and the minimum and maximum site-specific CCME guideline for lead (0.001 and 0.00302 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 12 to 96 mg/L.
** Indicates mean concentrations that are higher than the CCME guideline.*
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Iron and Total Lead Concentrations in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-16

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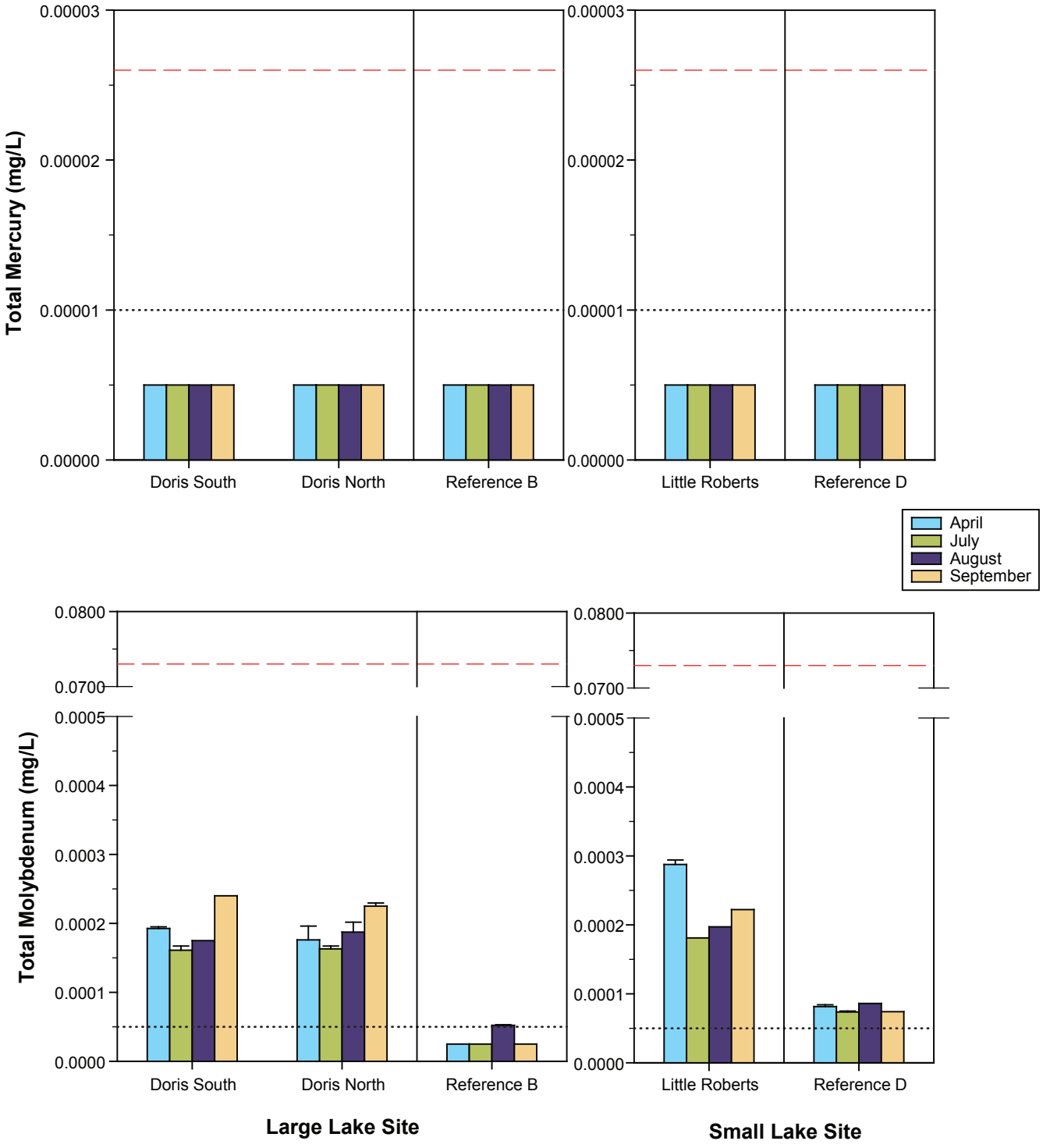

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME guidelines for inorganic mercury (0.000026 mg/L) and molybdenum (0.073 mg/L).
Total mercury and total molybdenum are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Mercury and Total Molybdenum Concentrations in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-17

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A1.2.2.17 Total Nickel

Total nickel concentrations were lowest in Reference Lake B, but were similar among the exposure sites and Reference Lake D. Concentrations were below or near the detection limit of 0.0002 mg/L in Reference B, and ranged from 0.00043 to 0.00098 mg/L in the other sampled lakes (Figure A1.2-18). A slight seasonal trend was apparent in the small lakes only, as concentrations were highest in April and decreased over the summer. July total nickel concentrations should be interpreted with caution because of potential contamination introduced by the GO-FLO sampler (see Section A1.2.2.4).

A1.2.2.18 Total Zinc

Total zinc concentrations were below the analytical detection limit of 0.003 mg/L in 91% of lake samples, and barely over the detection limit in the remaining 9% of samples (Figure A1.2-18).

A1.2.2.19 Comparison with CCME Guidelines

Lake water quality parameters were compared against CCME water quality guidelines for the protection of freshwater aquatic life (CCME 2011b). Table A1.2-5 presents the percentage of samples collected from each lake in which parameter concentrations were higher than CCME guidelines, and Table A1.2-6 presents the factor by which average parameter concentrations were higher than CCME guidelines.

Based on the CCME guidance framework for total phosphorus, all three exposure lake sites would be categorized as mesotrophic to meso-eutrophic systems (depending on the month of sampling), Reference Lake B would be categorized as ultra-oligotrophic to oligotrophic, and Reference Lake D would be categorized as oligotrophic to mesotrophic.

In Doris Lake North in September and Little Roberts Lake in April, mean concentrations of total cyanide were slightly higher than the CCME guideline for free cyanide. However, the CCME guideline of 0.005 mg/L as free cyanide (cyanide existing in the form of HCN and CN^-) is not directly comparable to total cyanide, which includes all forms of cyanide (free cyanides, metallocyanides, organocyanides, etc. (Singleton 1986)).

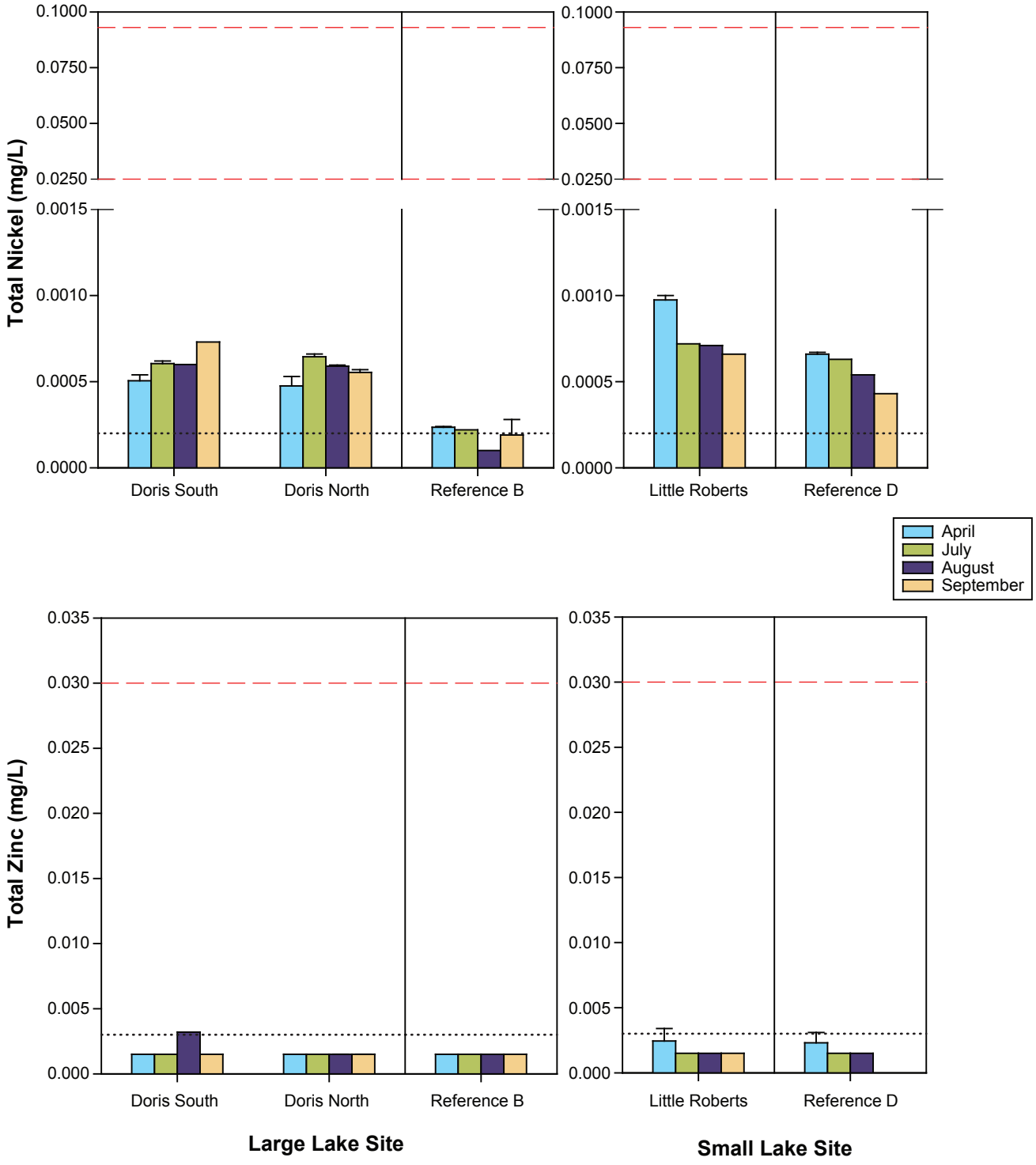
At all lake sites except for Reference B, April total copper concentrations exceeded the hardness-dependent CCME guideline. In Little Roberts Lake, July concentrations also exceeded the CCME guideline.

Within the large lake sites, the anomalously high concentration of total cadmium measured at Doris Lake South in August exceeded the hardness-dependent CCME guideline for cadmium. The hardness-dependent lead guideline was also exceeded in a single sample collected from Reference Lake B.

Within the small lake sites, total aluminum concentrations in both Little Roberts Lake and Reference Lake D were higher than the CCME guideline in all samples collected during July and August. In Little Roberts Lake, total iron and total lead concentrations were higher than CCME guidelines during a single sampling month.

A1.2.3 Marine

Water quality samples from marine sites were collected once during the ice-covered season (April) and three times during the open-water season (July, August, and September). Samples were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Reference Bay (REF-Marine). All water quality samples were collected at the surface.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the CCME guideline for zinc (0.03 mg/L) and the minimum and maximum site-specific CCME guideline for nickel (0.025 and 0.093 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 12 to 96 mg/L.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Nickel and Total Zinc Concentrations in AEMP Lake Sites, Doris North Project, 2010

Figure A1.2-18

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Table A1.2-5. Water Quality in AEMP Lake Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Total Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Chromium (Cr)-Total
			6.5-9.0	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L (as free CN)	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]	Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]
Large Lake Site													
Doris South	6		0	0	0	0	Mesotrophic to Meso-eutrophic	0	0	0	0	16.7	0
Doris North	10		0	0	0	0	Mesotrophic to Meso-eutrophic	20	0	0	0	0	0
Reference B	8		0	0	0	0	Ultra-oligotrophic to Oligotrophic	0	0	0	0	0	0
Small Lake Site													
Little Roberts	5		0	0	0	0	Mesotrophic to Meso-eutrophic	40	40	0	0	0	0
Reference D	6		0	0	0	0	Oligotrophic to Mesotrophic	0	50	0	0	0	0

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	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)-Total	Zinc (Zn)-Total
			≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Large Lake Site													
Doris South	6		33.3	0	0	0	0	0	0	0	0	0	0
Doris North	10		10	0	0	0	0	0	0	0	0	0	0
Reference B	8		0	0	12.5	0	0	0	0	0	0	0	0
Small Lake Site													
Little Roberts	5		60	40	20	0	0	0	0	0	0	0	0
Reference D	6		33.3	0	0	0	0	0	0	0	0	0	0

Values represent the percentages of 2010 samples that are both above detection limits and higher than CCME guidelines.

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) Interim guideline

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 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) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{[0.86[\log(\text{hardness})]-3.2]}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{[0.8545[\ln(\text{hardness})]-1.465]}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{[1.273[\ln(\text{hardness})]-4.705]}$ / 1000. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{[0.76[\ln(\text{hardness})]+1.06]}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

Table A1.2-6. Water Quality in AEMP Lake Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Total Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Chromium (Cr)-Total
			6.5-9.0	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L (as free CN)	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]	Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]
Large Lake Site													
Doris South	6		-	-	-	-	Mesotrophic to Meso-eutrophic	-	-	-	-	1.80	-
Doris North	10		-	-	-	-	Mesotrophic to Meso-eutrophic	-	-	-	-	-	-
Reference B	8		-	-	-	-	Ultra-oligotrophic to Oligotrophic	-	-	-	-	-	-
Small Lake Site													
Little Roberts	5		-	-	-	-	Mesotrophic to Meso-eutrophic	1.14	-	-	-	-	-
Reference D	6		-	-	-	-	Oligotrophic to Mesotrophic	-	1.57	-	-	-	-

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	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)-Total	Zinc (Zn)-Total
			≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Large Lake Site													
Doris South	6		-	-	-	-	-	-	-	-	-	-	-
Doris North	10		-	-	-	-	-	-	-	-	-	-	-
Reference B	8		-	-	-	-	-	-	-	-	-	-	-
Small Lake Site													
Little Roberts	5		1.53	1.08	-	-	-	-	-	-	-	-	-
Reference D	6		-	-	-	-	-	-	-	-	-	-	-

Values represent the factor by which average 2010 concentrations are higher than CCME guidelines; dashes represent average 2010 concentrations that are below CCME guidelines

The average 2010 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration

For hardness-dependent guidelines, the average 2010 hardness was used to determine the applicable CCME guideline

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) Interim guideline

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 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) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{[0.86[\log(\text{hardness})]-3.2]}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{[0.8545[\ln(\text{hardness})]-1.465]}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ / 1000. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

A1.2.3.1 pH

Mean pH levels were consistent among marine sites and seasons, ranging from 7.7 to 7.9 in all samples (Figure A1.2-19).

A1.2.3.2 Total Alkalinity

As expected for the marine environment, total alkalinity (as $CaCO_3$) at all sampled sites generally ranged from 96.3 to 120 mg/L, indicating that marine waters had a high buffering capacity and very low sensitivity to acid deposition (Table A1.2-1). However, total alkalinity levels in August dropped to 36.2 mg/L at RBE and 49.7 mg/L at REF-Marine, indicating that buffering capacity was slightly reduced at these sites (Figure A1.2-19). This decrease in alkalinity is likely due to seasonal increases in freshwater inputs from rivers or streams.

A1.2.3.3 Hardness

As expected for the marine environment, hardness (as $CaCO_3$) levels in marine sites typically ranged from 3,870 to 5,120 mg/L, indicative of very hard water (Table A1.2-2). As observed for total alkalinity, hardness levels in August dropped sharply to 745 mg/L at RBE and dipped slightly to 3,005 mg/L at REF-Marine (Figure A1.2-20). These seasonal declines in hardness are likely attributable to increased freshwater influence.

A1.2.3.4 Total Suspended Solids

Mean TSS concentrations in the exposure sites were highly variable spatially and seasonally, ranging from 4.6 mg/L (RBW in July) to 24 mg/L (RBE in August; Figure A1.2-20). The particularly high TSS concentration in August at RBE likely resulted from water column mixing and sediment re-suspension, as weather conditions were particularly windy during this sampling period. TSS concentrations at REF-Marine were less variable (9.0 to 13 mg/L), but were within the range observed at the exposure sites (Figure A1.2-20).

A1.2.3.5 Total Ammonia

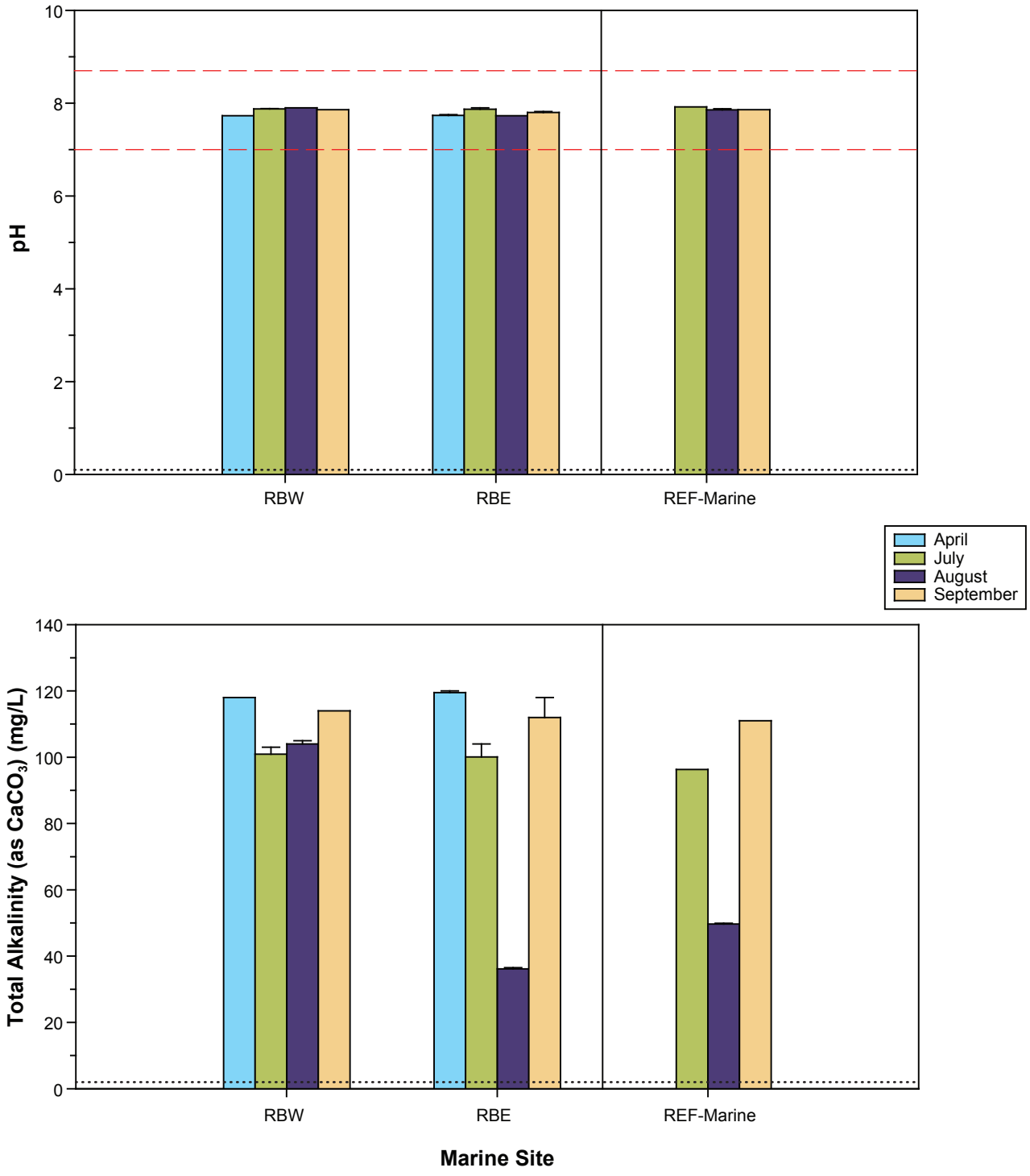
Total ammonia concentrations were below the detection limit of 0.005 mg ammonia-N/L in 89% of marine samples. The only site at which concentrations were above the detection limit was REF-Marine in August, where the mean ammonia concentration was 0.0079 mg ammonia-N/L (Figure A1.2-21). This August total ammonia concentration should be interpreted with caution because of potential ambient contamination evident in field blanks (see Section A1.2.2.4).

A1.2.3.6 Nitrate

Nitrate concentrations were below the variable detection limit of 0.006, 0.25, or 2.5 mg nitrate-N/L in 78% of marine samples. Mean concentrations were above detection limits at RBW in April (0.032 mg nitrate-N/L) and at RBE in April (0.025 mg nitrate-N/L) and August (0.0095 mg nitrate-N/L; Figure A1.2-21).

A1.2.3.7 Total Cyanide

Mean total cyanide concentrations ranged from 0.0013 mg/L (RBE and REF-Marine in July) to 0.0048 mg/L (RBE in August). With the exception of this maximum concentration of 0.0048 mg/L, concentrations were generally similar among exposure and reference sites (Figure A1.2-22).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME guideline pH range (7.0–8.7).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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pH and Total Alkalinity in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-19

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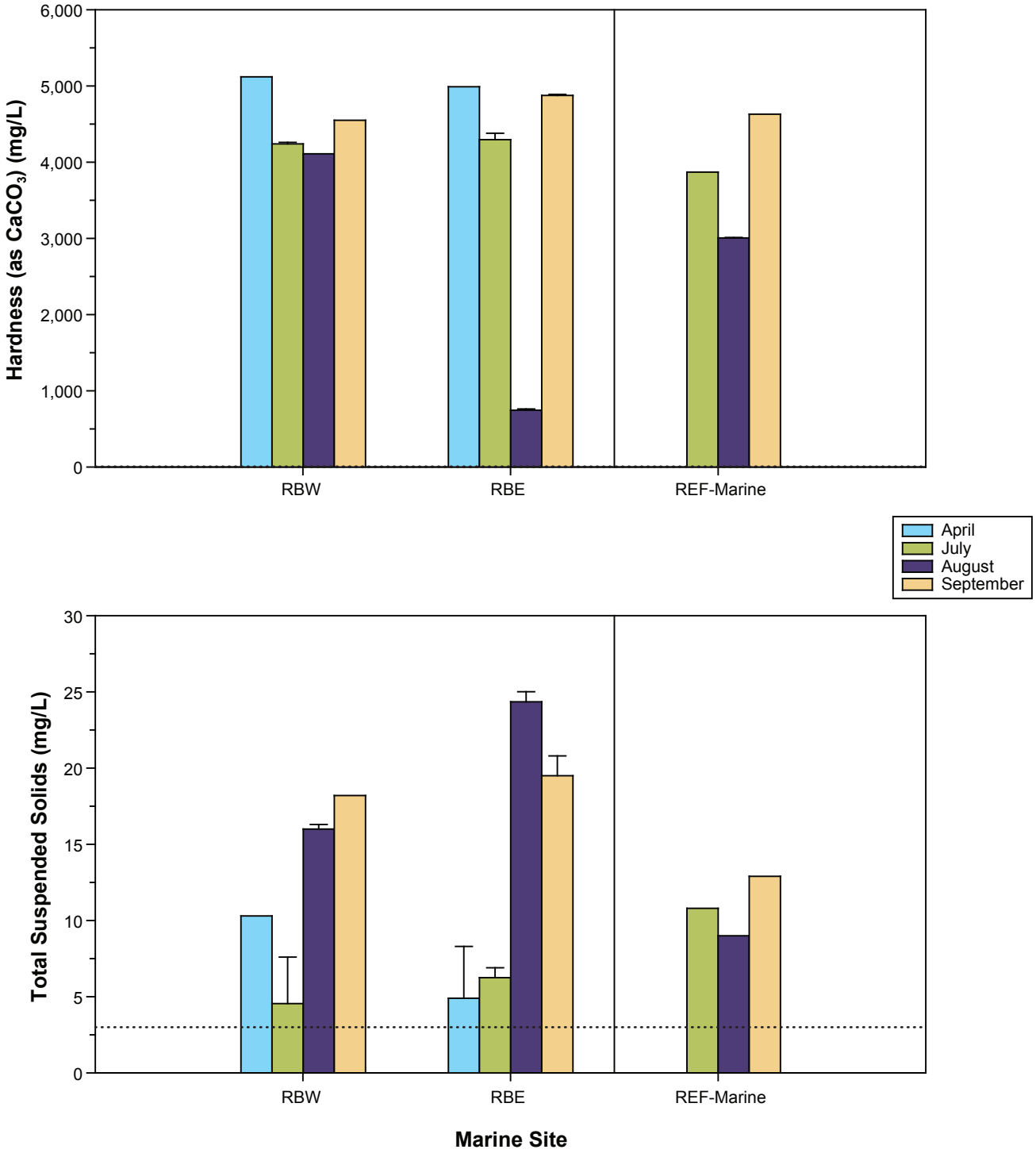

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit(s); values below the detection limit are plotted at half the detection limit.
The CCME guideline for total suspended solids is dependent upon background levels.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Hardness and Total Suspended Solids in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-20

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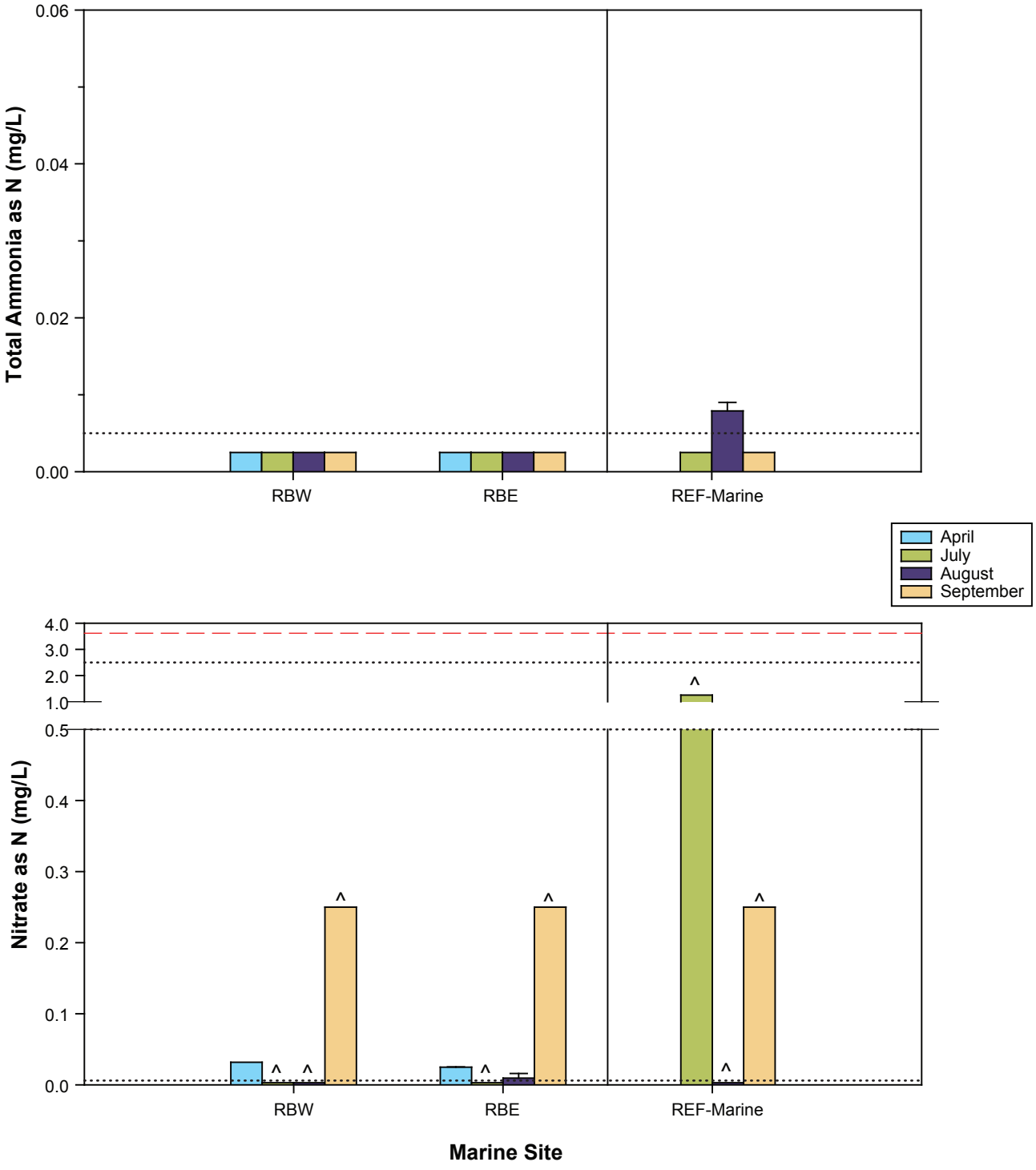

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit(s); values below the detection limit are plotted at half the detection limit.
^ Indicates that nitrate concentrations in all samples were below the detection limit.
Red dashed line represents the interim CCME guideline for nitrate as N (3.612 mg/L).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia and Nitrate Concentrations in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-21

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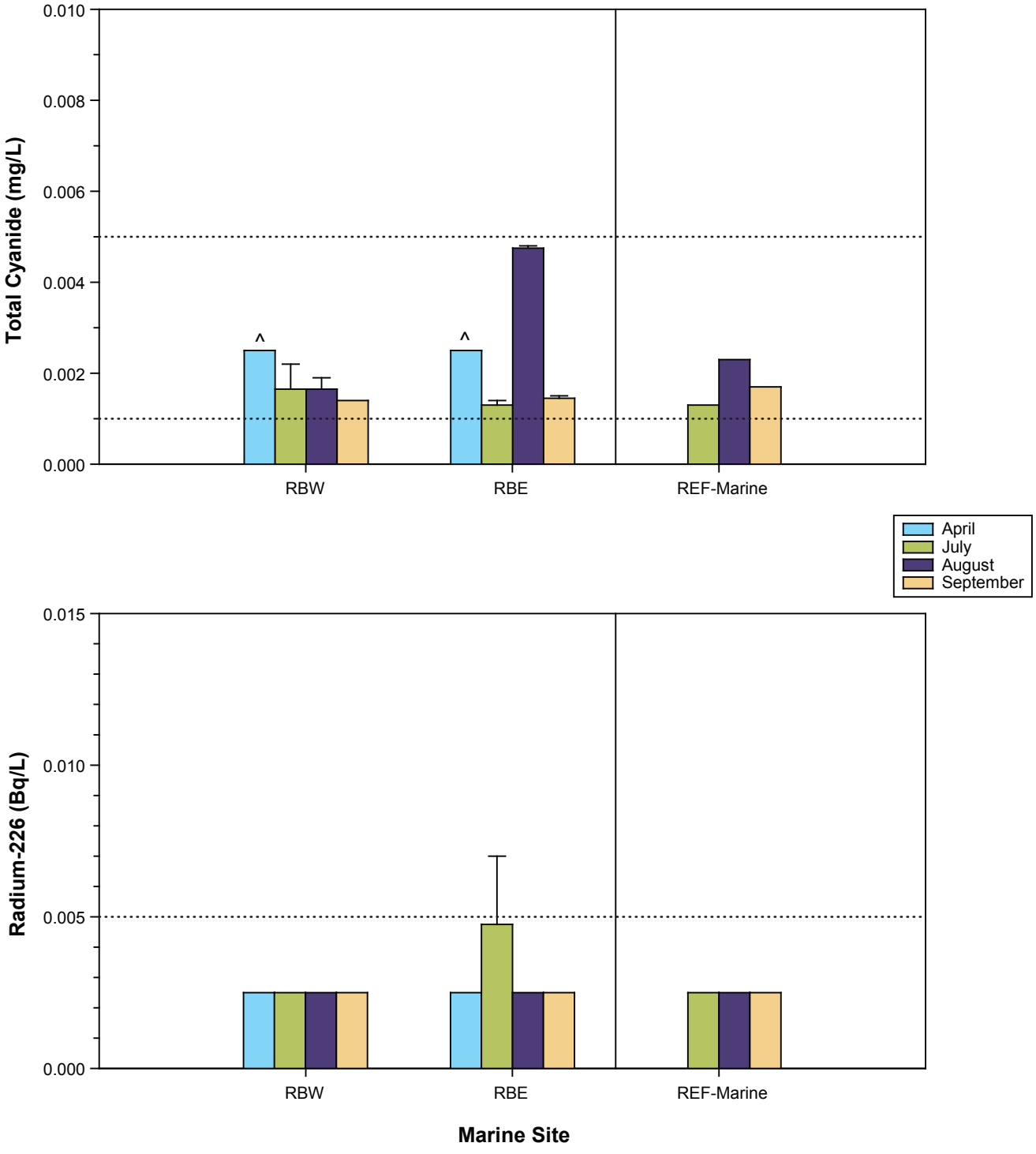

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit(s); values below the detection limit are plotted at half the detection limit.
^ Indicates that total cyanide concentrations in all samples were below the detection limit.
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Cyanide and Radium-226 Concentrations in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-22

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A1.2.3.8 Radium-226

Mean radium-226 concentrations in all marine samples were near or below the analytical detection limit of 0.005 mg/L, and no spatial or seasonal trends were apparent. Overall, radium-226 concentrations were below the analytical detection limit in 94% of marine samples (Figure A1.2-22). Any measurable concentrations of radium-226 may be due to ambient contamination, as the radium-226 concentration in the April field blank was 0.008 mg/L (see Section A1.2.2.4).

A1.2.3.9 Total Aluminum

Mean total aluminum concentrations generally ranged from below the detection limit of 0.010 mg/L (RBW in April) to 0.032 mg/L (REF-Marine in August); however, mean concentrations were more than an order of magnitude higher than this at the exposure sites in August: 0.30 mg/L at RBW and 0.54 mg/L at RBE (Figure A1.2-23). July total aluminum concentrations should be interpreted with caution because of potential contamination introduced by the GO-FLO sampler (see Section A1.2.2.4).

A1.2.3.10 Total Arsenic

Concentrations of total arsenic in all marine samples collected from April to August were below the analytical detection limit of 0.002 mg/L. For some September samples, a lower detection limit of 0.0004 mg/L was achieved. Measurable September total arsenic concentrations were very similar among exposure and reference sites, ranging from 0.0011 to 0.0012 mg/L (Figure A1.2-23).

A1.2.3.11 Total Cadmium

Similar to arsenic, concentrations of total cadmium in all marine samples collected from April to August were below the analytical detection limit of 0.00012 mg/L. For some September samples, a lower detection limit of 0.00002 mg/L was achieved. Measurable September total cadmium concentrations were very similar among exposure and reference sites, ranging from 0.000040 to 0.000043 mg/L (Figure A1.2-24).

A1.2.3.12 Total Copper

At all marine sites, total copper concentrations were below the analytical detection limit of 0.001 mg/L during at least one sampling month. The maximum total copper concentration measured at each site was: 0.0012 mg/L at RBW in August, 0.0023 mg/L at RBE in August, and 0.0013 mg/L at REF-Marine in July (Figure A1.2-24).

A1.2.3.13 Total Iron

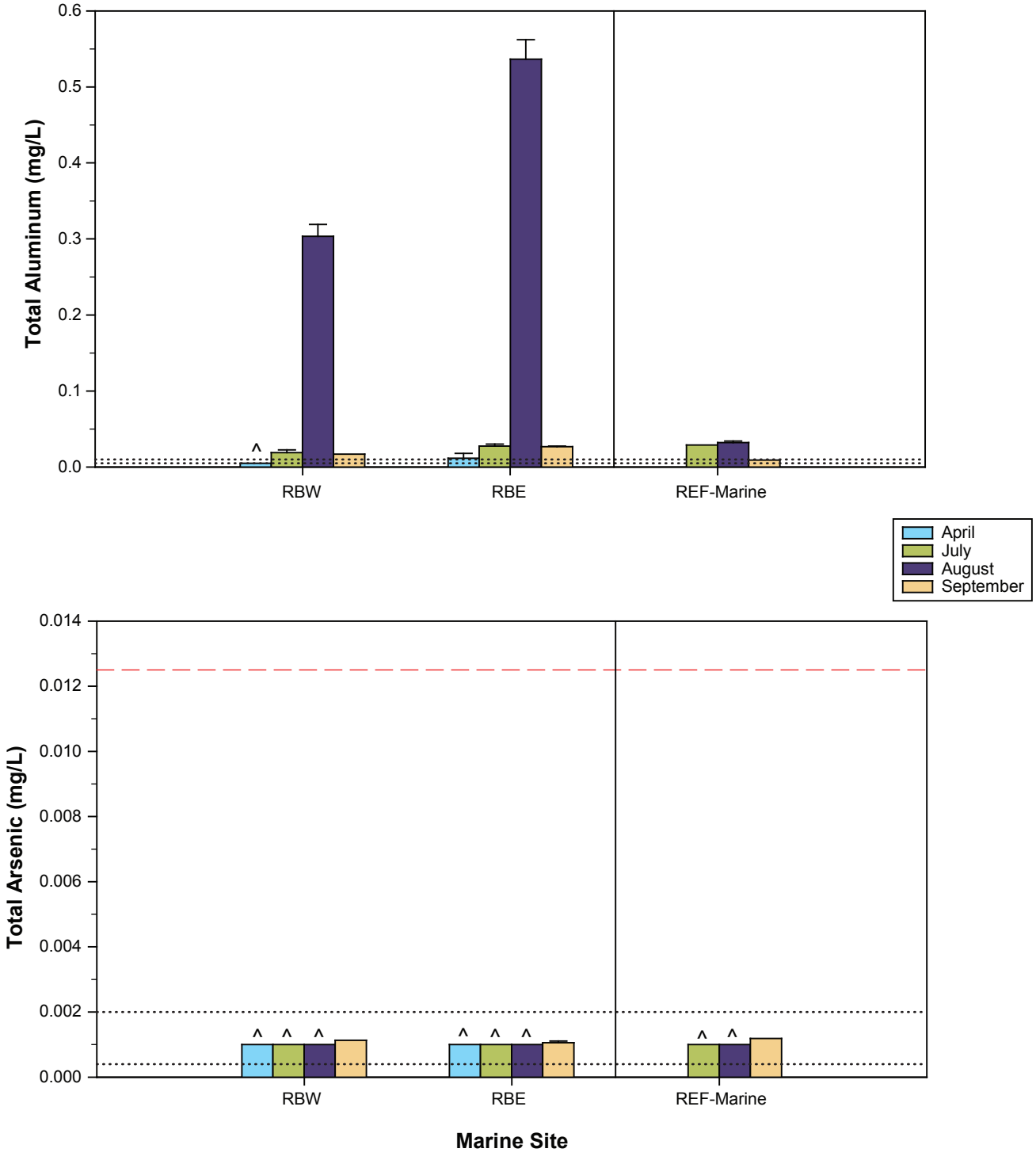
Mean total iron concentrations at all sites generally ranged from 0.022 mg/L (REF-Marine in September) to 0.067 mg/L (REF-Marine in July). However, mean concentrations were much higher than this at the exposure sites in August: 0.35 mg/L at RBW and 0.63 mg/L at RBE (Figure A1.2-25). This is similar to the pattern seen for total aluminum (Figure A1.2-23).

A1.2.3.14 Total Lead

Except for a single sample collected at RBE in September, total lead concentrations in all marine samples were below the analytical detection limit of either 0.00005 or 0.001 mg/L (Figure A1.2-25).

A1.2.3.15 Total Mercury

Total mercury concentrations in all marine samples were below the analytical detection limit of 0.00001 mg/L (Figure A1.2-26).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the detection limit.
^ Indicates that total aluminum or total arsenic concentrations in all samples were below the detection limit.
Red dashed line represents the interim CCME guideline for arsenic (0.0125 mg/L).
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Aluminum and Total Arsenic Concentrations in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-23

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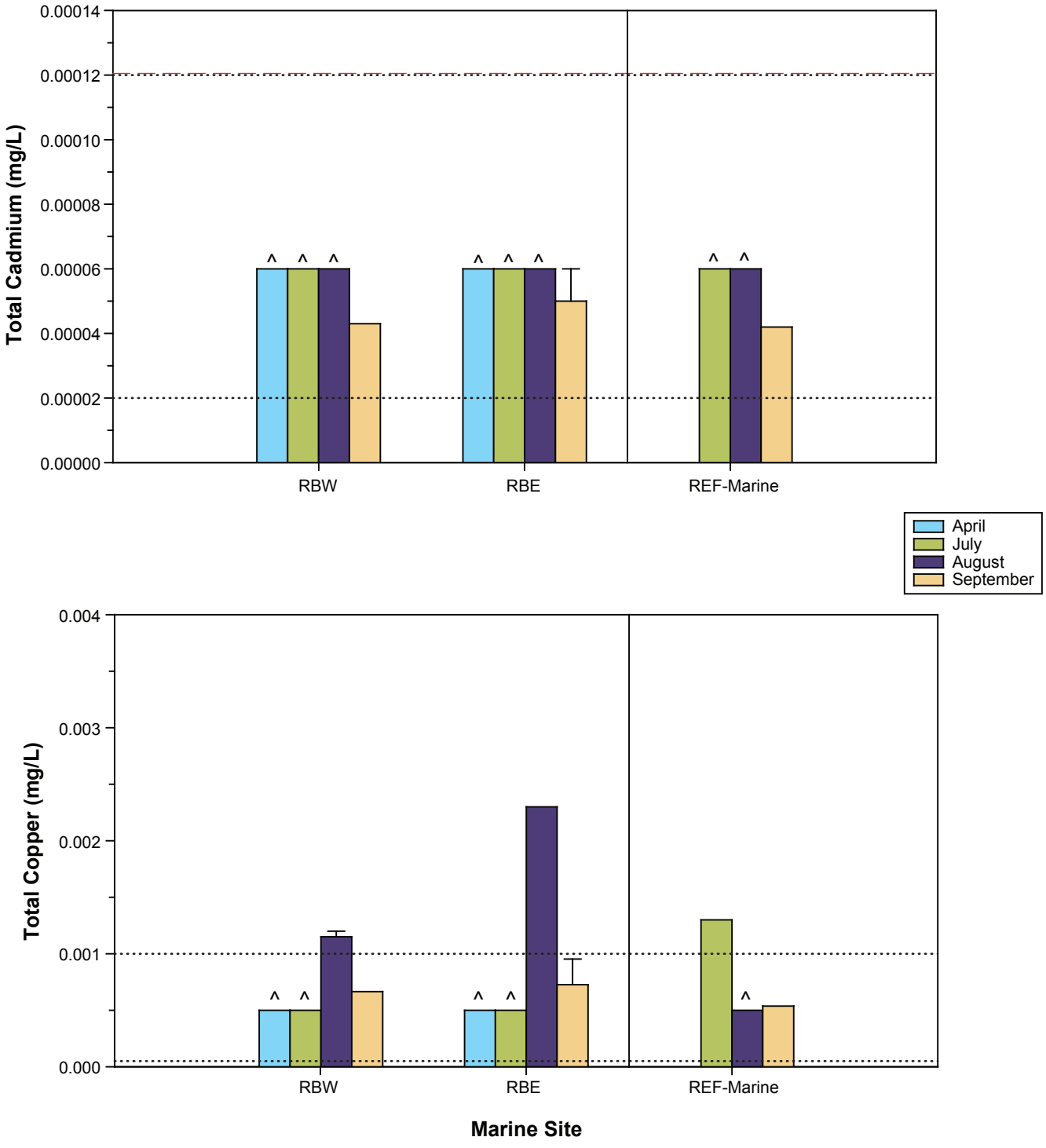

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the detection limit.
^ Indicates that total cadmium or total copper concentrations in all samples were below the detection limit.
Red dashed line represents the CCME guideline for cadmium (0.00012 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cadmium and Total Copper Concentrations in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-24

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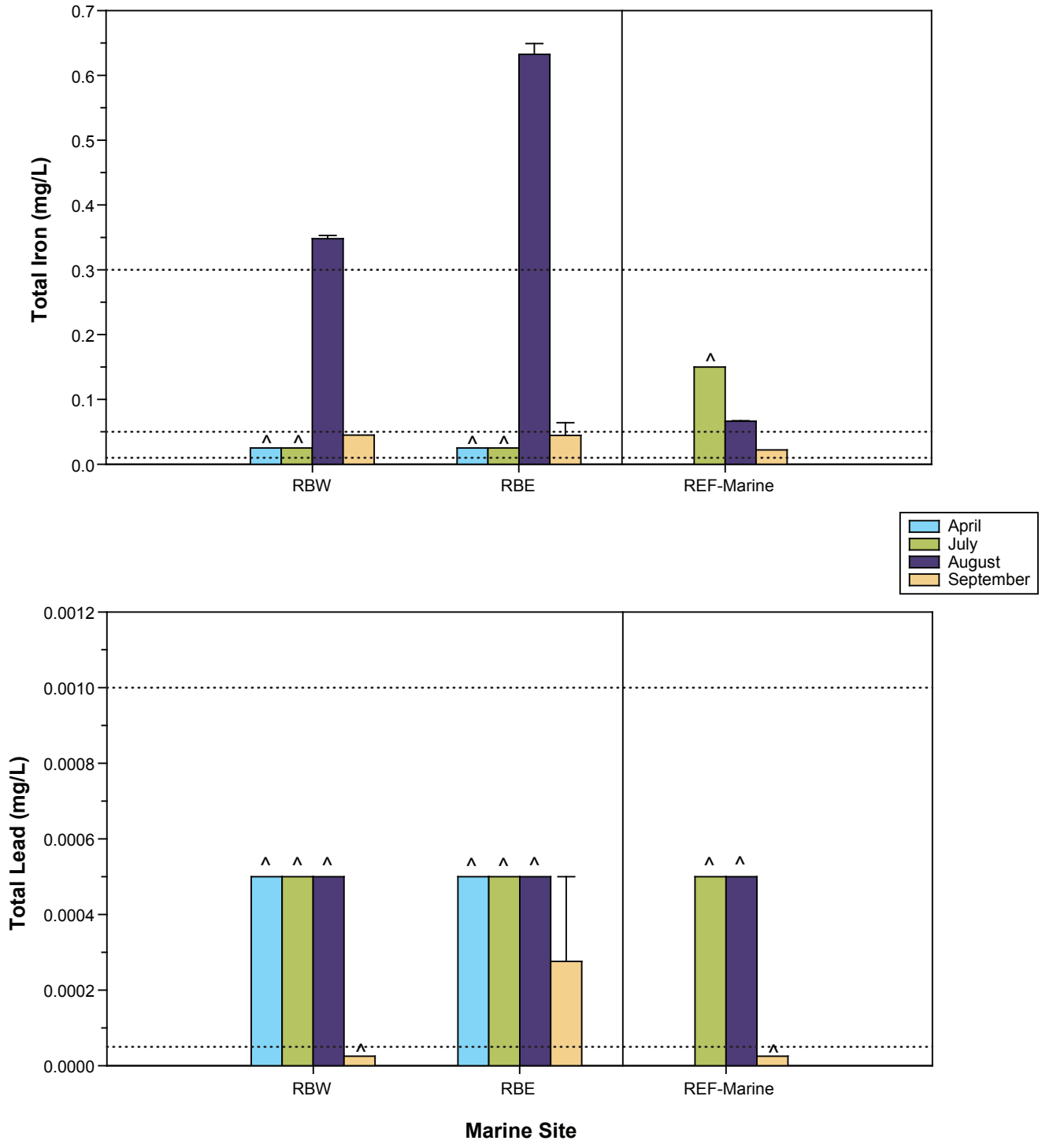

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the detection limit.
^ Indicates that total iron or total lead concentrations in all samples were below the detection limit.
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Iron and Total Lead Concentrations in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-25

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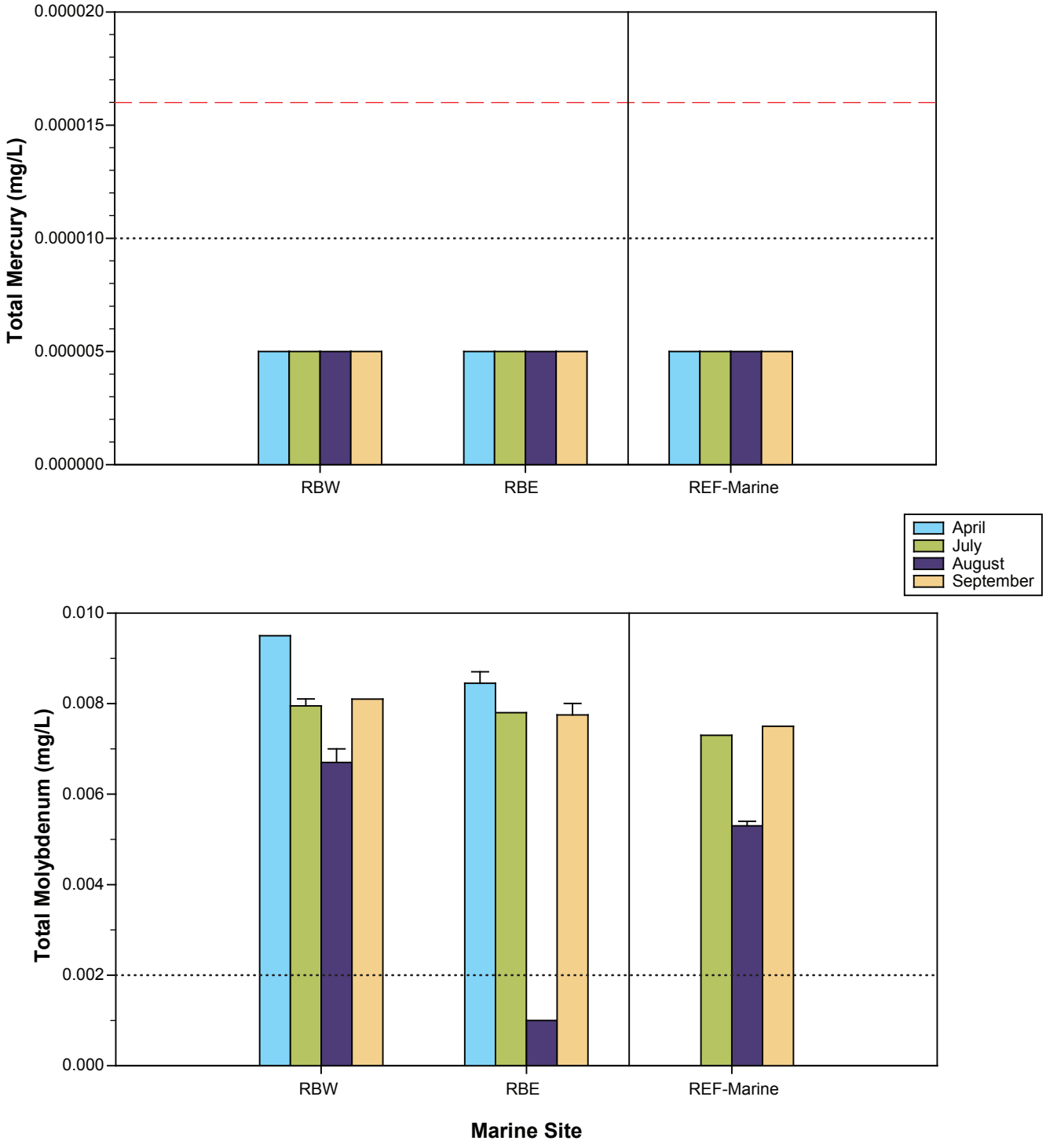

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed line represents the interim CCME guideline for inorganic mercury (0.000016 mg/L).
Total mercury and total molybdenum are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Mercury and Total Molybdenum Concentrations in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-26

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A1.2.3.16 Total Molybdenum

Mean total molybdenum concentrations typically ranged from 0.0053 mg/L (REF-Marine in August) to 0.0095 mg/L (RBW and in April). The concentration measured at RBE in August was below the analytical detection limit of 0.002 mg/L, which was particularly low compared to the other samples (Figure A1.2-26). This may be partly attributable to freshwater dilution as there was evidence of freshwater inputs at RBE during August (Figures A1.2-19 and A1.2-20) and the total molybdenum concentration in freshwater sites (Figures A1.2-8 and A1.2-17) was generally much lower than marine sites (Figure A1.2-26).

A1.2.3.17 Total Nickel

At all marine sites, total nickel concentrations were below the analytical detection limit of 0.0005 mg/L during at least one sampling period. The maximum total nickel concentration measured at each site was 0.00091 mg/L at RBW in August, 0.0013 mg/L at RBE in August, and 0.0012 mg/L at REF-Marine in July (Figure A1.2-27). July total nickel concentrations should be interpreted with caution because of potential contamination introduced by the GO-FLO sampler (see Section A1.2.2.4).

A1.2.3.18 Total Zinc

Total zinc concentrations were below the variable analytical detection limit of 0.0008, 0.0013, or 0.005 mg/L in 78% of marine samples, and barely over the detection limit in the remaining samples. The highest mean zinc concentration was 0.0061 mg/L at RBE in August (Figure A1.2-27).

A1.2.3.19 Comparison with CCME Guidelines

Marine water quality parameters were compared against CCME water quality guidelines for the protection of marine aquatic life (CCME 2011b). All measured parameters in marine samples were below recommended CCME guidelines.

A1.2.4 Quality Assurance and Quality Control (QA/QC)

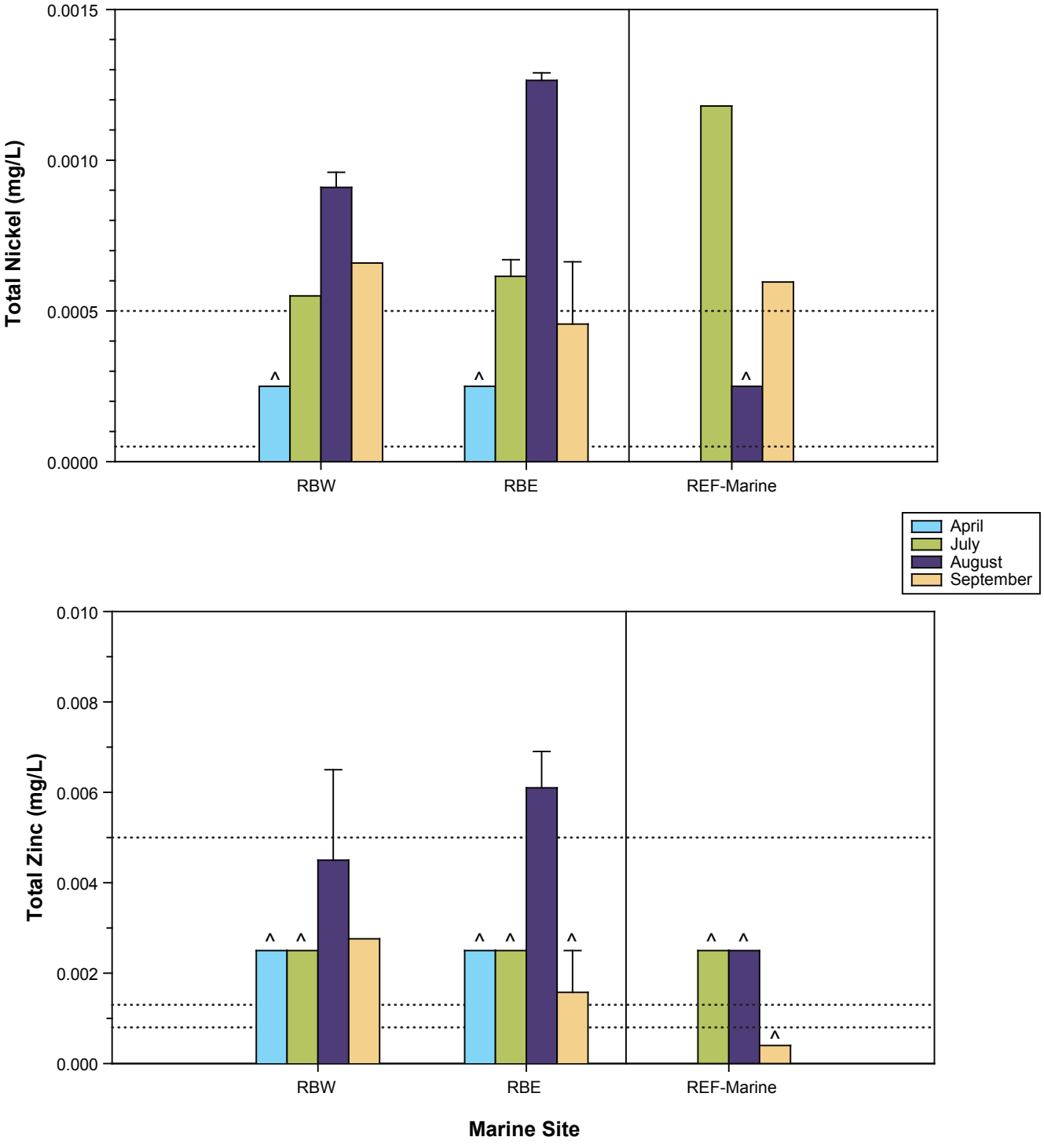
As part of the QA/QC measures, duplicate water quality samples were collected at certain sites. Specifically, duplicates samples were collected for 100% of stream samples, 21% of lake samples, and 64% of marine samples.

Another important aspect of the QA/QC program was the collection and analysis of field, travel, and equipment blanks alongside the water quality samples to identify potential sources of contamination.

Over the course of the 2010 AEMP field season, 17 blank samples were submitted and analyzed. These blank samples consisted of 3 equipment blanks, 8 field blanks, and 6 travel blanks. Blank results relating to the 18 evaluated water quality parameters are discussed below. The complete analytical results of the blank samples are provided in Appendix A2-5.

A1.2.4.1 Equipment Blanks

Equipment blanks are collected by first thoroughly rinsing the GO-FLO water sampler with double de-ionized water supplied by ALS Laboratories, and then collecting a sample of double de-ionized water that has passed through the GO-FLO. The purpose of an equipment blank is to determine whether any contamination is introduced to the water quality samples by the GO-FLO itself. Any contamination attributable to the GO-FLO could influence the interpretation of marine and lake water quality results, but not stream results as stream samples are not collected using a GO-FLO.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the detection limit.
^ Indicates that total nickel or total zinc concentrations in all samples were below the detection limit.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Nickel and Total Zinc Concentrations in AEMP Marine Sites, Doris North Project, 2010

Figure A1.2-27

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Equipment blanks for AEMP water quality samples were collected three times in 2010 (April, July, and August). Although some parameters were above detection limits in the April and August equipment blanks (see Appendix A2-5), none of the 18 evaluated parameters were above detection limits in either of these blanks. In the July equipment blank, concentrations of 4 out of the 18 evaluated parameters were higher than detection limits, namely: total aluminum (0.0238 mg/L), total lead (0.000078 mg/L), total nickel (0.0212 mg/L), and total zinc (0.0040 mg/L).

Based on the measured concentrations of total aluminum in lakes during July, the level of contamination introduced by the GO-FLO (0.0238 mg/L) could account for as little as 8% of the total aluminum measured at the site with the highest concentration (Reference D: 0.303 mg/L) and as much as 100% of the aluminum measured at the site with the lowest concentration (Reference B: 0.0104 mg/L). In Reference D and Little Roberts lakes, where particularly high total aluminum concentrations were measured in July, the potential contamination introduced by the GO-FLO is relatively minor (< 15%). In comparison, aluminum contamination could be significant in Doris Lake South, Doris Lake North, and Reference Lake B, where the contamination could account for 28 to 100% of the measured concentrations. In marine sites, contamination introduced by the GO-FLO could account for 82 to 100% of total aluminum concentrations measured in July.

The level of total lead contamination introduced by the GO-FLO (0.000078 mg/L) could account for 39 to 100% of the total lead concentrations measured in lakes in July. Therefore, caution should be applied when interpreting July lead concentrations in lakes. Total lead concentrations in marine sites in July were always below detection limits, so contamination did not affect measured concentrations.

The potential nickel contamination introduced by the GO-FLO (0.00212 mg/L) in July was more than an order of magnitude higher than any measured concentrations in lake or marine sites.

Total zinc concentrations in all lake and marine sites in July were below analytical detection limits, and were therefore unaffected by potential GO-FLO contamination levels of 0.004 mg/L.

A1.2.4.2 Field Blanks

Field blanks are sample bottles filled with double de-ionized water at ALS Laboratories that are subsequently sealed and shipped along with sample bottles to the field site. In the field, field blanks are transported with the sample bottles to the sampling site, and the field blanks are uncapped for approximately the same length of time that sample bottles would be uncapped when collecting a water sample. Field blanks are handled and processed in the same manner as water quality samples, which may involve the addition of sample preservatives. The purpose of collecting a field blank is to determine whether any ambient contamination is introduced to the water quality samples during sample collection, processing, or transportation.

A total of eight field blanks were collected between April and September. Out of the 18 evaluated parameters, concentrations of two parameters (total ammonia and radium-226) were above detection limits in at least one field blank.

Total ammonia concentrations in two field blanks collected in August and September were 0.0186 and 0.0161 mg ammonia-N/L, respectively. These levels of contamination could account for 41 to 100% of the ammonia measured in stream samples, 100% of the ammonia measured in the single marine sample containing detectable concentrations of ammonia, and 71 to 100% of the ammonia measured in lake samples between August and September. Total ammonia concentrations were generally very low at all sites, as the majority of samples were either near or below the detection limit.

Radium-226 concentrations were only measured in two of the field blanks (one in April and one in September). In the April field blank, the radium-226 concentration was 0.008 mg/L, which is above the

detection limit of 0.005 mg/L. Radium-226 concentrations were below the detection limit in the majority of stream, lake, and marine samples. In the few samples that had detectable concentrations of radium-226, the mean concentration was always lower than the potential contamination level of 0.008 mg/L. Therefore, any measurable concentrations of radium-226 in field samples may be attributable to ambient contamination.

A1.2.4.3 Travel Blanks

Travel blanks are sample bottles that are filled with double de-ionized water at ALS Laboratories and are subsequently sealed and shipped along with the sample bottles to the field site. Unlike field blanks, travel blanks remain sealed while in the field. Travel blanks are transported back to ALS Laboratories with the water quality samples. The purpose of collecting a travel blank is to determine whether any ambient contamination is introduced to the water quality samples during sample transportation.

Concentrations of all 18 evaluated parameters were below analytical detection limits in all six travel blanks collected between April and September. This suggests that sample transportation did not introduce any contamination to sample bottles, and any levels of contamination detected in field blanks and equipment blanks are the result of sample handling/processing and equipment contamination, respectively.

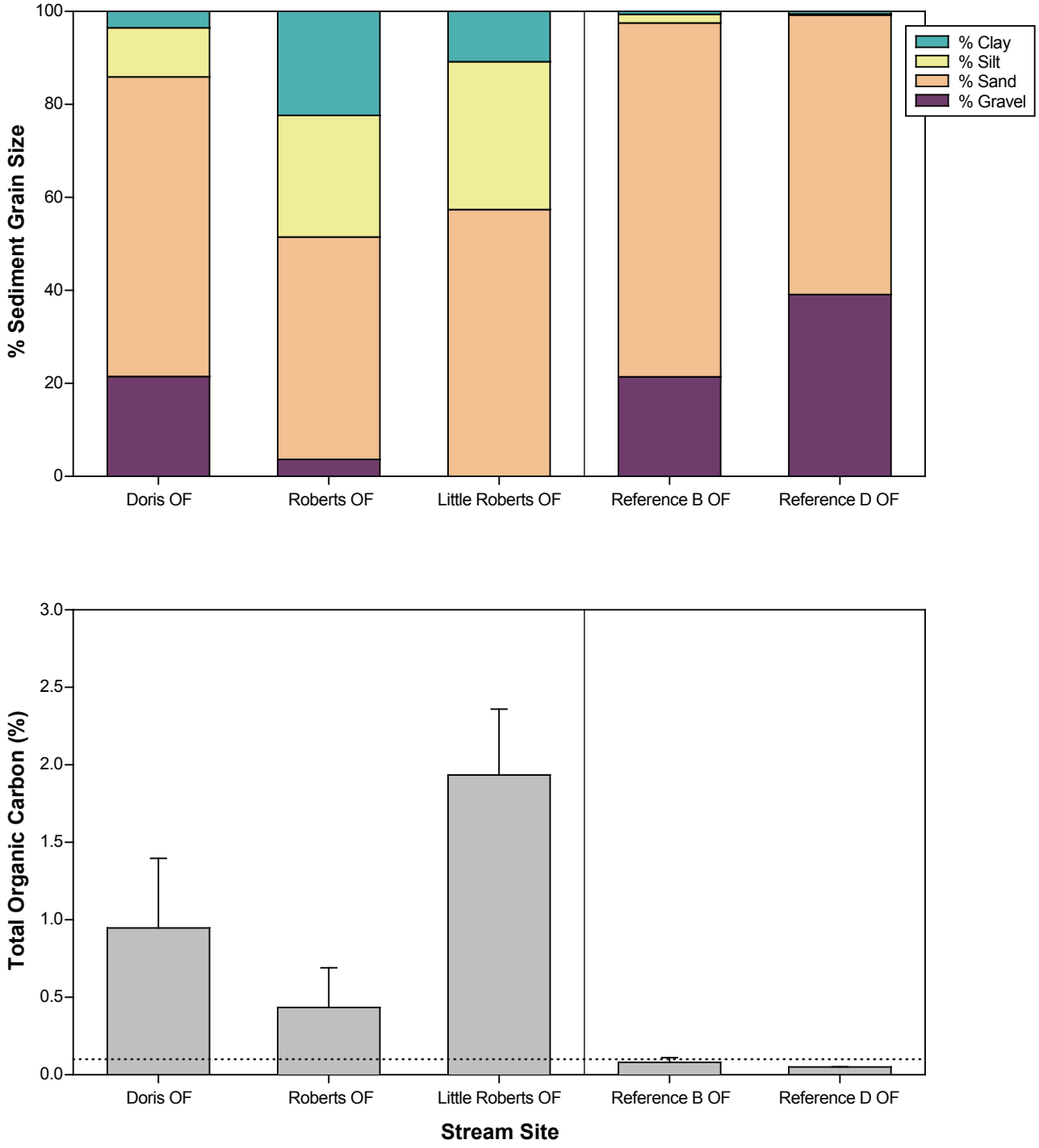
A1.3 SEDIMENT QUALITY

Triplicate sediment quality samples were collected during August 2010 in the stream, lake, and marine habitats. The raw data are provided in Appendix A2-6 and summary statistics are presented in Appendix A3-1. Where applicable, sediment quality parameters are compared against CCME sediment quality guidelines for the protection of aquatic life (CCME 2011a), including the interim sediment quality guidelines (ISQG), and probable effects levels (PEL). For graphing and data analysis, half the detection limit was substituted for sediment quality variables that were below analytical detection limits. Parameter concentrations that were below the detection limit in the majority or in all samples were generally not graphed (e.g., cadmium in stream sites, mercury in marine sites).

A1.3.1 Streams

The AEMP stream sediments were either composed of mainly coarse material (> 80% sand and gravel), or of equal proportions of sand and fine sediments (silt and clay; Figure A1.3-1). Sediments in Doris Outflow and the two reference streams were largely made up of sand, and to lesser degree, gravel. Doris Outflow sediments also contained some fines (15% total), while sediments in the reference streams were made up almost entirely of coarse material. Sediments from Little Roberts and Roberts outflows were composed of more than 40% fines, with Roberts Outflow having the highest proportion of clay in its sediments.

Despite the resemblance in grain size structure, Doris Outflow sediments were more similar in chemistry to Little Roberts Outflow and Roberts Outflow than to the reference stream sediments. The exposure streams had higher levels of total organic carbon, nutrients (total nitrogen, and available ammonia and phosphate), and metals in their sediments than both Reference B and D outflows (Figures A1.3-1 to A1.3-5; Appendix A2-6). Little Roberts Outflow had twice the proportion of total organic carbon in its sediments (mean: 1.9%; Figure A1.3-1) compared to the other streams (all < 1%), reflecting the higher nutrient levels in this stream (Figure A1.3-2). Total organic carbon and available phosphate concentrations were usually below detection limits in the reference streams.



Note: Error bars represent the standard error of the mean for replicate samples. Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.

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Grain Size and Total Organic Carbon Concentrations in AEMP Stream Sediments, Doris North Project, August 2010

Figure A1.3-1

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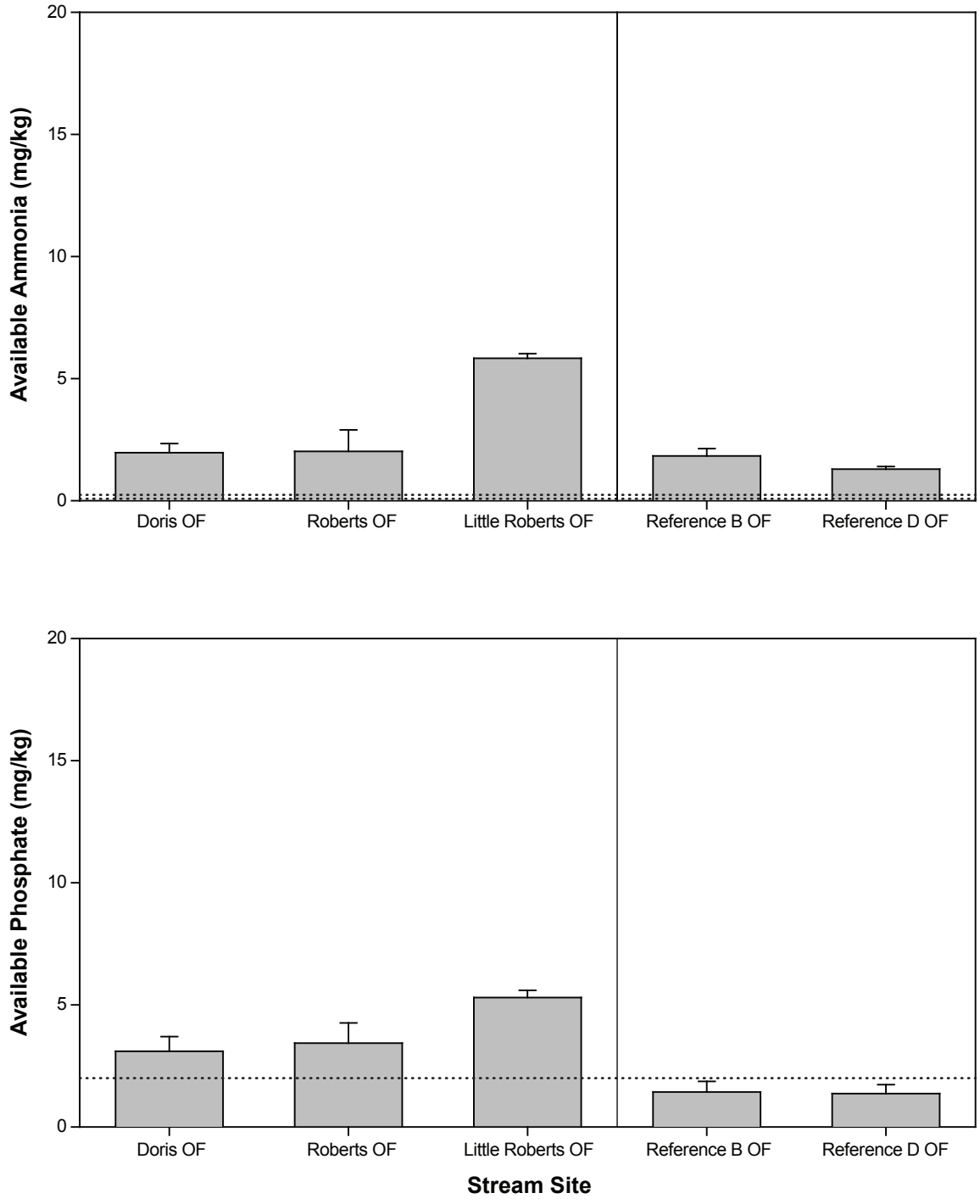

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.

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Available Ammonia and Phosphate Concentrations in AEMP Stream Sediments, Doris North Project, August 2010

Figure A1.3-2

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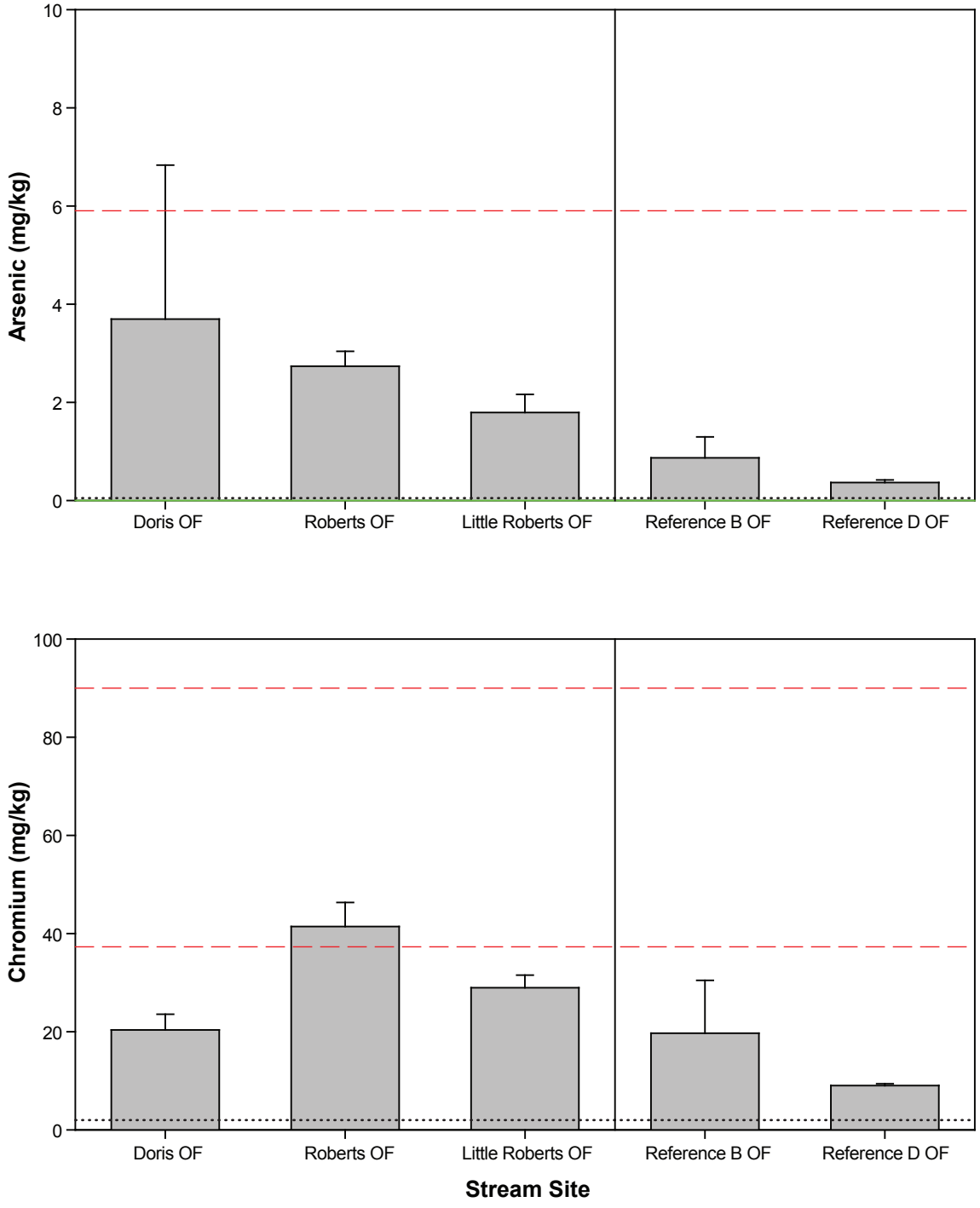

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for arsenic (5.9 mg/kg) and chromium (37.3 mg/kg); probable effects levels (PEL) for arsenic (17 mg/kg) and chromium (90 mg/kg) are not shown.

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Arsenic and Chromium Concentrations in AEMP Stream Sediments, Doris North Project, August 2010

Figure A1.3-3

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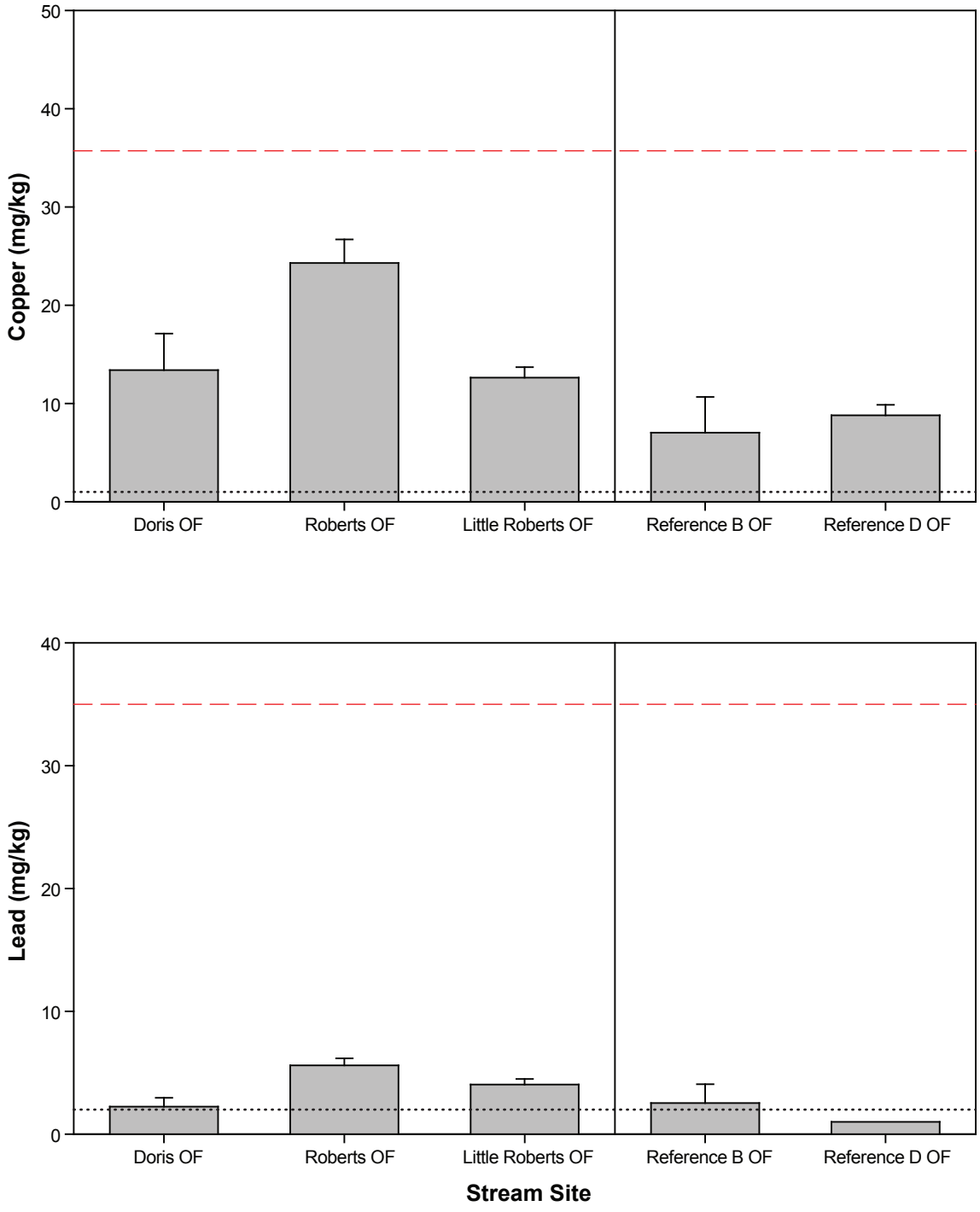

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for copper (35.7 mg/kg) and lead (35 mg/kg); probable effects levels (PEL) for copper (197 mg/kg) and lead (91.3 mg/kg) are not shown.

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Copper and Lead Concentrations in AEMP Stream Sediments, Doris North Project, August 2010

Figure A1.3-4

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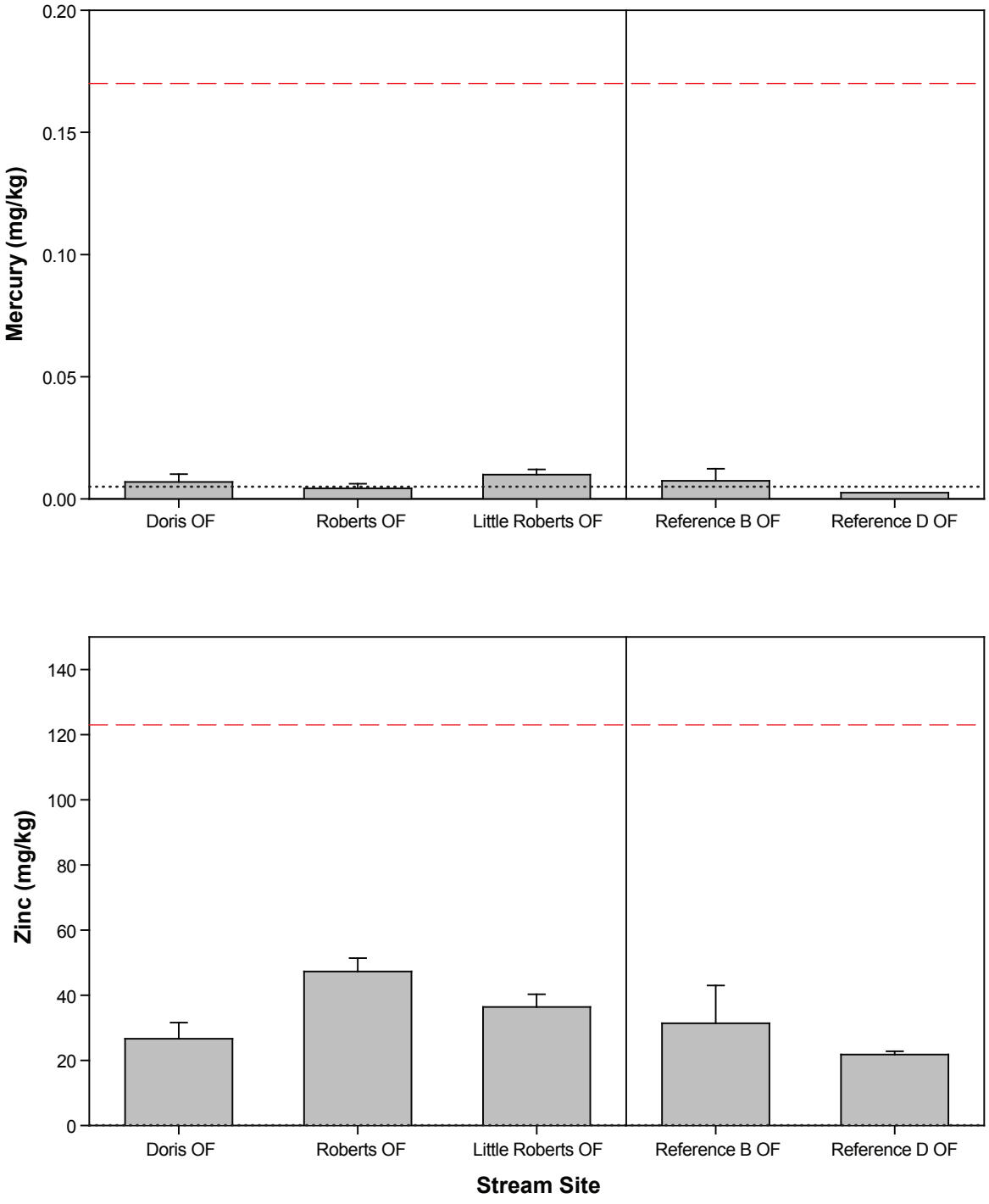

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for mercury (0.17 mg/kg) and zinc (123 mg/kg); probable effects levels (PEL) for mercury (0.486 mg/kg) and zinc (315 mg/kg) are not shown.

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Mercury and Zinc Concentrations in AEMP Stream Sediments, Doris North Project, August 2010

Figure A1.3-5

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Overall, most metals in the AEMP streams were positively correlated with the clay and silt content of the sediments, and negatively correlated with sand. The highest metal concentrations (32 analyzed metals) were found in the high silt-clay streams, Roberts Outflow and Little Roberts Outflow. Doris and Reference B outflows had intermediate levels of most metals, while Reference D Outflow consistently had the lowest metal concentrations of the five AEMP streams (Figures A1.3-3 to A1.3-5; Appendix A2-6). Roberts Outflow, which was included in the AEMP design because it was downstream of an abandoned silver mine, was the only site that had measureable levels of silver in its sediments (mean: 0.07 mg/kg; Appendix A2-6).

A1.3.1.1 Comparison with CCME Guidelines

Stream sediment quality parameters were compared against CCME sediment quality guidelines for the protection of freshwater aquatic life (CCME 2011a). Table A1.3-1 presents the percentage of samples collected from each stream in which parameter concentrations were higher than CCME guidelines, and Table A1.3-2 presents the factor by which average parameter concentrations were higher than CCME guidelines.

Most metal concentrations in AEMP stream sediments were below CCME guideline levels. No probable effects level (PEL) was exceeded for any metal (Table A1.3-1; Figures A1.3-3 to A1.3-5), and only chromium in Roberts Outflow (two out of three replicates) and Reference B Outflow (one out of three replicates), and arsenic in Doris Outflow (one out of three replicates) had concentrations that surpassed a CCME interim sediment quality guideline (ISQG) for the protection of aquatic life (Table A1.3-1). Chromium in Roberts Outflow (mean of replicates: 43.8 mg/kg) was the only average metal concentration that was above a CCME guideline, in this case by a factor of 1.11 over the ISQG level (Table A1.3-2).

A1.3.2 Lakes

The sediments in the five sampled AEMP lake sites were generally similar, with high proportions of silt (range: 53-89%) and low to intermediate proportions of clay (range: 4.5-32%). Among the five sites, the sediments in Reference Lake D were the most distinct in terms of particle size, with higher levels of sand (42%) and lower levels of silt (53%) and clay (4.5%) than the other lake sites. No other lake site had more than 8.3% sand in their sediments (Figure A1.3-6).

Due to the depositional nature of lakes, the total organic carbon content of lake sediments was higher than that measured in the adjacent streams, with mean levels usually between 2.2% (Doris Lake South) and 3.1% (Doris Lake North; Figure A1.3-6). Reference Lake B had substantially lower organic material than the other AEMP sites (0.6%). The nutrient levels in the lake sediments were generally low, as nitrate and nitrite concentrations were always below detection limits and available phosphate levels were usually below detection limits (Appendix A2-6). The comparatively high concentrations of available ammonia at Little Roberts Lake (23.3 mg/kg), Reference Lake D (15.5 mg/kg), and Doris Lake North (13.9 mg/kg) may suggest that these areas had higher levels of microbial activity in their sediments, which may result from higher levels of organic carbon deposition at these sites.

Like the streams, the metal content in the lake sediments was positively correlated with silt content, and negatively correlated with the amount of sand (results not shown). Except for cadmium, cobalt, and molybdenum, there was little relationship between the metal content in the lake sediments and clay content.

Table A1.3-1. Sediment Quality in AEMP Stream Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Stream	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of samples higher than ISQG[b] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			5.9	**0.6**	**37.3**	**35.7**	**35**	**0.17**	**123**
Doris Outflow	3		33.3	0	0	0	0	0	0
Roberts Outflow	3		0	0	66.7	0	0	0	0
Little Roberts Outflow	3		0	0	0	0	0	0	0
Reference B Outflow	3		0	0	33.3	0	0	0	0
Reference D Outflow	3		0	0	0	0	0	0	0

Stream	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of samples higher than PEL[c] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			17	**3.5**	**90**	**197**	**91.3**	**0.486**	**315**
Doris Outflow	3		0	0	0	0	0	0	0
Roberts Outflow	3		0	0	0	0	0	0	0
Little Roberts Outflow	3		0	0	0	0	0	0	0
Reference B Outflow	3		0	0	0	0	0	0	0
Reference D Outflow	3		0	0	0	0	0	0	0

Notes:

Values represent the percentages of 2010 samples that are higher than CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Table A1.3-2. Sediment Quality in AEMP Stream Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Stream	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are higher than ISQG[b] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			5.9	**0.6**	**37.3**	**35.7**	**35**	**0.17**	**123**
Doris Outflow	3		-	-	-	-	-	-	-
Roberts Outflow	3		-	-	1.11	-	-	-	-
Little Roberts Outflow	3		-	-	-	-	-	-	-
Reference B Outflow	3		-	-	-	-	-	-	-
Reference D Outflow	3		-	-	-	-	-	-	-

Stream	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are higher than PEL[c] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			17	**3.5**	**90**	**197**	**91.3**	**0.486**	**315**
Doris Outflow	3		-	-	-	-	-	-	-
Roberts Outflow	3		-	-	-	-	-	-	-
Little Roberts Outflow	3		-	-	-	-	-	-	-
Reference B Outflow	3		-	-	-	-	-	-	-
Reference D Outflow	3		-	-	-	-	-	-	-

Notes:

Values represent the factor by which average 2010 concentrations are higher than CCME guidelines; dashes represent average 2010 concentrations that are below CCME guidelines.

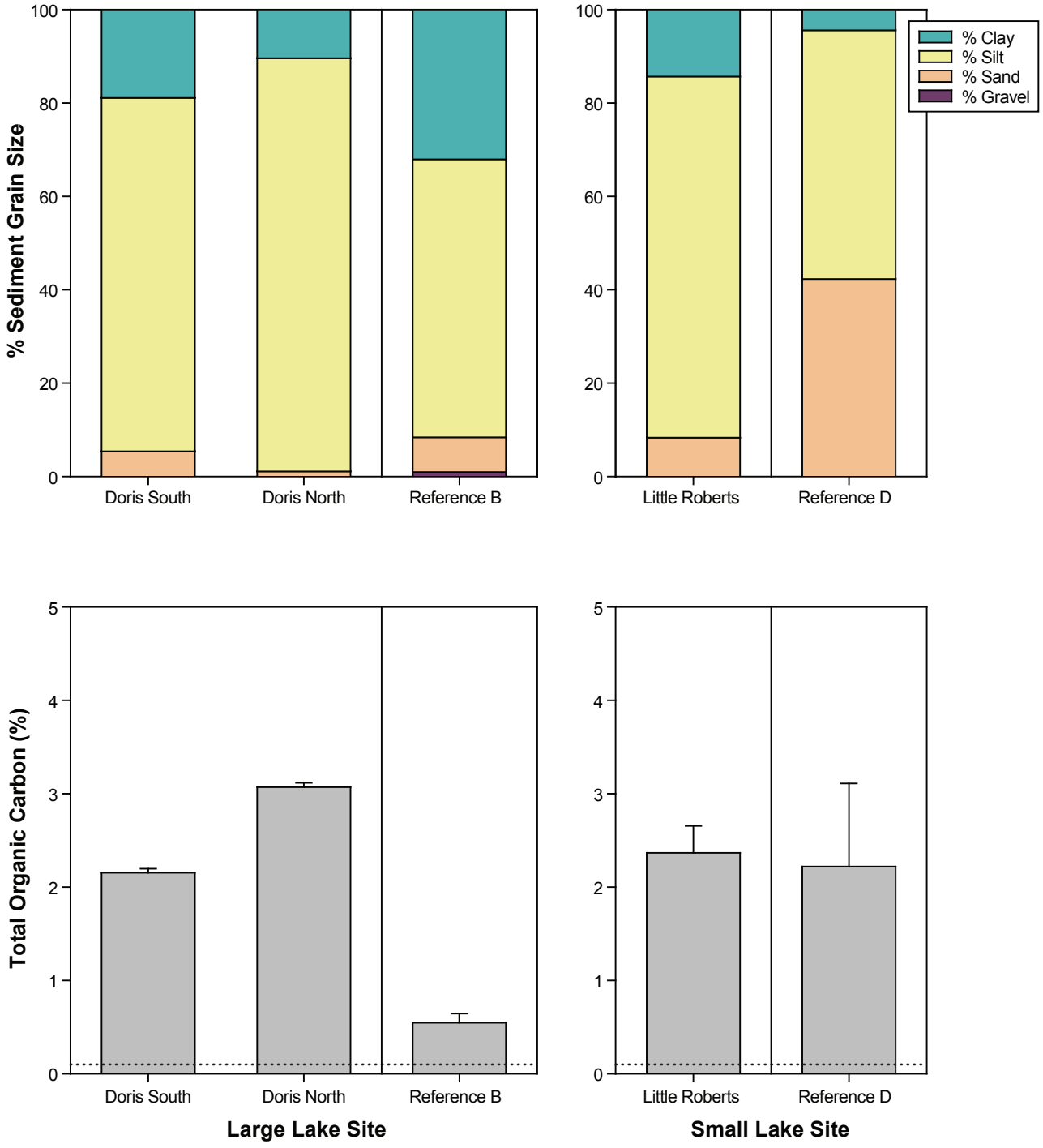
The average 2010 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration.

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level



Note: Error bars represent the standard error of the mean for replicate samples. Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.

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Grain Size and Total Organic Carbon Concentrations in AEMP Lake Sediments, Doris North Project, August 2010

Figure A1.3-6

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Doris Lake North sediments usually contained the highest levels of metals among the AEMP lake sites, with the highest mean concentrations for 23 of the 27 detectable metals (Figures A1.3-7 to A1.3-9; Appendix A2-6). Conversely, Reference Lake D had the lowest mean concentrations for 23 of the 27 detectable metals. Reference Lake B had distinctive sediment chemistry due to its higher clay content. Besides Doris Lake North, Reference Lake B was the only other site that had the highest levels of more than one metal, specifically, cadmium (0.24 mg/kg; Figure A1.3-7), cobalt (16.4 mg/kg), and molybdenum (2.23 mg/kg).

A1.3.2.1 Comparison with CCME Guidelines

Lake sediment quality parameters were compared against CCME sediment quality guidelines for the protection of freshwater aquatic life (CCME 2011a). Table A1.3-3 presents the percentage of samples collected from each lake in which parameter concentrations were higher than CCME guidelines, and Table A1.3-4 presents the factor by which average parameter concentrations were higher than CCME guidelines.

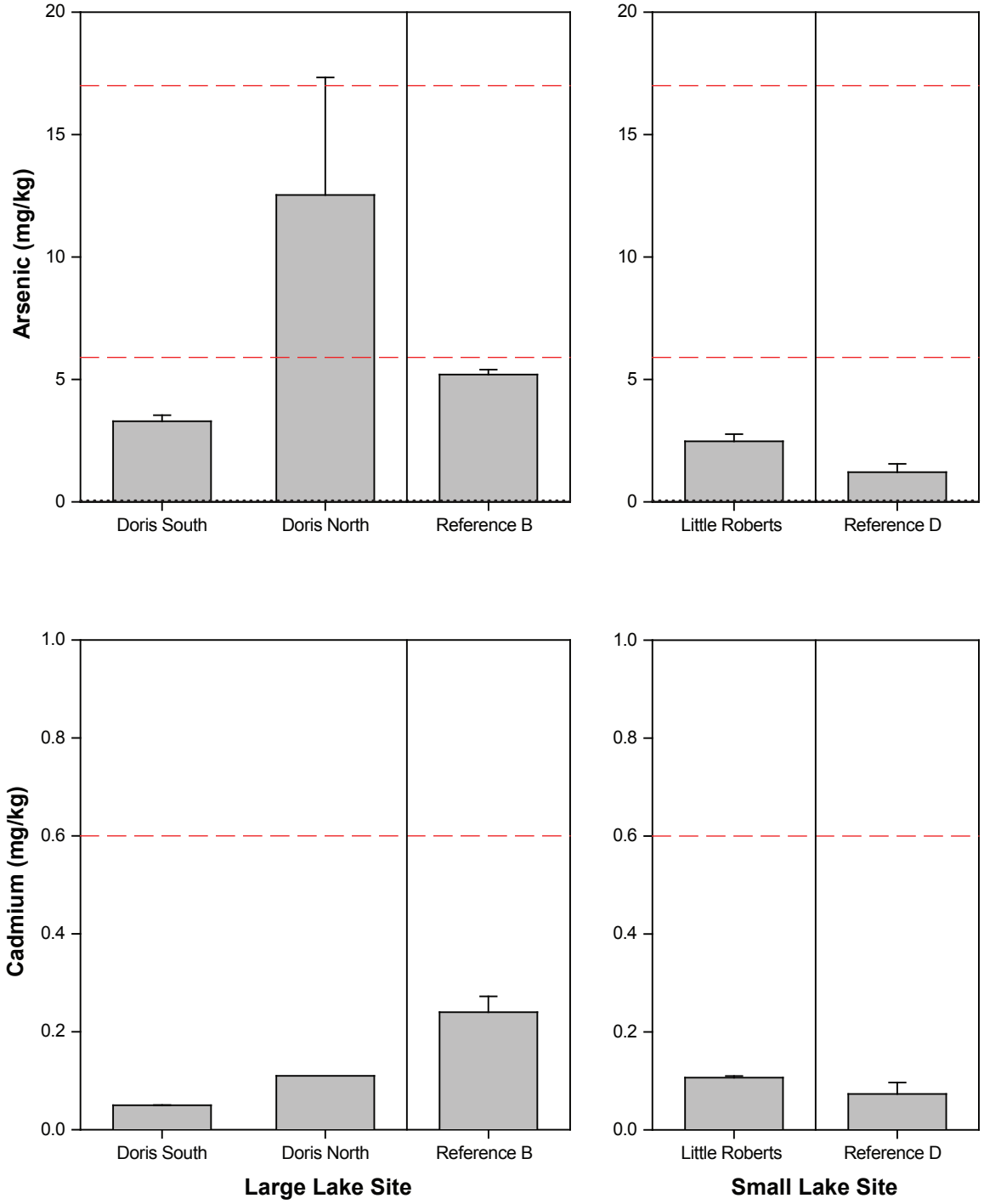
Because of the higher metal concentrations at Doris Lake North (Figures A1.3-7 to A1.3-9), this site exceeded the most CCME sediment quality guidelines. Mean arsenic (12.5 mg/kg) chromium (79.7 mg/kg) and copper (45.4 mg/kg) levels exceeded their respective ISQGs at Doris Lake North, although none of these mean concentrations were higher than their PEL guidelines. Arsenic in one replicate at Doris Lake North (21 mg/kg) was the only metal to exceed a PEL guideline. Chromium concentrations were higher than the ISQG limit (37.3 mg/kg) in all sediment samples collected from all AEMP lakes, except at Reference Lake D where only one out of three replicates surpassed the guideline (Table A1.3-3). When mean metal concentrations were higher than CCME guidelines, the factor by which mean concentrations exceeded these guidelines was usually two times or less (Table A1.3-4).

A1.3.3 Marine

The dominant grain size class in sediments collected from the three marine AEMP sites was sand, particularly at RBE where 93% of the sediment was made up of sand (Figure A1.3-10). This shallow site is susceptible to the north and northward winds, and receives direct freshwater input from Little Roberts Outflow. Hence, this site has more turbulent waters, with higher suspended solids in the water column because of the erosive nature of this area. RBW and REF-Marine, on the other hand, are slightly more sheltered, and have more indirect exposure to freshwater inputs. This allows for the presence of more fines in the sediments. These sites had four (26%; RBW) to six times (38%; REF-Marine) more silt in their sediments than RBE (6%).

The proportion of total organic carbon was much lower in marine sediment than in lake and stream sediments, with marine sediment levels usually remaining below 0.5% (Figure A1.3-10). Mean total organic carbon content was highest at REF-Marine in Reference Bay (0.56%), as was the proportion of total nitrogen (Appendix A2-6) and available ammonia and phosphate (Figure A1.3-11). Mean available phosphate levels were much higher in the marine sediments (11.5 mg/kg) than in the lake (73% of samples below detection) or stream sediments (2.9 mg/kg), since phosphate is generally not the limiting nutrient in marine areas as is often the case in freshwater environments.

The metal concentrations in the marine AEMP sediments reflected their grain size composition. The sandy sediments in RBE consistently had the lowest levels of metals compared to RBW and REF-Marine (Figures A1.3-12 to A1.3-14; Appendix A2-6), with the exception of copper, cobalt, and uranium (higher than at least one other site). Conversely, the higher and similar silt content in RBW and REF-Marine was associated with higher and similar metal concentrations at these two sites.



Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for arsenic (5.9 mg/kg) and cadmium (0.6 mg/kg) and the probable effects level (PEL) for arsenic (17 mg/kg). The PEL cadmium (3.5 mg/kg) is not shown.

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Arsenic and Cadmium Concentrations in AEMP Lake Sediments, Doris North Project, August 2010

Figure A1.3-7

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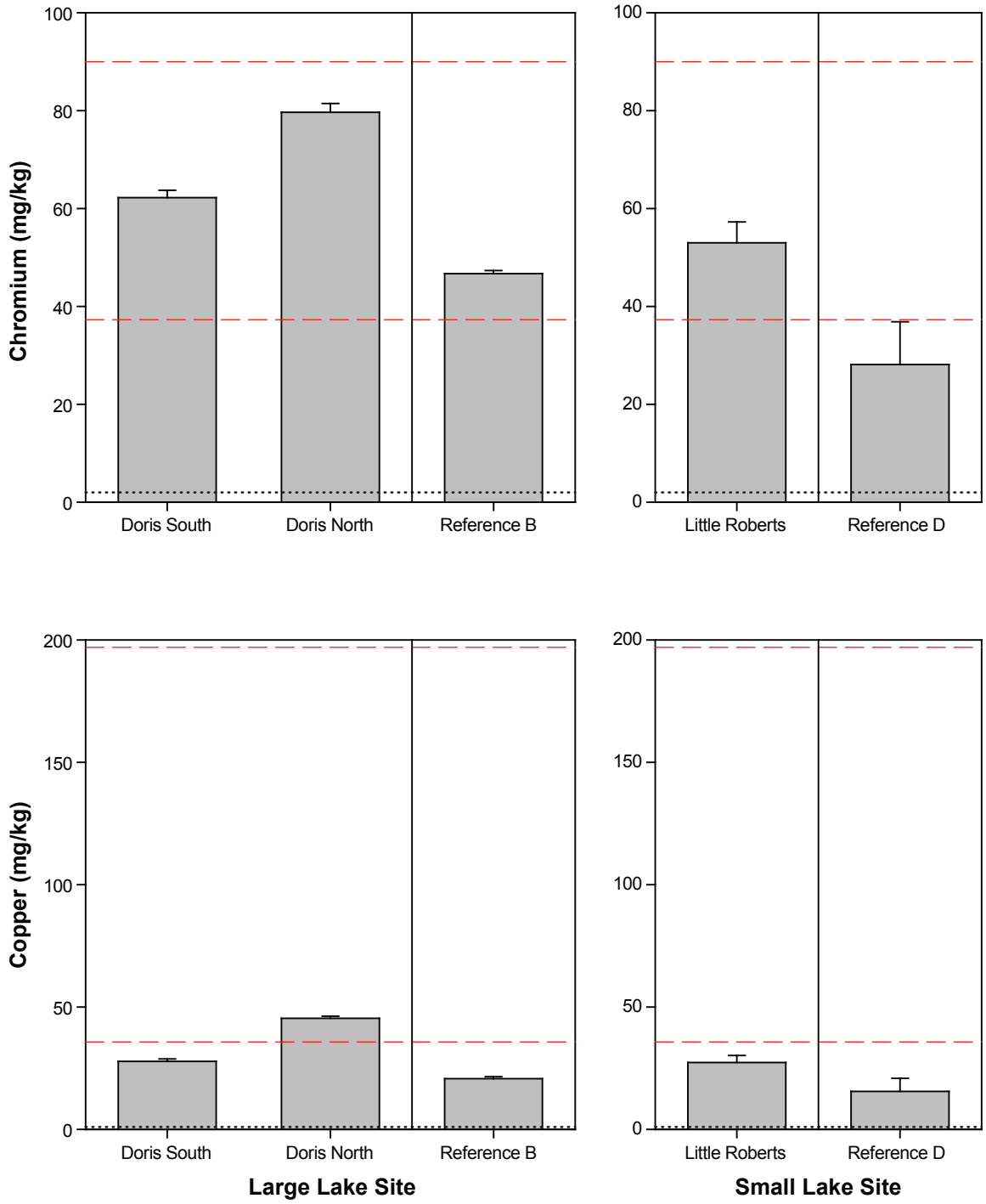

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for chromium (37.3 mg/kg) and copper (35.7 mg/kg) and the probable effects levels (PEL) for chromium (90 mg/kg) and copper (197 mg/kg).

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Chromium and Copper Concentrations in AEMP Lake Sediments, Doris North Project, August 2010

Figure A1.3-8

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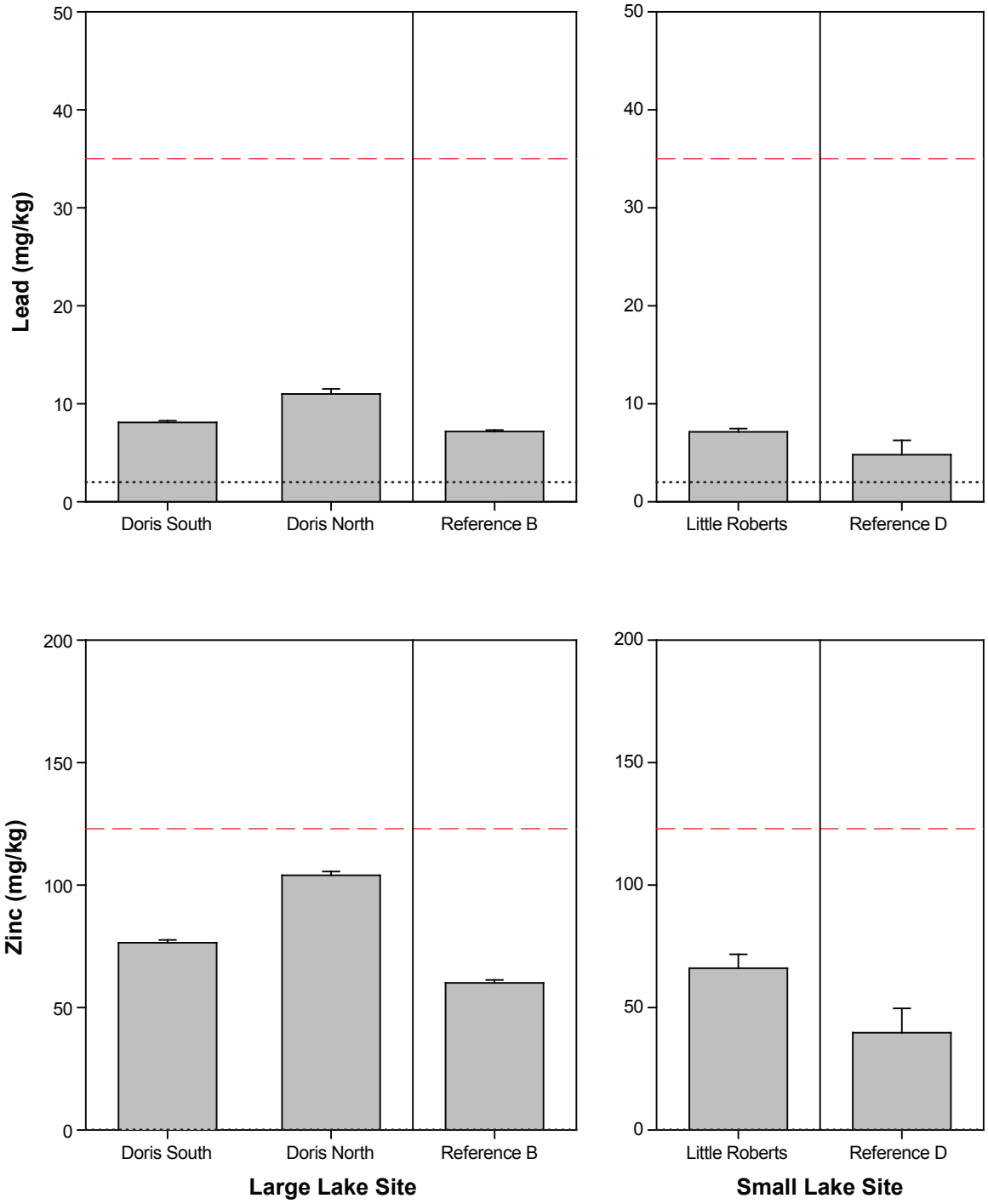

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim sediment quality guidelines (ISQG) for lead (35.7 mg/kg) and zinc (123 mg/kg); probable effects levels (PEL) for lead (91.3 mg/kg) and zinc (315 mg/kg) are not shown.

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Lead and Zinc Concentrations in AEMP Lake Sediments, Doris North Project, August 2010

Figure A1.3-9

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Table A1.3-3. Sediment Quality in AEMP Lake Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Lake	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of samples higher than ISQG[b] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			5.9	0.6	37.3	35.7	35	0.17	123
Large Lake Site									
Doris South	3		0	0	100	0	0	0	0
Doris North	3		66.7	0	100	100	0	0	0
Reference B	3		0	0	100	0	0	0	0
Small Lake Site									
Little Roberts	3		0	0	100	0	0	0	0
Reference D	3		0	0	33.3	0	0	0	0

Lake	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of samples higher than PEL[c] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			17	3.5	90	197	91.3	0.486	315
Large Lake Site									
Doris South	3		0	0	0	0	0	0	0
Doris North	3		33.3	0	0	0	0	0	0
Reference B	3		0	0	0	0	0	0	0
Small Lake Site									
Little Roberts	3		0	0	0	0	0	0	0
Reference D	3		0	0	0	0	0	0	0

Values represent the percentages of 2010 samples that are higher than CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Table A1.3-4. Sediment Quality in AEMP Lake Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2010

Lake	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which average concentrations are higher than ISQG[b] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			5.9	0.6	37.3	35.7	35	0.17	123
Large Lake Site									
Doris South	3		-	-	1.67	-	-	-	-
Doris North	3		2.12	-	2.14	1.27	-	-	-
Reference B	3		-	-	1.25	-	-	-	-
Small Lake Site									
Little Roberts	3		-	-	1.42	-	-	-	-
Reference D	3		-	-	-	-	-	-	-

Lake	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which average concentrations are higher than PEL[c] guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			17	3.5	90	197	91.3	0.486	315
Large Lake Site									
Doris South	3		-	-	-	-	-	-	-
Doris North	3		-	-	-	-	-	-	-
Reference B	3		-	-	-	-	-	-	-
Small Lake Site									
Little Roberts	3		-	-	-	-	-	-	-
Reference D	3		-	-	-	-	-	-	-

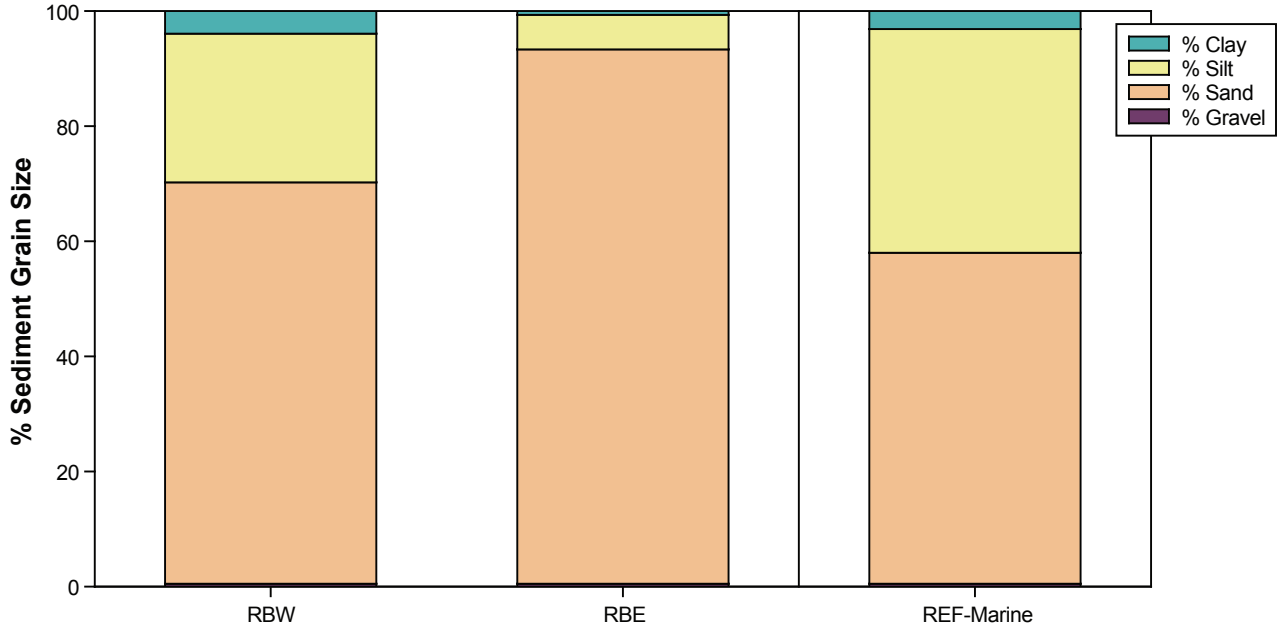
The average 2010 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration.

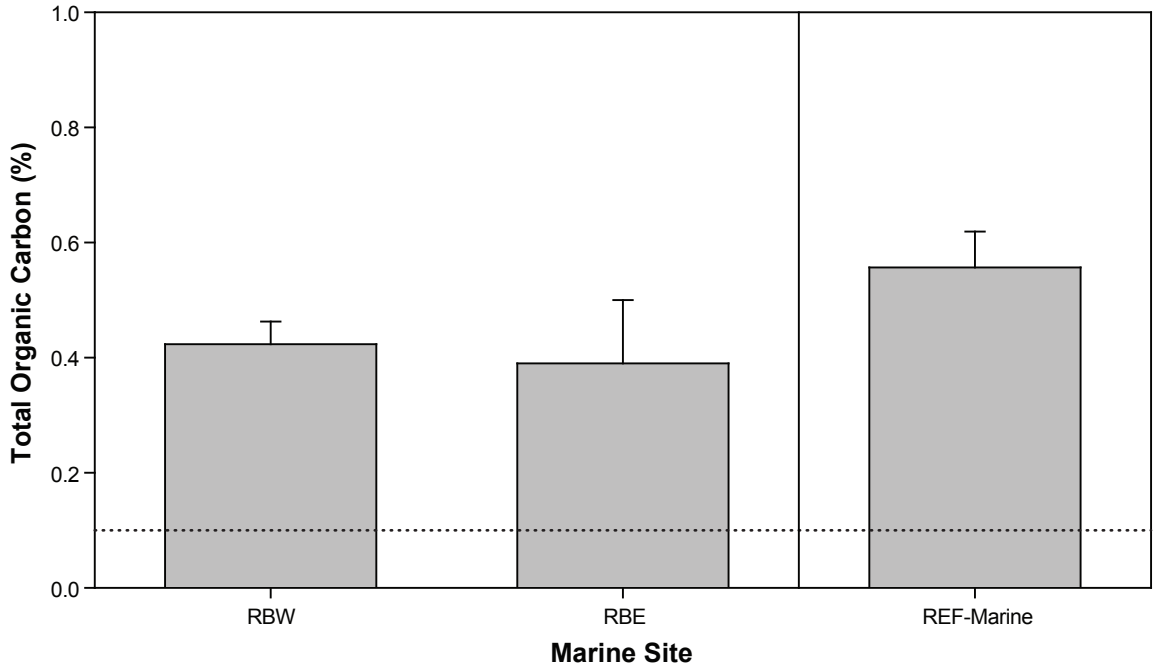
Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level





Note: Error bars represent the standard error of the mean for replicate samples. Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.

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Grain Size and Total Organic Carbon Concentrations in AEMP Marine Sediments, Doris North Project, August 2010

Figure A1.3-10

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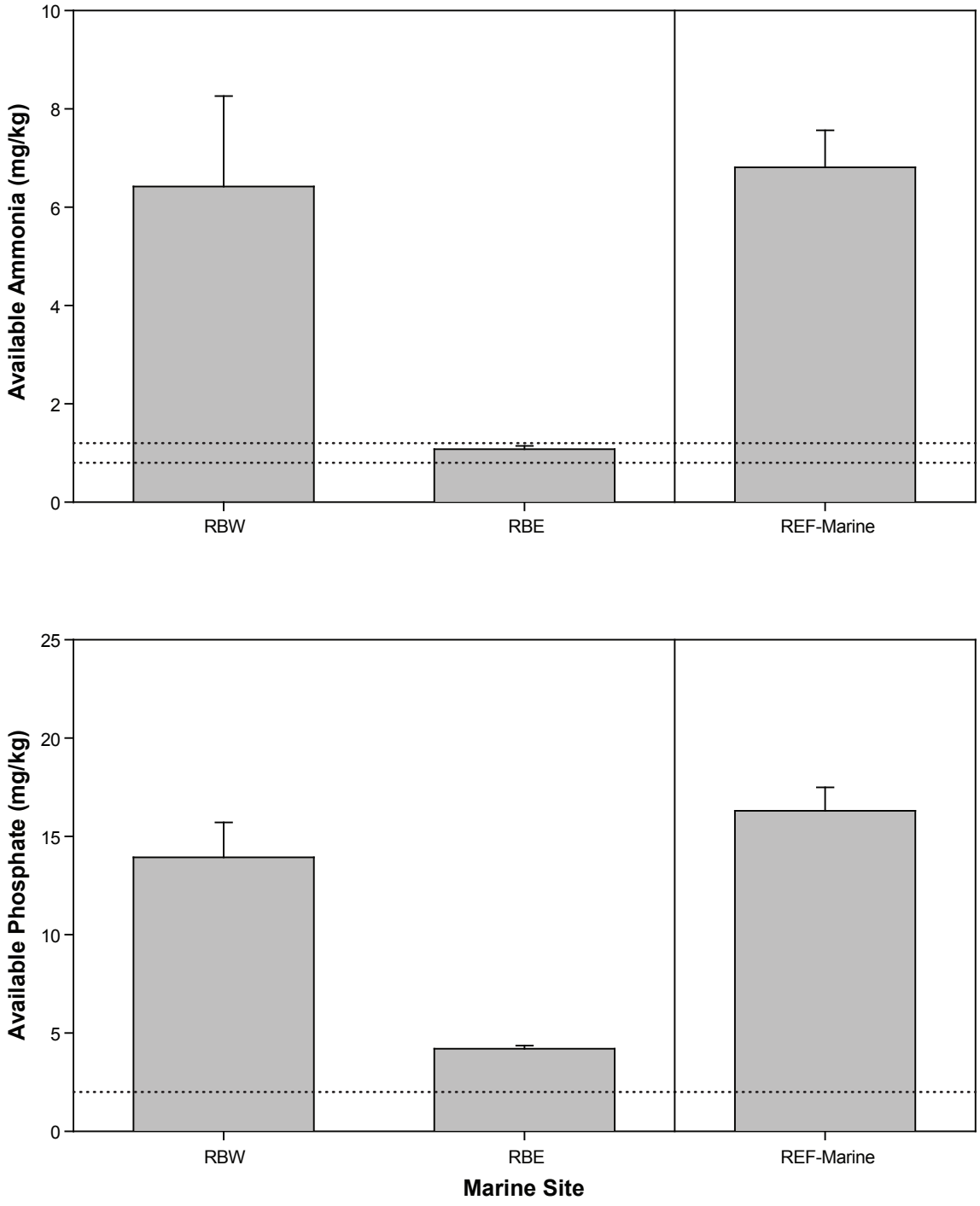

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.

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Available Ammonia and Phosphate Concentrations in AEMP Marine Sediments, Doris North Project, August 2010

Figure A1.3-11

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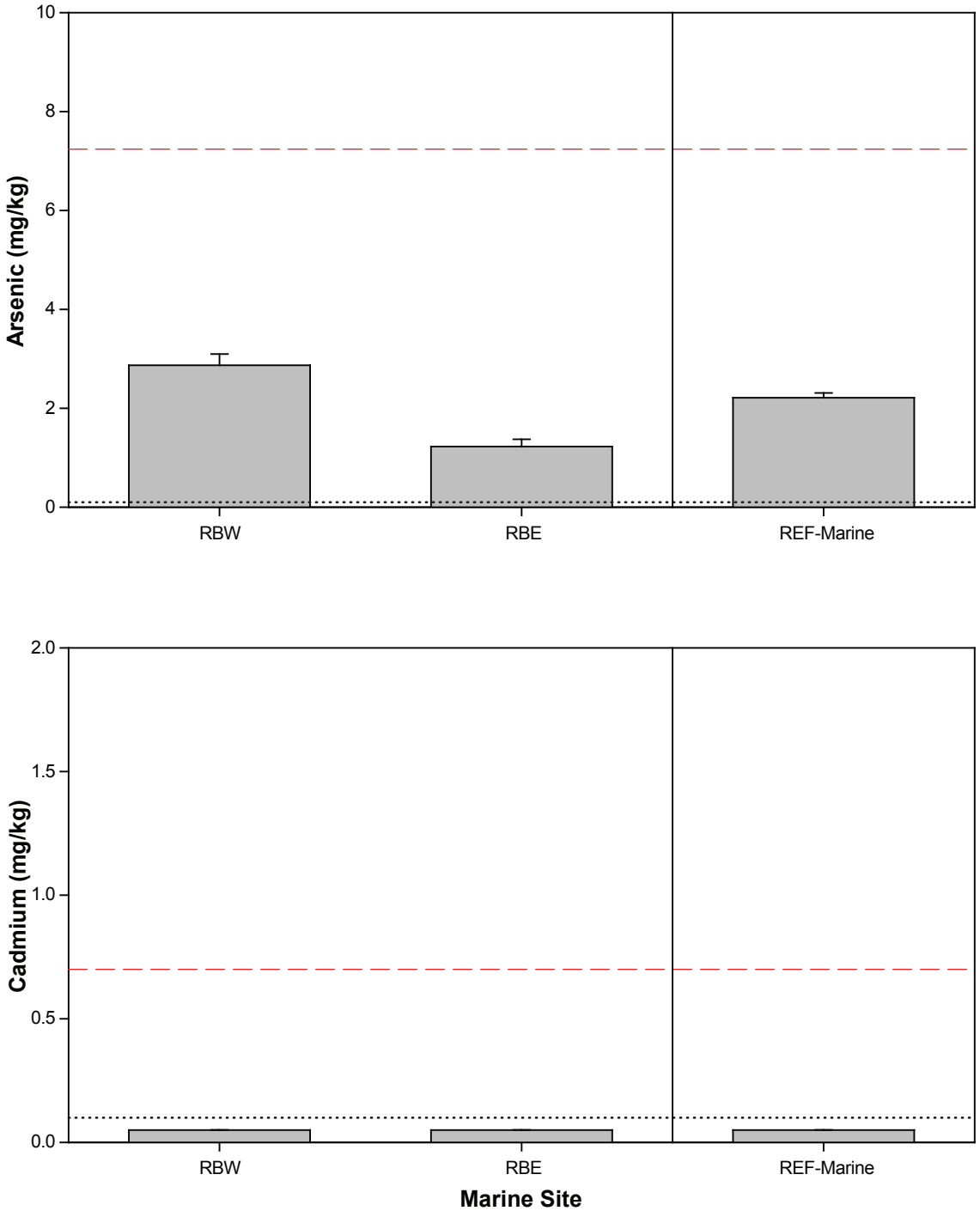

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim marine sediment quality guideline (ISQG) for arsenic (7.24 mg/kg) and cadmium (0.7 mg/kg); probable effects levels (PEL) for arsenic (41.6 mg/kg) and cadmium (4.2 mg/kg) are not shown.

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Arsenic and Cadmium Concentrations in AEMP Marine Sediments, Doris North Project, August 2010

Figure A1.3-12

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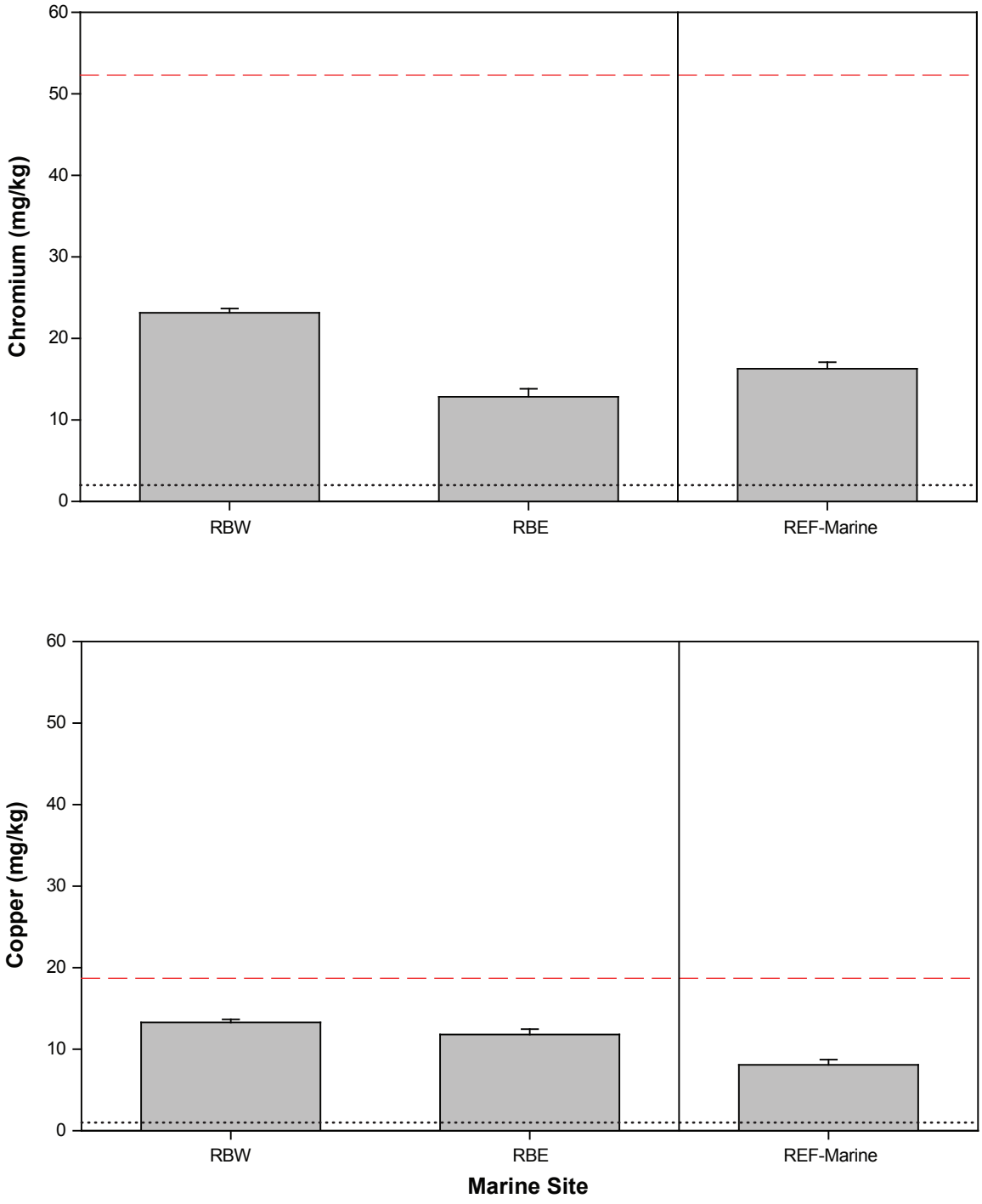

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim marine sediment quality guideline (ISQG) for chromium (52.3 mg/kg) and copper (18.7 mg/kg); probable effects levels (PEL) for chromium (160 mg/kg) and copper (108 mg/kg) are not shown.

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Chromium and Copper Concentrations in AEMP Marine Sediments, Doris North Project, August 2010

Figure A1.3-13

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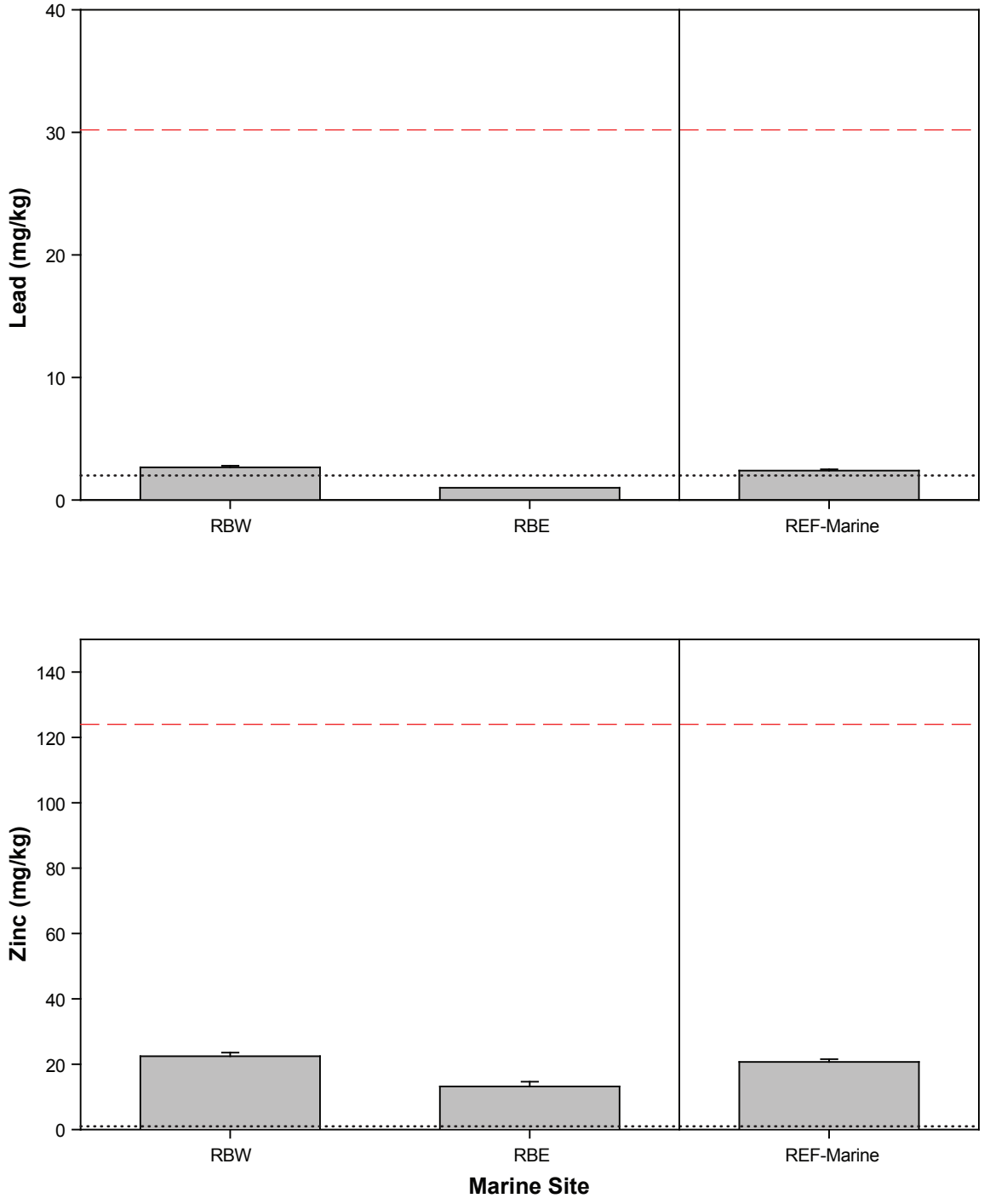

Note: Error bars represent the standard error of the mean for replicate samples.
Black dotted lines represent analytical detection limits; values below the analytical detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME interim marine sediment quality guideline (ISQG) for lead (30.2 mg/kg) and zinc (124 mg/kg); probable effects levels (PEL) for lead (112 mg/kg) and zinc (271 mg/kg) are not shown.

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Lead and Zinc Concentrations in AEMP Marine Sediments, Doris North Project, August 2010

Figure A1.3-14

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A1.3.3.1 Comparison with CCME Guidelines

No metals in any of the AEMP marine sediment samples exceeded CCME sediment quality guideline levels (Figures A1.3-12 to A1.3-14). Aside from copper (Figure A1.3-13), no metal came within 50% of its ISQG (CCME 2011a).

A1.4 PRIMARY PRODUCERS

All chlorophyll *a* data are presented in Appendix A2-7 and summary statistics are presented in Appendix A3-2. Figure A1.4-1 presents the mean chlorophyll *a* concentrations for each month measured at each stream, lake, and marine site.

A1.4.1 Stream Periphyton

Overall, periphyton biomass tended to be higher in streams flowing from the smaller lakes (Little Roberts and Reference D outflows) compared to those flowing from the larger lakes (Doris, Roberts, and Reference B outflows; Figure A1.4-1). The lowest concentrations were consistently found at Reference B Outflow (annual mean: 0.10 µg chl *a*/cm^2), while the highest concentrations were always in Little Roberts Outflow (annual mean: 0.56 µg chl *a*/cm^2). Some seasonality was apparent, as the highest biomass levels tended to occur in August, and the lowest levels in July. The highest individual replicate concentration was 2.6 µg chl *a*/cm^2 at Little Roberts Outflow in August.

A1.4.2 Lake Phytoplankton

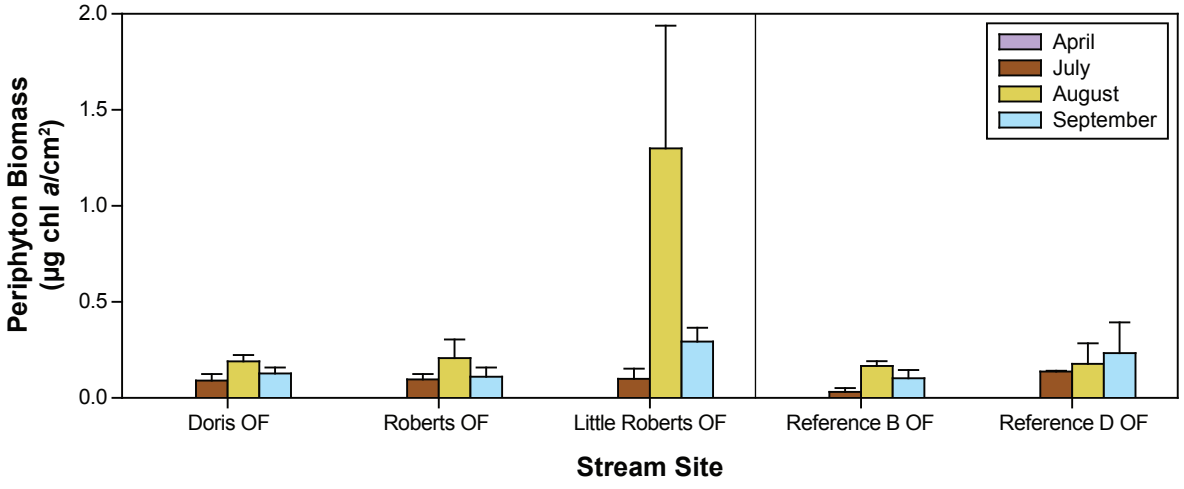
There was an obvious spatial trend in the lake phytoplankton biomass, as the exposure lakes had higher concentrations than the two reference lakes (Figure A1.4-1). Overall, the biomass concentrations in the exposure lakes were quite high, with mean 2010 concentrations of approximately 5 µg chl *a*/L at Little Roberts Lake and 10 to 13 µg chl *a*/L at the Doris Lake sites. The highest monthly mean biomass level was found in the surface waters of Doris Lake South during September (26.1 µg chl *a*/L). There was a general trend of increasing phytoplankton standing stocks from the under-ice period (April) to later summer (August and September). Chlorophyll *a* concentrations in the reference sites were consistently below 1 µg/L during the surveys (range: 0.16—1.1 µg chl *a*/L; mean: 0.7 µg chl *a*/L). In the case of Reference Lake D, the abundance of submerged macrophytes that were found at this site (Plate A1.4-1) suggests that these plants may have dominated the lake-wide primary productivity and nutrient uptake because of the shallow nature of this lake (mean depth: 2.4 m).

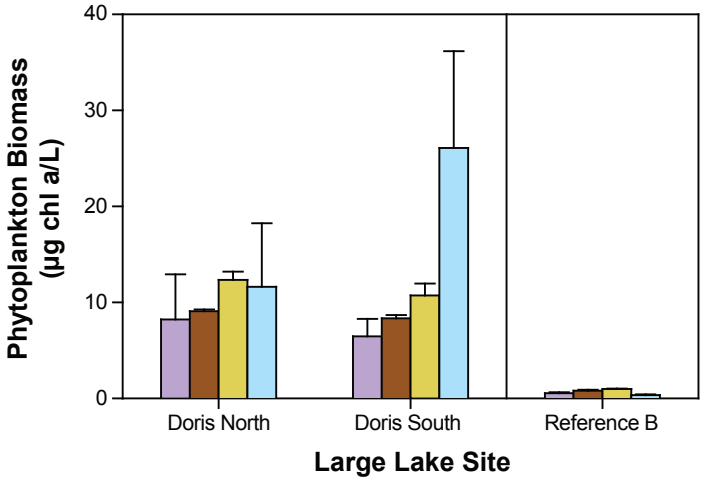
A1.4.3 Marine Phytoplankton

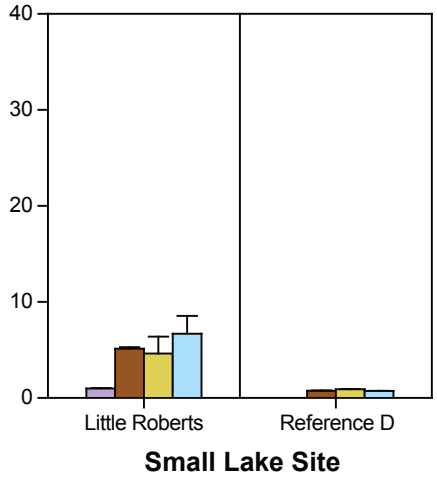
Phytoplankton biomass in the marine environment was typically low. Biomass levels were usually less than 1 µg chl *a*/L, and the lowest mean chlorophyll *a* concentration was found in the reference site, REF-Marine, in September (0.16 µg chl *a*/L). The highest mean biomass level was found at RBE in August (7.0 µg chl *a*/L). Notably, the winds were high and sustained during this sampling period, with elevated levels of suspended material. Hence, the unusually high biomass found in this sandy, shallow area during August may have been resuspended episammic periphyton. Chlorophyll *a* concentrations were always highest in August at each marine site and lowest in July (Figure A1.4-1).

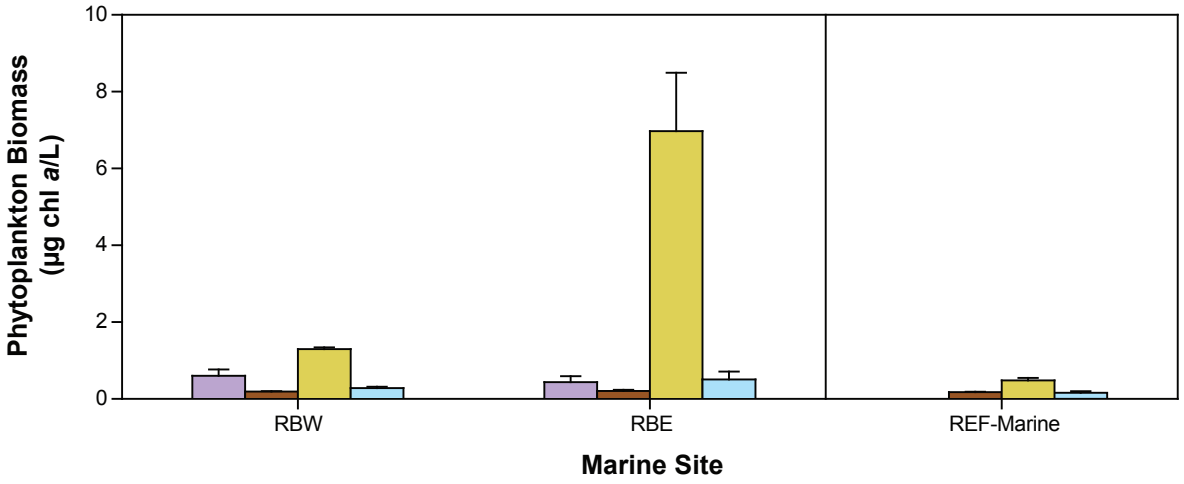
A1.5 BENTHOS

Benthos samples were collected during August 2010 at all AEMP sites. Results from the enumeration and taxonomic identification of all benthos samples are provided in Appendix A2-8, Summary statistics are provided in Appendix A3-3.









Note: Error bars represent the standard error of the mean

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Periphyton and Phytoplankton Biomass (as chl *a*) in AEMP Stream, Lake and Marine Sites, Doris North Project, August 2010

Figure A1.4-1

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Plate A1.4-1. Submerged macrophytes collected in Ekman grab at Reference Lake D, August 2010.

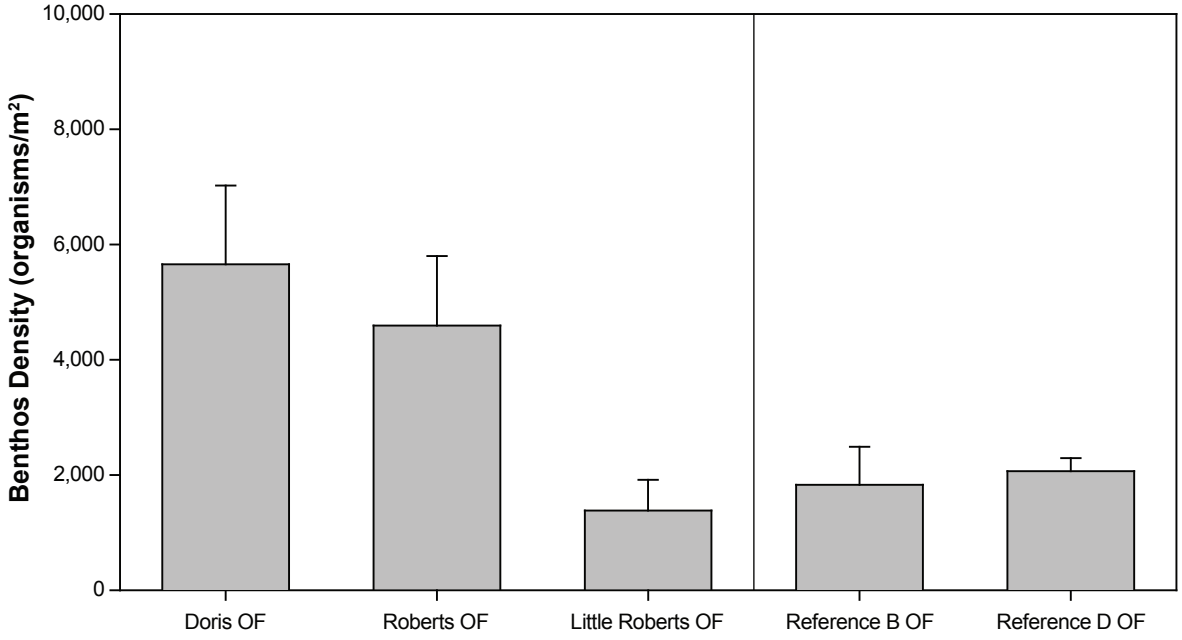
A1.5.1 Streams

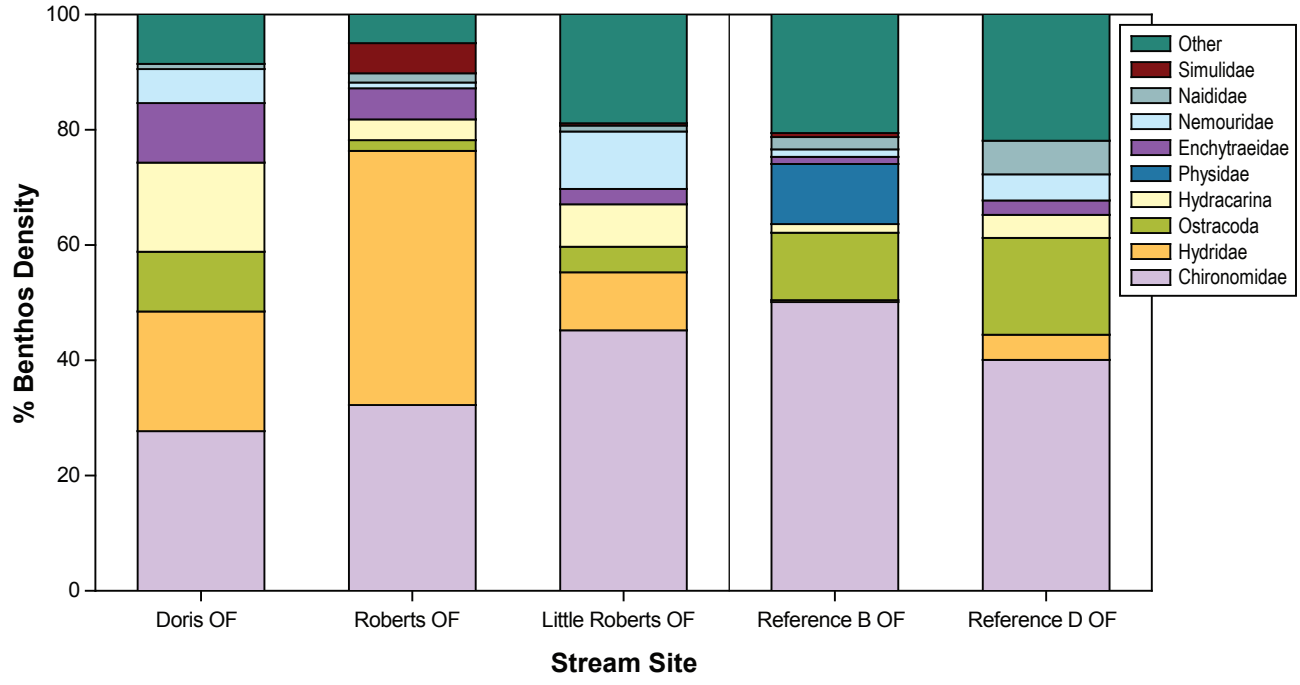
A1.5.1.1 Density and Community Composition

Benthos density was variable among AEMP stream sites. Mean density was more than twice as high in Doris (5,650 organisms/m^2) and Roberts outflows (4,590 organisms/m^2) than in Little Roberts, Reference B, and Reference D outflows (all below 2,100 organisms/m^2). Both Doris and Roberts outflows had heterogeneous sediment composition, with measurable portions of gravel, sand, silt, and clay (Figure A1.5-1). This may have provided additional habitat for the benthos.

The dipteran family, Chironomidae (non-biting midges), were the most abundant group in all stream sites, except Roberts Outflow, making up 50% of the assemblage in Reference B Outflow, 45% in Little Roberts Outflow, 40% in Reference D Outflow, and 28% in Doris Outflow (Figure A1.5-1). Although Roberts Outflow had an abundant chironomid population (32%), the predominant group in this stream was the cnidarian family, Hydridae, which made up 44% of the benthic assemblage. Doris Outflow also had a high percentage of these predatory animals (21%). The orders Ostracoda (seed shrimp) and Hydracarina (water mites), and the families Physidae (bladder snails), Enchytraeidae (annelids), and Nemouridae (type of stonefly) were also common in AEMP streams (Figure A1.5-1).

Given the higher benthos densities and lower proportions of chironomids at Doris OF and Roberts OF, the benthos community structure was most similar between these sites and was most dissimilar between these sites and the reference sites, particularly Reference D OF (Figure A1.5-2). Little Roberts OF had comparable benthos densities to the reference sites, but was made up of higher proportions of Hydridae, Hydracarina, and Nemouridae, therefore had Bray-Curtis dissimilarity values intermediate to Doris and Roberts outflows and the two reference stream sites.





Note: Error bars represent the standard error of the mean

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Benthos Density and Community Composition in AEMP Streams, Doris North Project, August 2010

Figure A1.5-1

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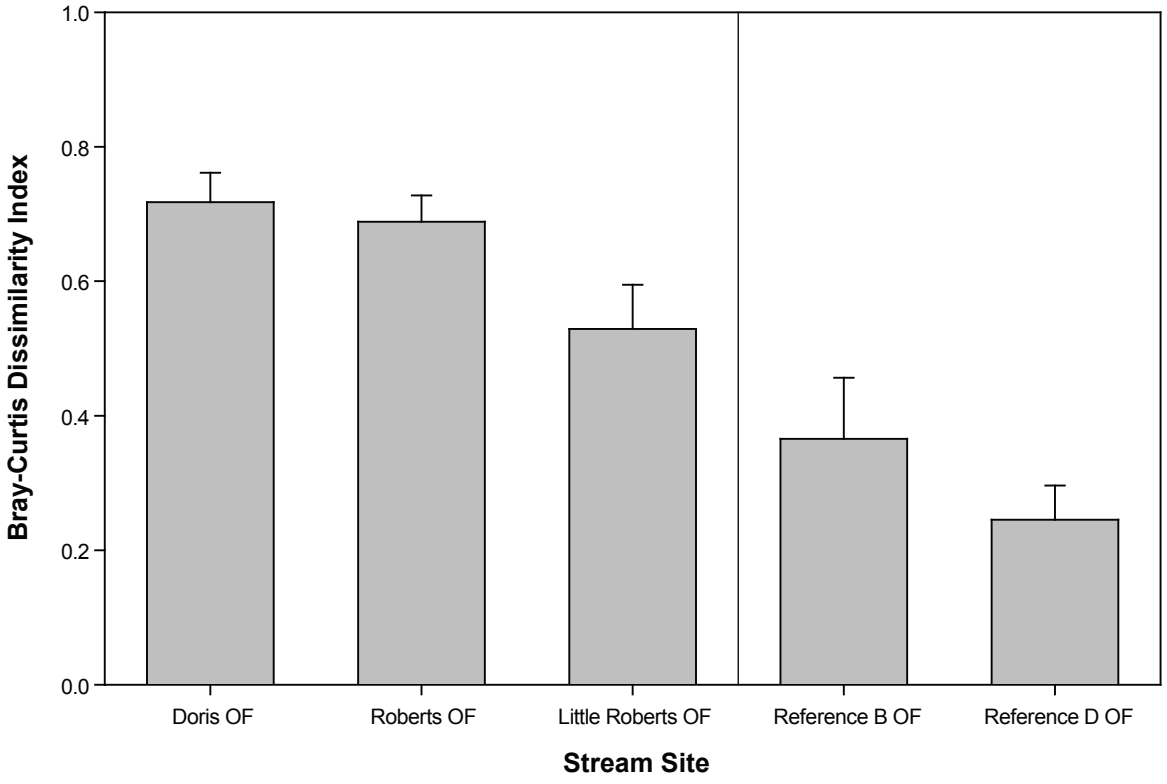

Note: Error bars represent the standard error of the mean

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Benthos Bray-Curtis Index in AEMP Streams, Doris North Project, August 2010

Figure A1.5-2

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A1.5.1.2 Diversity

Figure A1.5-3 presents the mean diversity indices for the AEMP stream benthos communities. Overall, the AEMP streams were similarly diverse systems. Mean family richness ranged between 11.6 in Little Roberts Outflow and 14.6 at Reference B Outflow and both reference streams had slightly higher benthos richness than the exposure streams. Diversity in the streams was high, with Simpson's index values ranging from 0.64 (Roberts Outflow) to 0.78 (Doris Outflow). There was little difference in diversity among the sites, since the higher richness found in the reference streams was balanced by lower evenness, while the converse was true in the exposure streams. The AEMP streams were generally more diverse systems than the AEMP lake and marine sites.

A1.5.2 Lakes

A1.5.2.1 Density and Community Composition

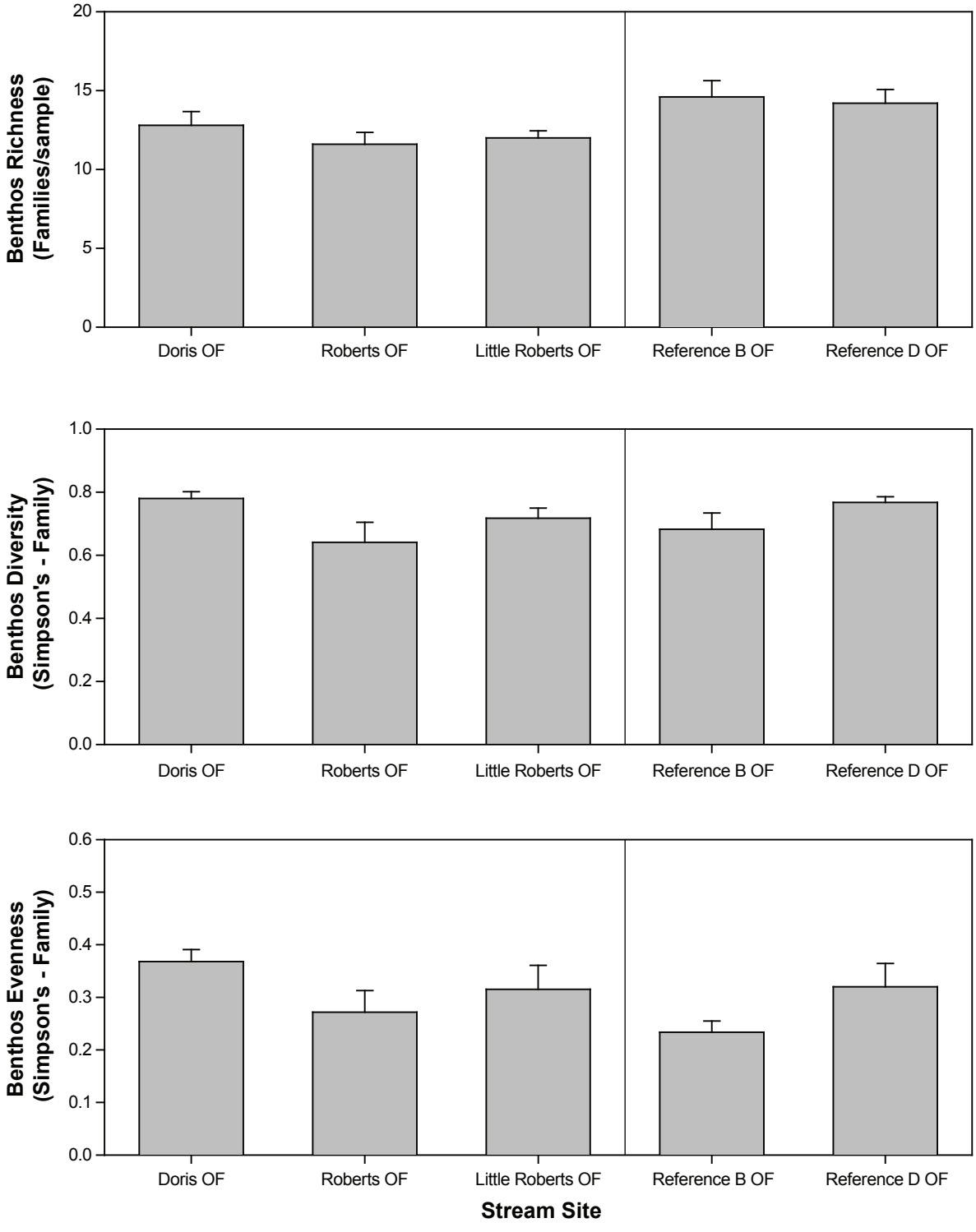
Mean benthos density varied more than 7-fold in the AEMP lakes, from just under 2,000 organisms/m^2 in Doris Lake South to nearly 14,000 organisms/m^2 in Little Roberts Lake (Figure A1.5-4). Densities were much higher in the smaller lakes (Little Roberts Lake and Reference Lake D) than the larger lakes, and densities within each lake class were relatively similar.

The benthos communities in the AEMP lakes were composed of a few main families (Figure A1.5-4). The non-biting midges (Chironomidae) were the most abundant, making up more than 40% of the benthos community in all the AEMP lakes, and accounting for 83% of the benthos in Little Roberts Lake (Figure A1.5-4). *Tanytarsus* sp. was the most common species in this lake. Ostracods were prominent in the relatively shallow Doris Lake South (42%), and made up approximately 10% of the benthos communities in the small, shallow lakes (Little Roberts Lake and Reference Lake D). Higher proportions of small fingernail clams (family: Sphaeriidae) were found in Reference Lake B (25%) and Reference Lake D (23%), and a sizeable proportion of the benthic community at Reference Lake B was also made up of Tubificidae (32%), a family of ciliate oligochaete worms that inhabit freshwater and marine benthic environments. The Tubificidae family was also abundant in Doris Lake North (19%; Figure A1.5-4).

Based on their Bray-Curtis dissimilarities, there were small differences in benthos community structure among the large lakes (Figure A1.5-5). The Doris Lake North and Reference Lake B benthos communities were most similar given the high proportions of chironomids and oligochaete worms (Tubificidae) at each site. Doris Lake South a higher proportion of ostracods; thus, its benthos community structure was more dissimilar to the two other large lakes. Due to the particularly high abundance of chironomids at Little Roberts Lake and sphaeriidian clams in Reference Lake D, these lakes had much different Bray-Curtis dissimilarity values (Figure A1.5-5), which is indicative of their different benthic invertebrate communities.

A1.5.2.2 Diversity

Benthos community diversity indices for the AEMP lakes are presented in Figure A1.5-6. Family benthos richness in all AEMP lakes was generally low, with slightly more families represented in the smaller lake sites (range: 5.6-6.8) than in the three larger lake sites (range: 3.8–4.8). There was no apparent pattern observed for diversity. In the larger lakes, mean benthos diversity was 0.33 at Doris Lake North, 0.55 at Doris Lake South, and 0.62 at Reference Lake B (Figure A1.5-6). Benthos diversity was also higher in Reference Lake D (0.54) than in Little Roberts Lake (0.29). The difference in benthos diversity among sites was mainly due to the more evenly distributed benthos communities at the high diversity sites.



Note: Error bars represent the standard error of the mean

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Benthos Diversity Indices in AEMP Streams, Doris North Project, August 2010

Figure A1.5-3

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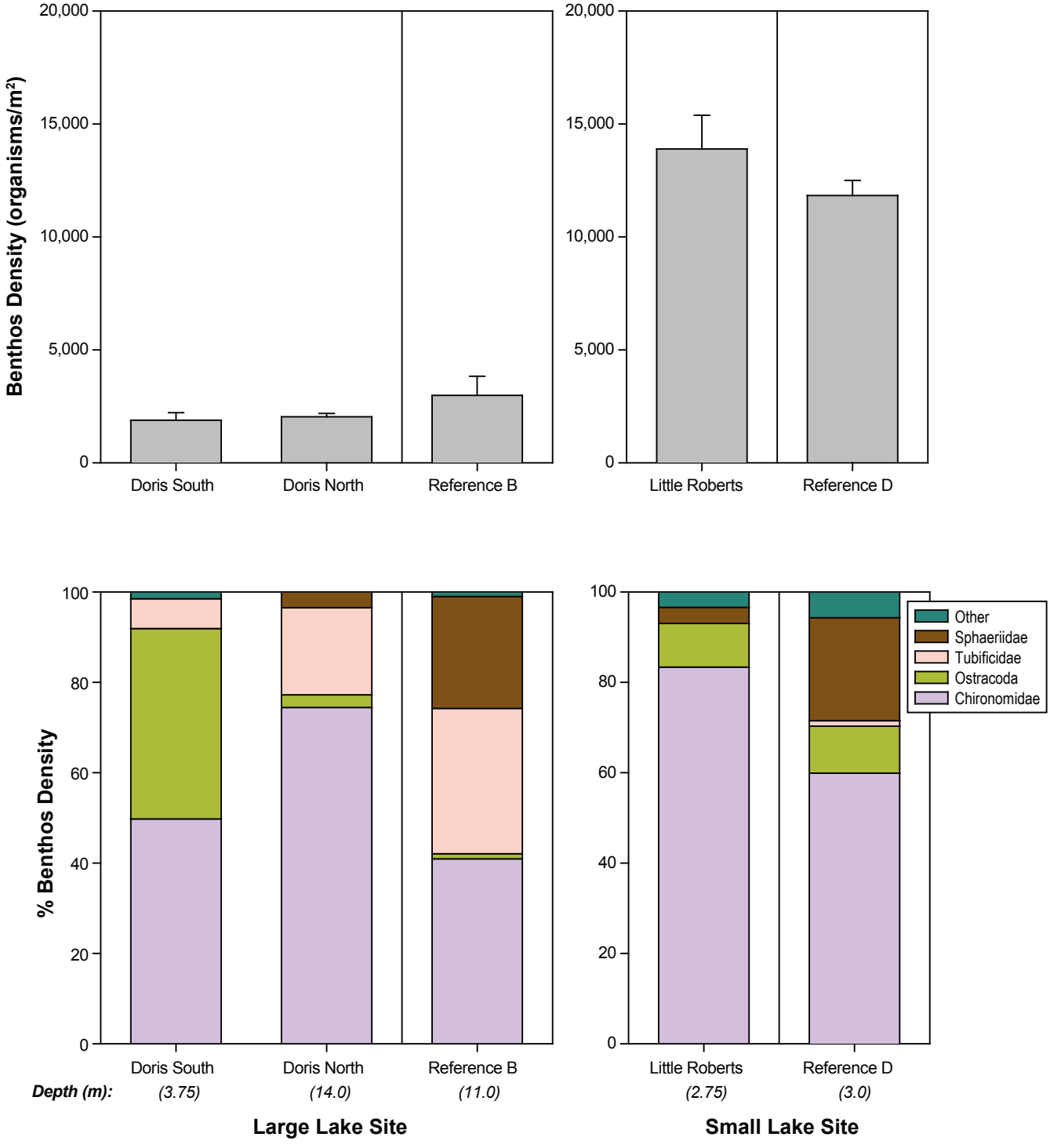
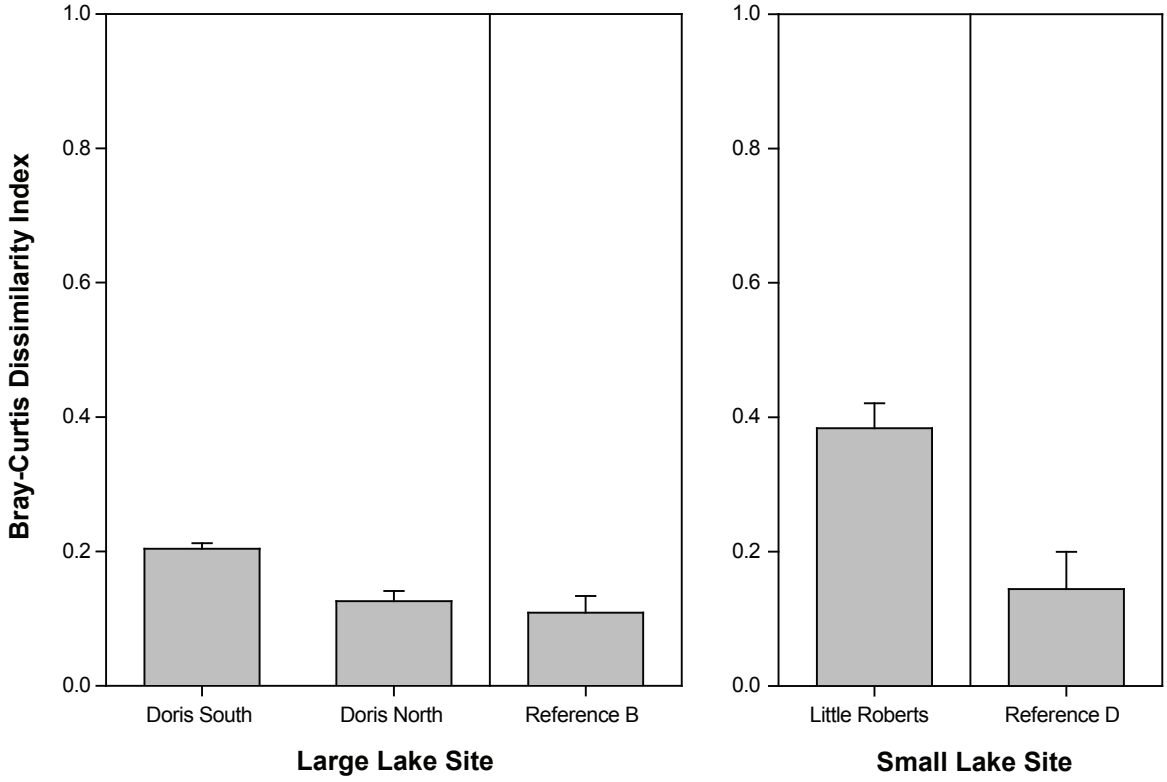


Note: Error bars represent the standard error of the mean

Benthos Density and Community Composition in AEMP Lakes, Doris North Project, August 2010

Figure A1.5-4



Note: Error bars represent the standard error of the mean

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Benthos Bray-Curtis Index in AEMP Lakes, Doris North Project, August 2010

Figure A1.5-5

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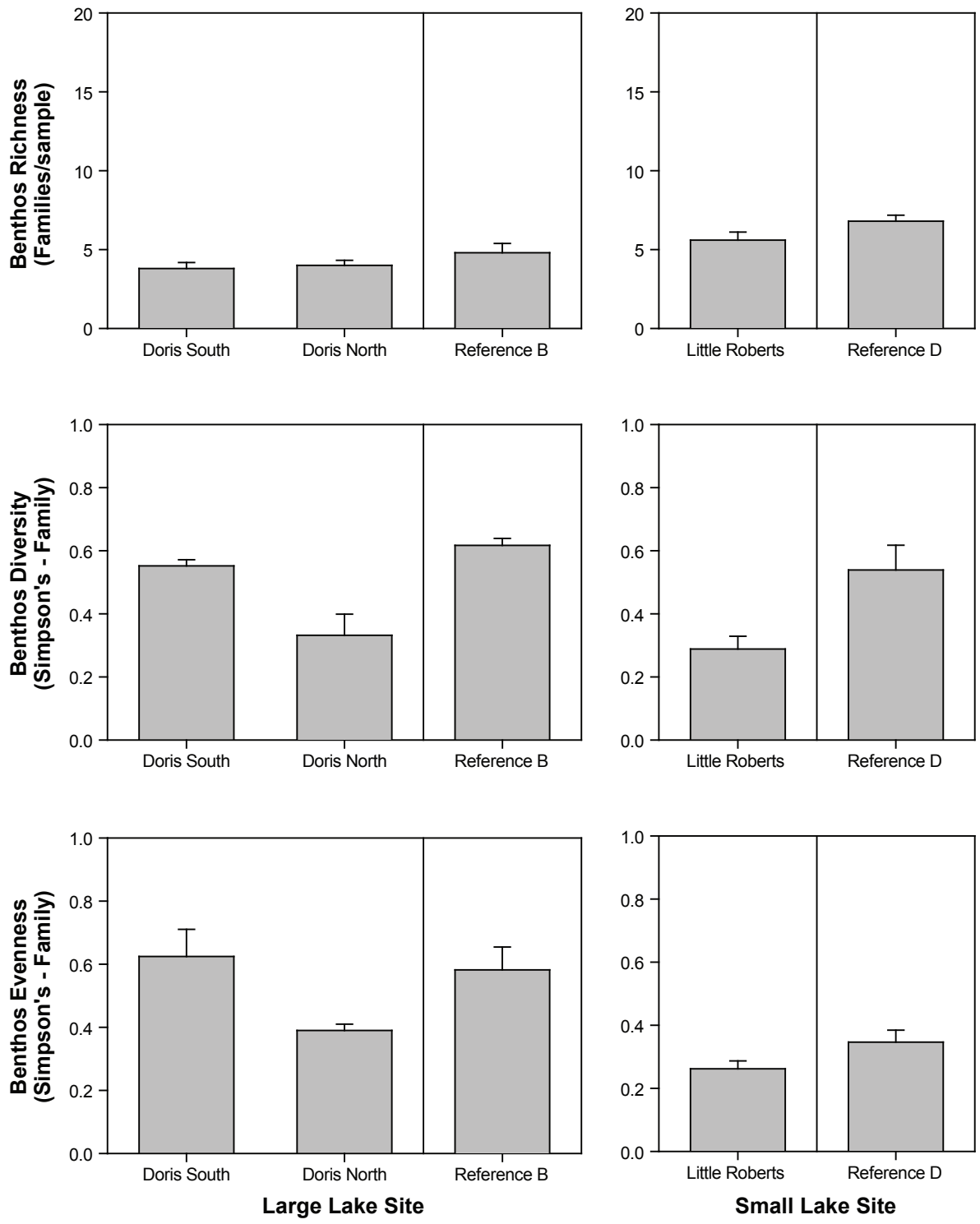

Note: Error bars represent the standard error of the mean

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Benthos Diversity Indices in AEMP Lakes, Doris North Project, August 2010

Figure A1.5-6

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A1.5.3 Marine

A1.5.3.1 Density and Community Composition

There was an approximately 30-fold range in the mean benthos densities among the marine sites, and different taxa were predominant at each site (Figure A1.5-7). The highest mean benthos density was found near the jetty in Roberts Bay (RBW; approximately 30,000 organisms/m^2), while the lowest was in the southeastern Roberts Bay (RBE; 959 organisms/m^2. The benthos community at RBW was dominated by polychaete worms from the family, Nephtyidae (80%), and was mainly composed of a single unidentified species within the genus *Nephtys*. This differed greatly from the sandy RBE site, which was populated by polychaetes from the family Spionidae (47%). This group was entirely represented by the brackish worm, *Marenzellaria arctica*.

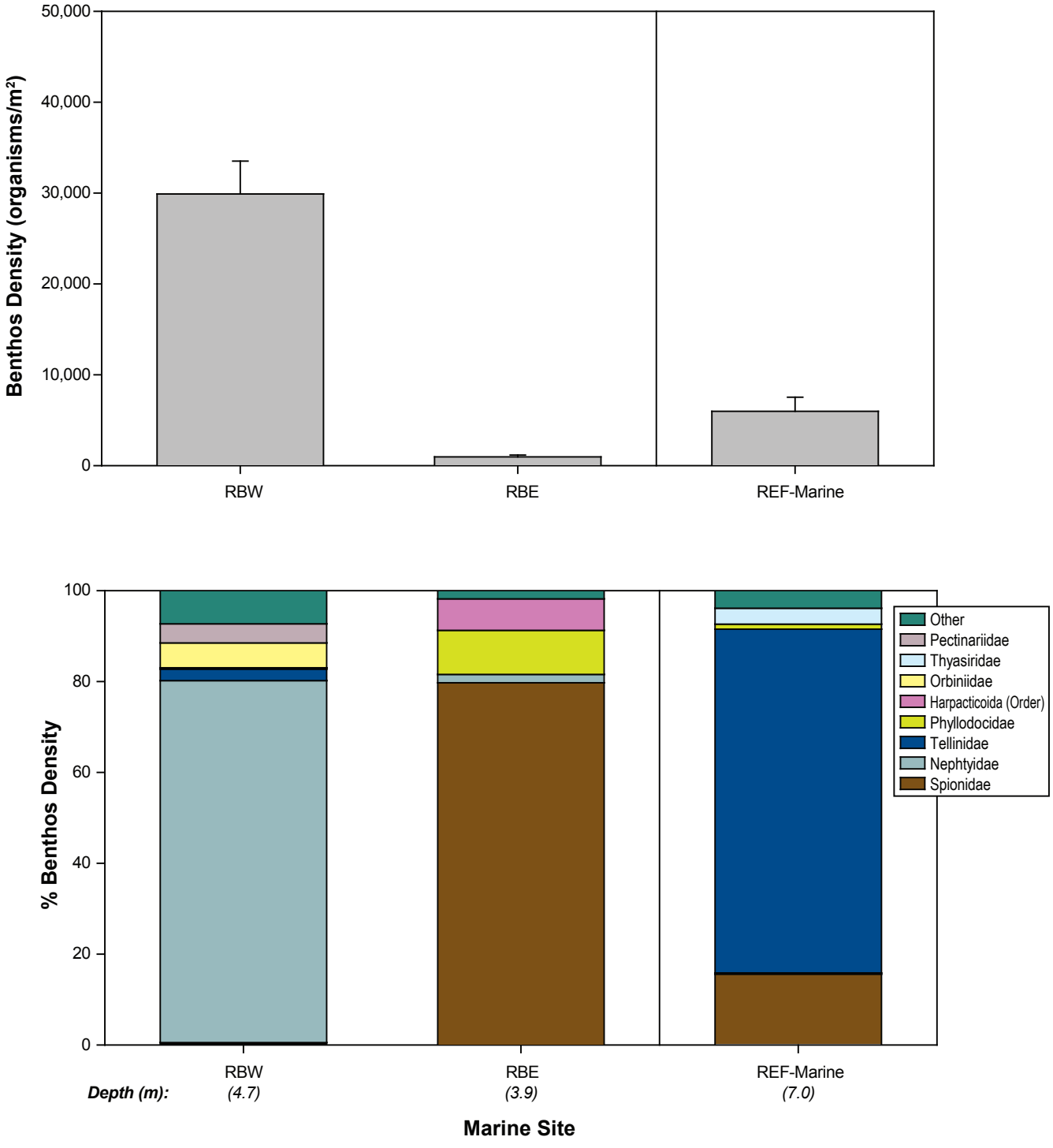
While the two Roberts Bay sites were dominated by polychaetes, the benthos community in Reference Bay was largely made up of *Macoma baltica*, a small bivalve from the family, Tellinidae (74%). Lower numbers of the Spionidae polychaete, *Marenzellaria arctica* (15%), were also found. The mean benthos density at REF-Marine was nearly 6,000 organisms/m^2, which was higher than the density at RBE, but much lower than the density at RBW. Because of the differences in community composition, RBE and RBW had very different Bray-Curtis dissimilarity values than the reference site, REF-Marine, with Bray-Curtis dissimilarities of 80 and 95% (Figure A1.5-8).

A1.5.3.2 Diversity

Figure A1.5-9 presents the mean diversity indices for the marine benthos communities. The benthos communities in Roberts and Reference bays consisted of between 1 (RBE) and 16 families (RBW) in any replicate sample, and average richness ranged between 2.6 (RBE) and 13.4 families (RBW). Overall, the marine benthos communities were not very diverse, with mean Simpson's index values below 0.4 at each site. The marine site with the highest richness had the lowest evenness (RBW), and conversely, the site with the lowest richness had the highest evenness (RBE). Consequently, there was little difference in Simpson's diversity among marine sites.

A1.5.4 Quality Control and Quality Assurance (QA/QC)

As part of the QC program, the re-sorting of benthic sample residues was conducted on 10% of the freshwater samples and 100% of the marine samples to determine the level of sorting efficiency (Appendix A2-9). The level of sorting efficiency obtained for the five randomly selected freshwater samples averaged 98.5%, and all samples were above 90%. All marine samples had sorting efficiencies of 100%. These sorting efficiencies were greater than 90%, as required by Environment Canada for invertebrate community surveys (Wrona, Culp, and Davies 1982; Glozier, Culp, and Halliwell 2002).



Note: Error bars represent the standard error of the mean

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Benthos Density and Community Composition in AEMP Marine Sites, Doris North Project, August 2010

Figure A1.5-7

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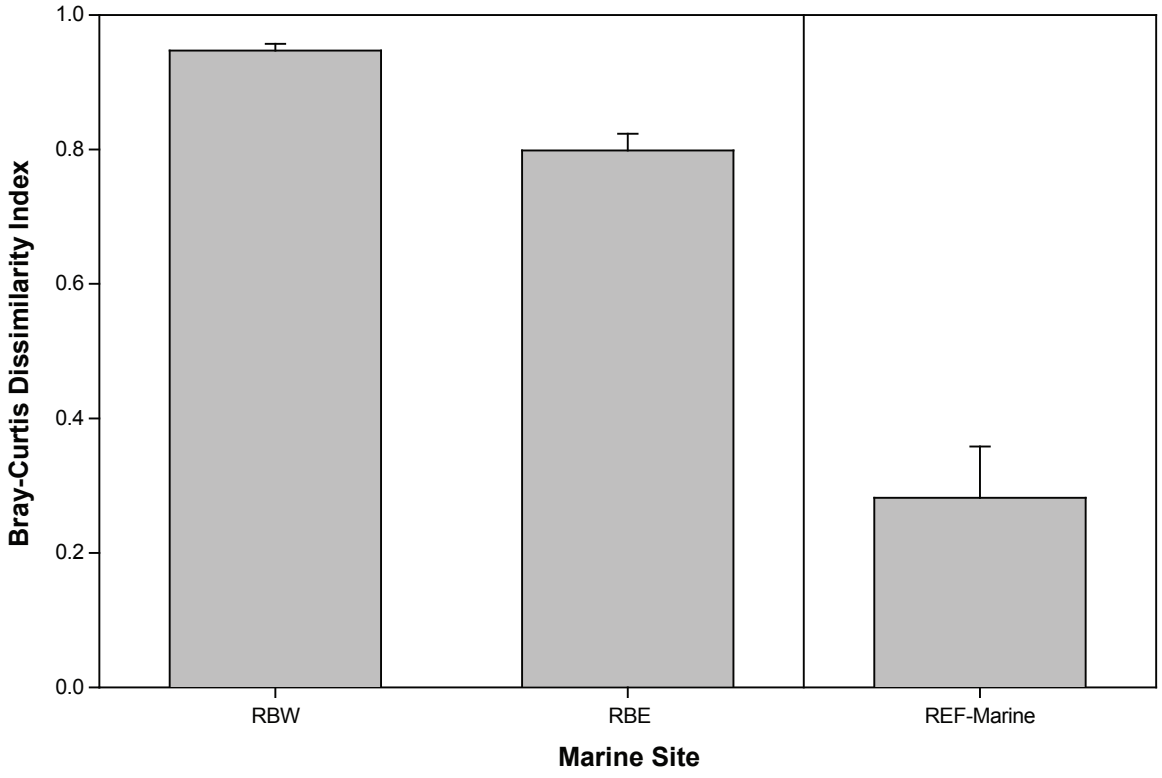

Note: Error bars represent the standard error of the mean

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Benthos Bray-Curtis Index in AEMP Marine Sites, Doris North Project, August 2010

Figure A1.5-8

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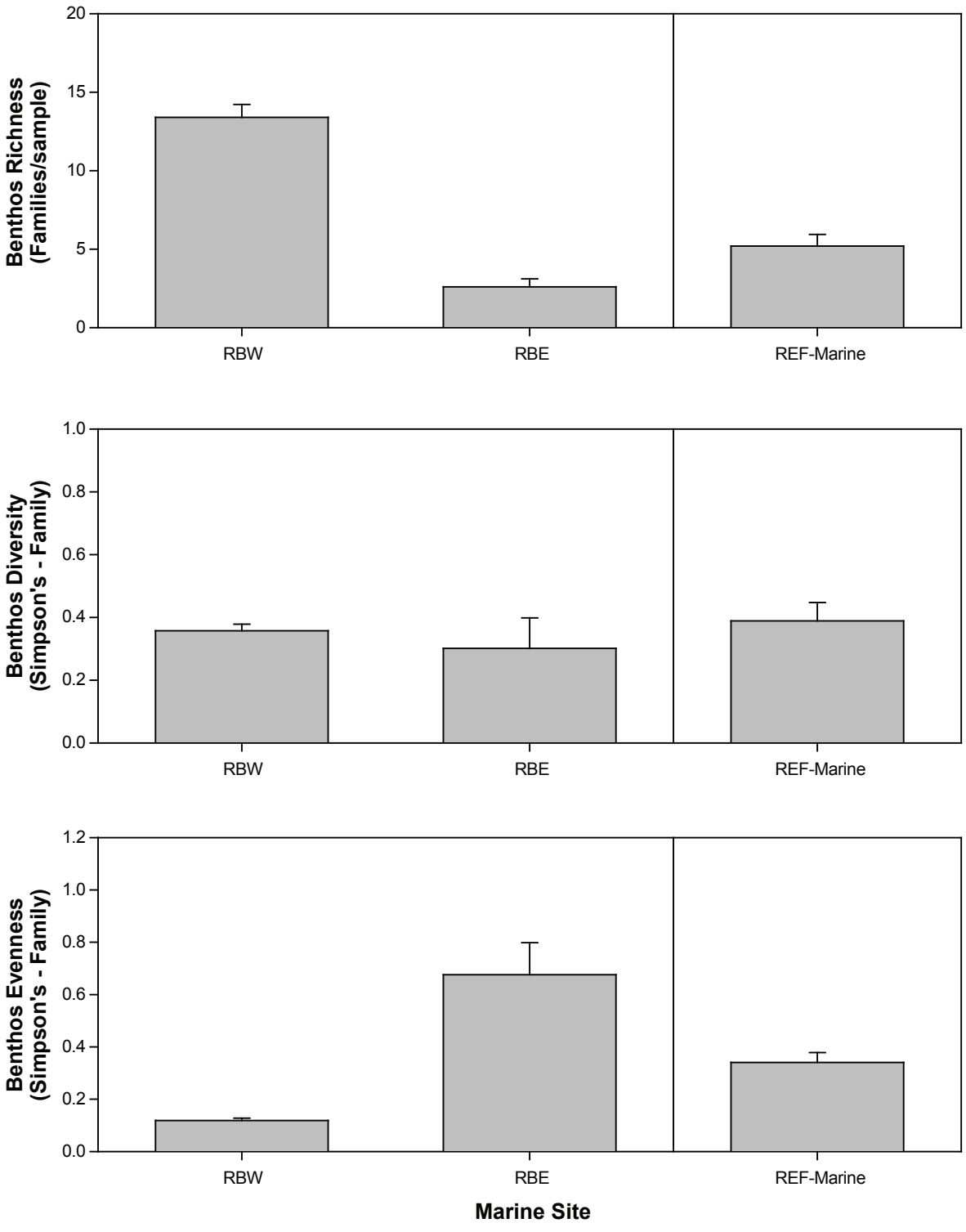

Note: Error bars represent the standard error of the mean

NEWMONT NORTH AMERICA

Benthos Diversity Indices in AEMP Marine Sites, Doris North Project, August 2010

Figure A1.5-9

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Appendix A2

2010 Aquatic Resources Raw Data, Doris North Project

Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Appendix A2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2010

Appendix A2-3. Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2010

Appendix A2-4. Water Quality Data for AEMP Aquatic Sites, Doris North Project, 2010

Appendix A2-5. QA/QC Blank Data for AEMP Water Quality Sampling, Doris North Project, 2010

Appendix A2-6. Sediment Quality Data for AEMP Aquatic Sites, Doris North Project, 2010

Appendix A2-7. Primary Production Data for AEMP Aquatic Sites, Doris North Project, 2010

Appendix A2-8. Benthos Taxonomy Data for AEMP Aquatic Sites, Doris North Project, 2010

Appendix A2-9. Results of Benthos QA/QC Sorting Efficiencies, Doris North Project, 2010

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Appendix A2-1

Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

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Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Doris South			
Date	22-Apr-10			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	2	1.1	10.09	91.3
	2.5	1.4	10.40	94.9

Doris South			
15-Jul-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	10.9	12.08	109.5
0.5	10.9	12.07	109.2
1	10.9	12.05	109.2
1.5	10.8	12.08	109.0
2	10.8	12.09	109.0
2.5	10.5	12.06	106.9
3	9.7	11.77	103.6
3.5	9.6	11.48	101.5
4	9.5	-	-

Doris South			
8-Aug-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	14.2	10.55	101.9
0.5	13.7	10.58	102.0
1	13.6	10.60	101.9
1.5	13.6	10.60	102.0
2	13.6	10.60	101.8
2.5	13.5	10.61	101.8
3	13.5	10.59	101.6

Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Doris South			
Date	12-Sep-10			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0	8.6	11.05	94.4
	0.5	8.6	11.01	94.4
	1	8.6	11.05	94.7
	1.5	8.6	11.05	94.9
	2	8.6	11.11	95.2
	2.5	8.6	11.22	96.2

Doris North			
22-Apr-10			
Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2	1.4	10.00	91.5
3	1.6	9.76	89.5
4	1.6	9.74	89.2
5	1.6	9.71	89.0
6	1.6	9.68	88.7
7	1.6	9.58	87.8
8	1.6	9.53	87.4
9	1.6	9.44	86.5
9.5	1.6	9.19	84.2
10	1.6	6.07	55.7
11	1.7	5.54	50.9
12	1.8	5.22	47.9
13	1.9	5.46	50.4

Doris North			
15-Jul-10			
Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	9.9	12.32	109.0
0.5	9.9	12.33	109.0
1	9.9	12.31	108.9
1.5	9.9	12.32	108.9
2	9.9	12.35	108.9
2.5	9.9	12.28	108.7
3	9.8	12.28	108.6
3.5	9.8	12.33	108.8
4	9.8	12.33	108.8
4.5	9.8	12.32	108.6
5	9.8	12.24	108.0
5.5	9.8	12.33	108.5
6	9.8	12.26	108.1
6.5	9.8	12.22	107.7
7	9.7	12.17	107.2
7.5	9.8	12.20	107.4
8	9.7	12.23	107.2
8.5	9.7	12.20	107.1
9	9.7	12.15	106.0
9.5	9.6	12.10	106.4
10	9.6	12.04	105.8
10.5	9.6	12.06	105.9
11	9.5	12.04	105.5
11.5	9.6	12.01	105.1
12	9.5	11.97	105.2
12.5	9.5	12.04	105.3
13	9.5	12.04	105.4

Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Doris North			
Date	9-Aug-10			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0	14.5	10.41	101.9
	0.5	14.1	10.49	101.9
	1	14.0	10.51	101.6
	1.5	13.7	10.54	101.6
	2	13.3	10.48	100.1
	2.5	13.3	10.42	99.6
	3	13.2	10.38	99.0
	3.5	13.1	10.16	96.6
	4	13.1	10.09	96.0
	4.5	13.0	9.97	94.6
	5	13.0	9.96	94.4
	5.5	13.0	9.94	94.3
	6	13.0	9.92	94.1
	6.5	13.0	9.90	93.9
	7	12.9	9.92	94.0
	7.5	12.9	9.88	93.6
	8	12.9	9.87	93.4
	8.5	12.9	9.76	92.3
	9	12.8	9.72	91.9
	9.5	12.8	9.65	91.2
	10	12.8	9.64	91.1
	10.5	12.8	9.64	91.1
	11	12.8	9.64	91.2
	11.5	12.8	9.62	90.8
	12	12.8	9.56	90.5
	12.5	12.8	9.50	89.7
	13	12.7	9.30	87.6
	13.5	12.7	9.21	86.6
	14	12.6	8.97	84.3

Doris North			
12-Sep-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	9.5	10.42	91.3
0.5	9.6	10.31	90.3
1	9.6	10.36	90.7
1.5	9.6	10.36	90.7
2	9.6	10.36	90.9
2.5	9.6	10.36	90.7
3	9.6	10.37	90.6
3.5	9.6	10.39	91.0
4	9.6	10.40	91.2
4.5	9.6	10.31	90.3
5	9.6	10.31	90.4
5.5	9.5	10.36	90.9
6	9.6	10.39	91.1
6.5	9.6	10.29	90.3
7	9.6	10.39	91.1
7.5	9.5	10.32	90.3
8	9.5	10.29	90.3
8.5	9.6	10.29	90.5
9	9.5	10.26	90.0
9.5	9.6	10.34	90.3
10	9.6	10.31	90.3
10.5	9.6	10.36	90.7
11	9.6	10.33	90.5
11.5	9.6	10.32	90.4
12	9.6	10.31	90.5
12.5	9.6	10.31	90.5

Little Roberts			
22-Apr-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2	1.3	10.02	91.1
2.5	1.4	10.19	92.9

Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Little Roberts			
Date	19-Jul-10			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0	10.5	11.71	104.9
	0.5	10.5	11.74	105.4
	1	10.5	11.66	105.1
	1.5	10.5	11.74	105.2
	2	10.4	11.77	105.2

Station	Little Roberts			
Date	10-Aug-10			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0	15.4	10.14	101.4
	0.5	15.2	10.20	101.5
	1	15.2	10.18	101.3
	1.5	15.2	10.24	101.5
	2	14.8	10.26	101.3

Station	Reference B			
Date	19-Apr-10			
	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	2	0.7	12.39	111.2
	2.5	1.0	11.64	105.2
	3	1.2	11.51	104.5
	3.5	1.5	11.17	102.3
	4	1.7	10.87	99.9
	4.5	2.0	9.29	86.0
	5	2.2	6.51	60.6
	5.5	2.3	3.98	37.3

Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Reference B			
Date	18-Jul-10			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0	10.7	10.77	97.0
	0.5	10.7	10.76	96.2
	1	10.7	10.74	96.8
	1.5	10.7	10.80	96.9
	2	10.7	10.77	96.5
	2.5	10.7	10.70	96.3
	3	10.7	10.72	96.5
	3.5	10.7	10.75	96.8
	4	10.7	10.79	96.9
	4.5	10.7	10.70	96.4
	5	10.6	10.78	97.0

Reference B			
24-Aug-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	12.5	9.11	99.7
0.5	12.5	9.08	99.6
1	12.5	9.10	99.8
1.5	12.5	9.09	99.7
2	12.5	9.09	99.7
2.5	12.5	9.11	99.9
3	12.5	9.10	99.8
3.5	12.5	9.08	99.7
4	12.4	9.10	99.7
4.5	12.4	9.09	99.6
5	12.4	9.11	99.6
5.5	12.4	9.11	99.7
6	12.4	9.10	99.6
6.5	12.4	9.08	99.3
7	12.4	9.08	99.4
7.5	12.3	9.08	99.3
8	12.2	9.05	98.9
8.5	12.1	8.92	97.2
9	11.8	8.94	96.6
9.5	11.7	8.95	96.5
10	11.7	8.94	96.5
10.5	11.7	8.94	96.4

Reference B			
17-Sep-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	6.1	11.47	92.5
0.5	6.1	11.41	92.1
1	6.1	11.42	91.9
1.5	6.1	11.43	92.1
2	6.1	11.44	92.2
2.5	6.1	11.42	91.9
3	6.1	11.43	92.2
3.5	6.1	11.45	92.1
4	6.1	11.45	92.3
4.5	6.1	11.50	92.5
5	6.1	11.49	92.5
5.5	6.1	11.39	92.0
6	6.1	11.45	92.2
6.5	6.1	11.32	91.5
7	6.1	11.40	91.8
7.5	6.1	11.36	91.5
8	6.1	11.35	91.4
8.5	6.1	11.31	91.3
9	6.1	11.34	91.3
9.5	6.1	11.35	91.2
10	6.1	11.19	90.6

Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Reference D			
Date	19-Apr-10			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	2	0.4	10.43	92.6
	2.5	1.4	11.42	104.2

Reference D			
19-Jul-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	10.5	10.98	98.4
0.5	10.5	10.90	97.5
1	10.4	10.88	97.6
1.5	10.4	10.92	98.0
2	10.4	10.94	97.6
2.5	10.4	10.99	98.1
3	10.4	10.97	98.0

Reference D			
11-Aug-10			
Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	16.6	9.98	102.4
0.5	16.6	9.94	101.9
1	16.6	9.93	101.9
1.5	16.6	9.92	101.7
2	16.6	9.87	101.3
2.5	16.6	9.87	101.2
3	16.5	9.85	101.0

Appendix A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Reference D			
Date	25-Sep-10			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0	2.1	13.59	98.9
	0.5	2.1	13.61	99.0
	1	2.1	13.60	99.2
	1.5	2.1	13.62	99.2
	2	2.1	13.61	99.2
	2.5	2.1	13.61	99.2
	3	2.1	13.63	99.4

Appendix A2-2

Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2010

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Appendix A2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	RBW		
Date	24-Apr-10		
Parameter	Depth (m)	Temperature (˚C)	Salinity
	0.31	-1.50	16.95
	0.64	-1.42	26.68
	1.21	-1.40	26.56
	1.67	-1.40	26.60
	1.73	-1.40	26.59
	1.75	-1.40	26.59
	1.76	-1.39	26.61
	1.77	-1.39	26.62
	1.78	-1.39	26.63
	1.78	-1.38	26.62
	1.83	-1.38	26.61
	1.97	-1.38	26.59
	2.12	-1.38	26.57
	2.27	-1.38	26.53
	2.42	-1.38	26.52
	2.58	-1.38	26.51
	2.77	-1.38	26.51
	2.94	-1.38	26.51
	3.17	-1.38	26.51
	3.42	-1.38	26.51
	3.72	-1.38	26.51
	3.89	-1.38	26.51
	4.09	-1.38	26.51
	4.29	-1.38	26.52
	4.50	-1.38	26.51
	4.54	-1.38	26.52

RBW		
20-Jul-10		
Depth (m)	Temperature (˚C)	Salinity
0.08	12.24	20.04
0.06	10.66	20.90
0.09	9.83	21.38
0.15	9.41	21.63
0.19	9.10	21.83
0.43	9.09	21.82
0.81	8.95	21.91
1.43	8.95	21.91
1.98	8.85	21.97
2.49	8.84	21.99
2.93	8.76	22.02
3.43	8.67	22.09
3.99	8.57	22.21
4.53	8.39	22.21
4.72	7.99	22.49

RBW		
15-Aug-10		
Depth (m)	Temperature (˚C)	Salinity
0.30	11.10	21.37
1.32	11.23	21.61
2.50	11.24	21.65
3.73	11.26	22.09

RBW		
30-Sep-10		
Depth (m)	Temperature (˚C)	Salinity
0.34	3.72	24.84
0.85	3.72	24.84
1.49	3.72	24.86
2.18	3.71	24.85
2.85	3.71	24.85
3.60	3.71	24.86
4.22	3.69	24.88
4.89	3.69	24.87

Appendix A2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	RBE		
Date	24-Apr-10		
Parameter	Depth (m)	Temperature (˚C)	Salinity
	1.17	-1.47	26.53
	1.58	-1.44	26.43
	1.85	-1.42	26.49
	1.92	-1.41	26.51
	1.90	-1.41	26.51
	1.91	-1.40	26.53
	1.91	-1.39	26.53
	1.90	-1.39	26.52
	1.93	-1.38	26.52
	2.11	-1.38	26.48
	2.33	-1.39	26.46
	2.50	-1.38	26.46
	2.65	-1.38	26.46
	2.80	-1.38	26.46
	2.97	-1.39	26.46
	3.11	-1.39	26.47
	3.25	-1.39	26.48
	3.36	-1.38	26.50
	3.37	-1.38	26.49

RBE		
20-Jul-10		
Depth (m)	Temperature (˚C)	Salinity
0.06	9.02	21.88
0.10	8.84	21.98
0.10	8.82	22.01
0.12	8.85	22.01
0.12	8.81	22.00
0.12	8.78	22.01
0.19	8.74	22.04
0.37	8.75	22.03
0.65	8.74	22.03
1.09	8.70	22.06
1.24	8.74	22.05
1.46	8.65	22.11
1.51	8.68	22.04
1.51	8.67	21.89

RBE		
15-Aug-10		
Depth (m)	Temperature (˚C)	Salinity
0.38	7.94	4.01
0.69	10.12	4.84
0.80	10.63	4.75
0.83	10.79	4.65
0.82	10.87	4.56
0.86	10.91	4.52
0.88	10.92	4.55
0.86	10.91	4.75
0.90	10.89	4.80

RBE		
30-Sep-10		
Depth (m)	Temperature (˚C)	Salinity
0.35	3.37	24.53
0.76	3.37	24.53
1.25	3.37	24.54
1.66	3.38	24.53
2.24	3.39	24.53
2.71	3.41	24.52
3.73	3.43	24.57
3.91	3.43	24.59

Appendix A2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	REF-Marine		
Date	13-Jul-10		
Parameter	Depth (m)	Temperature (˚C)	Salinity
	0.30	8.32	20.44
	1.08	8.33	20.41
	1.63	8.25	20.37
	2.26	7.86	20.58
	2.86	7.66	20.66
	3.23	7.48	20.77
	3.82	7.43	20.78
	4.15	7.35	20.81
	4.85	7.28	20.86
	6.12	7.27	21.10
	7.35	6.95	21.67
	8.44	6.63	22.57
	9.01	5.97	23.89
	10.09	4.63	24.86
	11.03	3.57	24.90
	12.06	2.47	25.46
	12.59	1.84	25.97
	13.37	1.53	26.07
	13.95	1.35	26.13
	14.88	1.06	26.31
	15.86	0.90	26.37
	16.43	0.75	26.43
	16.70	0.59	26.59

	REF-Marine		
	19-Aug-10		
	Depth (m)	Temperature (˚C)	Salinity
	0.08	7.39	17.79
	0.76	8.73	17.21
	1.47	9.12	17.08
	2.02	9.27	18.53
	2.59	9.79	22.15
	3.13	10.53	21.74
	3.41	10.73	21.66

	REF-Marine		
	29-Sep-10		
	Depth (m)	Temperature (˚C)	Salinity
	0.18	4.00	24.58
	0.87	4.00	24.58
	1.54	4.00	24.59
	2.22	4.00	24.59
	2.92	4.00	24.58
	3.47	4.00	24.58
	4.20	4.00	24.59
	4.86	4.00	24.59
	5.72	4.01	24.58
	6.27	4.02	24.61
	6.90	4.04	24.64
	7.48	4.05	24.67
	7.98	4.06	24.72
	8.74	4.07	24.73
	9.15	4.07	24.75
	9.59	4.08	24.75
	10.25	4.12	24.72
	10.87	4.20	24.92
	11.77	4.22	25.12
	12.42	4.22	25.16
	12.93	4.21	25.17
	13.57	4.20	25.16
	14.34	4.22	25.25
	14.99	4.21	25.34
	15.87	4.14	25.50
	16.54	3.98	25.68
	16.55	4.03	25.65
	16.57	3.76	25.85
	16.68	3.40	26.09
	16.69	4.04	25.60
	16.75	4.00	25.60
	16.88	3.17	26.08
	16.92	3.16	26.00
	17.29	3.68	25.56

Appendix A2-3

Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2010

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Appendix A2-3. Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	RBW		
Date	24-Apr-10		
Parameter	Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	2	9.95	83.9
	2.5	9.94	83.9
	3	9.93	83.8
	3.5	9.94	83.8
	4	9.94	83.8

RBW		
17-Aug-10		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	8.72	88.7
0.5	8.80	89.4
1	8.91	90.1
1.5	8.66	89.3

RBW		
30-Sep-10		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	12.50	95.6
0.5	12.49	95.4
1	12.47	95.4
1.5	12.49	95.4
2	12.48	95.4
2.5	12.48	95.3
3	12.49	95.4
3.5	12.48	95.3
4	12.48	95.3
4.5	12.48	95.2
5	12.47	95.3
5.5	12.51	95.7

RBE		
24-Apr-10		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2	10.17	85.8
2.5	10.14	85.5
3	10.13	85.4

RBE		
17-Aug-10		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	9.75	98.1
0.5	9.46	96.1
1	9.52	98.1
1.5	8.14	85.3
2	8.45	88.7
2.5	8.68	90.5
3	8.75	91.3
3.5	8.31	86.6
4	8.22	85.5
4.5	8.12	85.3

Appendix A2-3. Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	RBE		
Date	30-Sep-10		
Parameter	Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0	12.68	96.0
	0.5	12.69	96.0
	1	12.68	96.0
	1.5	12.68	95.9
	2	12.67	95.8
	2.5	12.67	95.7
	3	12.65	95.7
	3.5	12.65	95.7

REF-Marine		
13-Jul-10		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	10.91	106.7
1	10.91	106.8
2	11.05	106
3	11.07	106.2
4	11.13	106.6
5	11.08	106.1
6	11.16	106.9
7	11.4	108.1
8	11.65	109.3
9	12.77	113.8
10	12.95	113.4
11	13.07	109.1
12	12.94	106.1
13	12.67	103.5
14	12.53	101.5
15	12.19	98.5
16	12.18	98.5
17	12.03	96.5
18	11.89	95.6

REF-Marine		
21-Aug-10		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	9.63	100.2
1	9.62	99.7
2	9.63	99.9
3	9.81	100.3
4	10.00	100.3
5	10.09	99.7
6	10.33	100.8
7	10.33	101.6

REF-Marine		
28-Sep-10		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	12.40	96.7
0.5	12.56	96.1
1	12.52	96.1
1.5	12.54	94.1
2	12.40	95.6
2.5	12.41	95.1
3	12.38	95.0
3.5	12.38	95.1
4	12.40	95.6
4.5	12.46	95.1
5	12.40	95.0
5.5	12.40	95.0
6	12.43	94.8
6.5	12.47	94.8
7	12.47	94.9
7.5	12.36	94.5
8	12.33	94.5
8.5	12.31	94.6
9	12.38	94.4
9.5	12.25	94.4
10	12.24	93.8
10.5	12.29	94.4
11	12.25	94.3
11.5	12.29	94.1
12	12.24	94.2
12.5	12.25	93.5
13	12.20	93.5
13.5	12.24	93.8
14	12.19	93.7
14.5	12.19	93.4
15	12.10	93.2
15.5	12.10	93.1
16	12.10	93.1
16.5	12.11	93.1

Appendix A2-4

Water Quality Data for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A2-4a. Water Quality Data for AEMP Streams, Doris North Project, 2010

Site ID:				Little Roberts OF	Little Roberts OF	Doris OF	Doris OF	Reference D OF	Reference D OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF	Little Roberts OF	Little Roberts OF	Doris OF	Doris OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Reference B OF
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Replicate:				1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1
Date Sampled:		**CCME Guideline for the Protection of Aquatic**	**Realized**	17-Jun-10	17-Jun-10	17-Jun-10	17-Jun-10	18-Jun-10	18-Jun-10	18-Jun-10	18-Jun-10	19-Jun-10	19-Jun-10	20-Jul-10	20-Jul-10	20-Jul-10	20-Jul-10	18-Jul-10	18-Jul-10	20-Jul-10	20-Jul-10	08-Aug-10
ALS Sample ID:	**Units**	**Life[a]**	**Detection Limit**	L899505-1	L899505-2	L899505-3	L899505-4	L900033-1	L900033-2	L900033-4	L900033-5	L900033-6	L900033-7	L911821-6	L911821-7	L911821-8	L911821-9	L911821-19	L911821-20	L911821-21	L911821-18	L919821-8
Physical Tests																						
Conductivity	µS/cm		2.0	189	188	218	218	102	102	185	187	49.7	49.8	241	239	260	261	40.4	40.3	89.9	90.4	43.0
Hardness (as $CaCO_3$)	mg/L		0.50	33.4	33.2	38.9	39.9	20.0	20.1	30.1	30.1	15.1	15.1	42.8	42.4	48.7	48.3	12.2	12.1	18.0	17.7	13.8
pH	pH	6.5-9.0	0.10	7.58	7.55	7.60	7.59	7.38	7.36	7.47	7.51	7.25	7.32	7.74	7.70	7.77	7.78	7.34	7.31	7.39	7.39	7.04
Total Suspended Solids	mg/L	dependent on background levels	3.0	5.7	3.7	4.4	5.1	<3.0	<3.0	8.3	6.9	<3.0	<3.0	3.5	<3.0	4.8	<3.0	<3.0	<3.0	8.0	<3.0	<3.0
Total Dissolved Solids	mg/L		10																			
Turbidity	NTU	dependent on background levels	0.10	8.01	8.94	6.13	7.14	4.68	4.47	15.1	15.3	0.64	0.62	5.22	4.91	4.29	4.14	1.22	1.10	6.17	6.39	0.34
Anions and Nutrients																						
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	18.4	18.3	21.4	21.6	13.0	12.6	16.6	16.6	11.1	11.0	23.4	23.3	26.9	26.8	9.2	8.7	11.4	10.8	8.9
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	0.013	0.021	0.035	0.033	<0.005	<0.005	0.012	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0069
Bromide (Br)	mg/L		0.050	0.117	0.112	0.123	0.125	<0.050	0.058	0.126	0.111	<0.050	<0.050	0.114	0.126	0.129	0.127	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L		0.50	42.0	42.0	49.3	49.3	20.3	20.3	42.3	42.3	6.50	6.52	55.3	55.9	61.1	61.4	5.61	5.60	19.0	18.9	6.15
Fluoride (F)	mg/L		0.020	0.029	0.027	0.029	0.030	0.028	0.030	0.033	0.031	<0.020	<0.020	0.039	0.040	0.042	0.042	<0.020	<0.020	0.029	0.026	<0.020
Nitrate (as N)	mg/L	2.935[b]	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0054	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0070
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	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0263	0.0250	0.0287	0.0287	0.0104	0.0097	0.0295	0.0290	0.0062	0.0066	0.0186	0.0173	0.0229	0.0211	0.0042	0.0045	0.0092	0.0088	0.0045
Sulphate (SO_4)	mg/L		0.50	2.36	2.33	2.05	2.05	1.69	1.63	2.40	2.40	1.37	1.36	3.27	3.32	2.54	2.55	1.27	1.27	1.75	1.61	1.49
Cyanides																						
Total Cyanide	mg/L	0.005 (as free CN)	0.0010	0.0052	0.0051	0.0064	0.0057	0.0047	0.0046	0.0063	0.0063	0.0036	0.0037	0.0043	0.0047	0.0041	0.0044	0.0030	0.0028	0.0033	0.0032	0.0029
Organic Carbon																						
Total Organic Carbon	mg/L		0.50	5.25	5.39	6.14	6.28	4.57	4.67	5.30	5.44	3.32	3.18	4.98	5.19	5.51	5.32	2.56	2.48	3.19	3.47	3.50
Total Metals																						
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.405	0.458	0.380	0.384	0.220	0.202	0.717	0.584	0.0224	0.0226	0.301	0.164	0.0597	0.0650	0.0471	0.0413	0.359	0.352	0.0112
Antimony (Sb)	mg/L		0.000010	0.000016	0.000015	0.000014	0.000014	<0.000010	<0.000010	0.000014	0.000022	<0.000010	<0.000010	0.000015	0.000013	0.000026	0.000013	<0.000010	<0.000010	<0.000010	<0.000010	0.000026
Arsenic (As)	mg/L	0.005	0.000050	0.000266	0.000259	0.000244	0.000235	0.000129	0.000130	0.000297	0.000326	0.000088	0.000090	0.000259	0.000255	0.000232	0.000217	0.000077	0.000070	0.000123	0.000115	0.000080
Barium (Ba)	mg/L		0.00010	0.00595	0.00665	0.00682	0.00655	0.00410	0.00400	0.00848	0.00730	0.00228	0.00231	0.00543	0.00433	0.00345	0.00353	0.00187	0.00180	0.00501	0.00518	0.00134
Beryllium (Be)	mg/L		0.0000050	0.0000124	0.0000147	0.0000116	0.0000124	0.0000075	0.0000075	0.0000202	0.0000182	<0.0000050	<0.0000050	0.0000467	0.0000271	0.0000078	0.0000547	<0.0000050	0.0000143	0.0000127	0.0000103	<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	<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	0.0050	0.0234	0.0239	0.0247	0.0239	0.0181	0.0180	0.0264	0.0257	0.0117	0.0109	0.0282	0.0280	0.0288	0.0260	0.0101	0.0097	0.0150	0.0162	0.0103
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	5.32	5.28	6.72	6.86	3.28	3.20	4.12	4.16	3.66	3.66	7.24	7.12	8.85	8.78	2.97	2.95	2.76	2.70	3.08
Cesium (Cs)	mg/L		0.0000050	0.0000236	0.0000244	0.0000167	0.0000170	0.0000104	0.0000101	0.0000349	0.0000324	<0.0000050	<0.0000050	0.0000146	0.0000080	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000209	0.0000206	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	0.00092	0.00088	0.00075	0.00078	0.00060	0.00057	0.00125	0.00124	<0.00050	<0.00050	0.00064	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00079	0.00075	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000200	0.000197	0.000193	0.000194	0.000099	0.000096	0.000315	0.000274	<0.000050	<0.000050	0.000140	0.000074	0.000050	0.000056	<0.000050	<0.000050	0.000124	0.000114	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00163	0.00167	0.00164	0.00172	0.00140	0.00137	0.00176	0.00183	0.00094	0.00079	0.00353	0.00291	0.00187	0.00378	0.00090	0.00147	0.00121	0.00125	0.00083
Gallium (Ga)	mg/L		0.000050	0.000115	0.000129	0.000105	0.000100	0.000055	0.000056	0.000195	0.000170	<0.000050	<0.000050	0.000072	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000105	0.000109	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.556	0.555	0.449	0.454	0.265	0.259	0.812	0.770	0.062	0.058	0.398	0.187	0.118	0.119	0.086	0.073	0.320	0.322	0.037
Lead (Pb)	mg/L	≥0.001[f]	0.000050	0.000166	0.000182	0.000171	0.000174	0.000083	0.000083	0.000232	0.000225	<0.000050	<0.000050	0.000097	0.000065	<0.000050	<0.000050	<0.000050	<0.000050	0.000106	0.000129	<0.000050
Lithium (Li)	mg/L		0.00020	0.00249	0.00249	0.00317	0.00319	0.00150	0.00146	0.00256	0.00243	0.00050	0.00048	0.00335	0.00316	0.00368	0.00370	0.00045	0.00044	0.00162	0.00161	0.00052
Magnesium (Mg)	mg/L		0.10	4.89	4.86	5.36	5.54	3.06	2.94	4.80	4.78	1.40	1.41	6.00	5.98	6.46	6.40	1.16	1.15	2.70	2.66	1.19
Manganese (Mn)	mg/L		0.00020	0.0213	0.0216	0.0255	0.0275	0.0135	0.0121	0.0299	0.0300	0.00682	0.00658	0.0160	0.00972	0.0170	0.0181	0.00270	0.00218	0.00625	0.00587	0.00181
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000168	0.000158	0.000158	0.000152	0.000057	0.000057	0.000154	0.000154	<0.000050	<0.000050	0.000200	0.000186	0.000162	0.000162	<0.000050	<0.000050	0.000072	0.000069	<0.000050
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	0.00094	0.00095	0.00094	0.00101	0.00067	0.00065	0.00115	0.00106	0.00033	0.00024	0.00080	0.00071	0.00055	0.00060	0.00024	0.00024	0.00065	0.00065	<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	<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	2.2	2.3	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	2.0	2.3	2.2	<2.0	<2.0	<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	<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	0.00183	0.00189	0.00193	0.00194	0.00137	0.00136	0.00228	0.00211	0.000868	0.000860	0.00168	0.00146	0.00145	0.00146	0.000732	0.000714	0.00161	0.00162	0.000738
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	<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	1.84	1.97	1.93	1.98	0.743	0.745	2.41	2.01	0.176	0.172	1.62	1.27	1.16	1.15	0.201	0.179	0.912	0.977	0.106
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	0.0000053	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	23.1	22.8	25.3	26.0	11.3	11.0	22.2	22.3	3.5	3.6	28.4	28.3	30.6	30.2	3.1	3.0	10.4	10.3	3.3
Strontium (Sr)	mg/L		0.000050	0.0285	0.0285	0.0302	0.0320	0.0180	0.0175	0.0240	0.0270	0.0154	0.0169	0.0397	0.0368	0.0426	0.0407	0.0137	0.0132	0.0157	0.0161	0.0152
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	0.0000058	0.0000054	0.0000040	0.0000040	0.0000028	0.0000028	0.0000077	0.0000068	<0.0000020	<0.0000020	0.0000035	0.0000021	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000040	0.0000040	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.000184	0.000193	0.000165	0.000164	0.000116	0.000115	0.000296	0.000261	0.0000212	0.0000200	0.000113	0.0000716	0.0000313	0.0000319	0.0000293	0.0000242	0.000132	0.000130	0.0000129
Tin (Sn)	mg/L		0.00020	<0.00020	0.00025	0.00024	0.00024	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<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	0.0170	0.0187	0.0118	0.0120	0.00754	0.00772	0.0309	0.0248	0.00051	0.00061	0.00998	0.00500	0.00193	0.00189	0.00205	0.00155	0.0137	0.0132	<0.00020
Tungsten (W)	mg/L		0.000010	0.000011	0.000011	0.000021	0.000016	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000013	0.000012	0.000020	0.000021	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000565	0.0000572	0.0000489	0.0000508	0.0000538	0.0000524	0.0000745	0.0000720	0.0000405	0.0000400	0.0000494	0.0000428	0.0000336	0.0000341	0.0000421	0.0000395	0.0000619	0.0000598	0.0000352
Vanadium (V)	mg/L		0.000050	0.000820	0.000871	0.000676	0.000677	0.000402	0.000382	0.00147	0.00115	0.000066	0.000061	0.000543	0.000309	0.000155	0.000172	0.000125	0.000101	0.000651	0.000610	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.000138	0.000145	0.000119	0.000118	0.0000942	0.0000911	0.000196	0.000187	0.0000260	0.0000246	0.0000930	0.0000671	0.0000336	0.0000327	0.0000336	0.0000311	0.0000941	0.0000912	0.0000146
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0040	<0.0030	<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	0.000181	0.000202	0.000196	0.000202	0.000127	0.000125	0.000308	0.000243	<0.000050	<0.000050	0.000143	0.000097	0.000055	0.000059	<0.000050	<0.000050	0.000151	0.000158	<0.000050
Radiochemistry																						
Radium-226	Bq/L		0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.005	<0.005	0.007	<0.005	<0.005

Notes:

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

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

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) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(\text{hardness})]-3.2\}}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(\text{hardness})]-1.465\}}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ / 1000. Lead guideline is a minimum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

Appendix A2-4a. Water Quality Data for AEMP Streams, Doris North Project, 2010

Site ID:				Reference B OF	Doris OF	Doris OF	Little Roberts OF	Little Roberts OF	Roberts OF	Roberts OF	Reference D OF	Reference D OF	Little Roberts OF	Little Roberts OF	Roberts OF	Roberts OF	Doris OF	Doris OF	Reference D OF	Reference D OF	Reference B OF	Reference B OF
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Replicate:				2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Date Sampled:		**CCME Guideline for the Protection of Aquatic Life[a]**	**Realized Detection Limit**	08-Aug-10	08-Aug-10	08-Aug-10	12-Aug-10	12-Aug-10	13-Aug-10	13-Aug-10	13-Aug-10	13-Aug-10	15-Sep-10	15-Sep-10	15-Sep-10	15-Sep-10	15-Sep-10	15-Sep-10	15-Sep-10	15-Sep-10	16-Sep-10	16-Sep-10
ALS Sample ID:	**Units**			L919821-9	L919821-10	L919821-11	L921162-1	L921162-2	L921162-3	L921162-4	L921162-5	L921162-6	L932990-1	L932990-2	L932990-3	L932990-4	L932990-5	L932990-6	L932990-7	L932990-8	L933175-1	L933175-2
Physical Tests																						
Conductivity	µS/cm		2.0	43.3	267	267	263	261	236	237	103	101	261	261	250	3050	275	273	51.2	105	109	54.0
Hardness (as $CaCO_3$)	mg/L		0.50	14.0	49.6	48.8	48.3	48.5	40.0	39.4	20.3	20.2	49.7	51.0	43.6	42.4	56.2	56.6	15.7	19.6	20.8	16.5
pH	pH	6.5-9.0	0.10	7.09	7.59	7.59	7.62	7.61	7.57	7.59	7.47	6.99	7.51	7.60	7.55	7.92	7.72	7.69	7.31	7.30	7.16	7.18
Total Suspended Solids	mg/L	dependent on background levels	3.0	<3.0	19.6	20.3	3.3	3.3	4.0	<3.0	<3.0	<3.0	4.3	3.6	8.9	5.6	5.6	7.6	<3.0	<3.0	<3.0	3.1
Total Dissolved Solids	mg/L		10																		66	31
Turbidity	NTU	dependent on background levels	0.10	0.33	12.1	10.9	4.13	4.26	2.47	2.42	2.41	2.42	6.00	5.82	8.25	6.53	7.23	6.82	0.51	1.29	0.62	0.63
Anions and Nutrients																						
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	9.5	27.5	27.6	26.2	26.4	20.9	22.1	11.9	11.8	26.3	26.3	22.3	22.6	29.0	29.0	12.5	12.7	12.5	11.8
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0058	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0112	0.0121	0.0096	0.0083	0.0101	<0.0050	<0.0050	0.0111	0.0242	0.0537	<0.0050	0.0073
Bromide (Br)	mg/L		0.050	<0.050	0.122	0.125	0.122	0.138	0.137	0.135	<0.050	<0.050	0.209	0.218	0.223	0.214	0.207	0.205	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L		0.50	6.10	62.0	62.0	60.4	60.2	55.3	55.4	21.1	21.1	63.0	63.0	60.7	60.7	66.4	66.3	7.24	23.0	23.0	7.21
Fluoride (F)	mg/L		0.020	<0.020	0.049	0.049	0.045	0.044	0.040	0.040	0.032	0.031	0.043	0.041	0.038	0.037	0.043	0.043	<0.020	0.031	0.030	<0.020
Nitrate (as N)	mg/L	2.935[b]	0.0050	0.0065	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0071	<0.0050	<0.0050	0.0196
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	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0047	0.0365	0.0356	0.0228	0.0202	0.0190	0.0196	0.0083	0.0073	0.0234	0.0235	0.0310	0.0208	0.0297	0.0303	0.0038	0.0072	0.0066	0.0049
Sulphate (SO_4)	mg/L		0.50	1.47	2.68	2.68	3.93	3.78	4.13	4.15	1.86	1.86	4.35	4.42	4.65	4.71	3.34	3.34	2.01	2.13	2.13	1.98
Cyanides																						
Total Cyanide	mg/L	0.005 (as free CN)	0.0010	0.0030	0.0052	0.0044	0.0049	0.0049	0.0038	0.0038	0.0037	0.0030	0.0018	0.0035	<0.0010	0.0029	0.0017	0.0021	<0.0010	0.0031	0.0020	0.0012
Organic Carbon																						
Total Organic Carbon	mg/L		0.50	3.41	6.37	6.47	6.33	6.57	5.39	5.36	4.66	4.65	5.31	5.25	4.85	4.78	5.49	5.24	3.32	3.98	3.93	3.27
Total Metals																						
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0110	0.633	0.478	0.112	0.0944	0.0734	0.0802	0.137	0.138	0.113	0.111	0.235	0.186	0.0522	0.0444	0.0163	0.0749	0.0677	0.0141
Antimony (Sb)	mg/L		0.000010	<0.000010	0.000016	0.000015	0.000017	0.000016	0.000017	0.000016	0.000013	0.000013	0.000015	0.000016	0.000015	0.000015	0.000014	0.000015	<0.000010	0.000011	<0.000010	0.000011
Arsenic (As)	mg/L	0.005	0.000050	0.000080	0.000303	0.000324	0.000314	0.000289	0.000275	0.000302	0.000162	0.000139	0.000272	0.000290	0.000341	0.000358	0.000312	0.000278	0.000083	0.000134	0.000133	0.000082
Barium (Ba)	mg/L		0.00010	0.00135	0.00810	0.00718	0.00390	0.00369	0.00304	0.00309	0.00289	0.00292	0.00392	0.00391	0.00523	0.00442	0.00361	0.00360	0.00173	0.00239	0.00223	0.00172
Beryllium (Be)	mg/L		0.0000050	<0.0000050	0.0000175	0.0000142	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000078	0.0000056	<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	<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	0.0050	0.0100	0.0258	0.0265	0.0251	0.0246	0.0255	0.0257	0.0135	0.0144	0.0293	0.0289	0.0293	0.0292	0.0278	0.0300	0.0123	0.0172	0.0161	0.0097
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	3.15	8.94	8.82	8.18	8.18	5.83	5.75	3.11	3.09	8.18	8.41	6.24	6.11	10.5	10.6	4.16	3.33	3.11	4.02
Cesium (Cs)	mg/L		0.0000050	<0.0000050	0.0000348	0.0000293	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000056	0.0000058	0.0000061	0.0000058	0.0000132	0.0000080	<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	0.00140	0.00116	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00056	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	0.000329	0.000284	0.000076	0.000063	<0.000050	<0.000050	0.000055	0.000056	0.000065	0.000066	0.000116	0.000069	0.000066	0.000057	<0.000050	0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00088	0.00228	0.00228	0.00160	0.00156	0.00163	0.00152	0.00118	0.00127	0.00154	0.00165	0.00177	0.00157	0.00175	0.00174	0.00110	0.00114	0.00115	0.00103
Gallium (Ga)	mg/L		0.000050	<0.000050	0.000203	0.000160	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000066	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.041	0.830	0.685	0.216	0.205	0.091	0.093	0.163	0.166	0.219	0.210	0.498	0.195	0.131	0.126	0.058	0.131	0.121	0.062
Lead (Pb)	mg/L	≥0.001[f]	0.000050	<0.000050	0.000205	0.000210	<0.000050	<0.000050	<0.000050	<0.000050	0.000051	0.000075	<0.000050	<0.000050	0.000111	0.000068	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00048	0.00421	0.00424	0.00353	0.00357	0.00269	0.00271	0.00158	0.00159	0.00349	0.00349	0.00291	0.00278	0.00386	0.00395	0.00054	0.00152	0.00145	0.00052
Magnesium (Mg)	mg/L		0.10	1.22	6.63	6.52	6.77	6.82	6.18	6.08	3.04	3.02	7.11	7.30	6.81	6.60	7.29	7.32	1.54	3.25	3.09	1.49
Manganese (Mn)	mg/L		0.00020	0.00184	0.0463	0.0451	0.0192	0.0193	0.00564	0.00598	0.00916	0.00900	0.0101	0.00994	0.00950	0.00767	0.0256	0.0248	0.00149	0.00545	0.00499	0.00158
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	<0.000050	0.000183	0.000161	0.000203	0.000201	0.000195	0.000206	0.000080	0.000081	0.000208	0.000211	0.000200	0.000201	0.000200	0.000214	0.000085	0.000077	0.000077	0.000080
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	<0.00020	0.00120	0.00102	0.00070	0.00062	0.00052	0.00054	0.00045	0.00047	0.00060	0.00061	0.00069	0.00064	0.00059	0.00051	<0.00020	0.00042	0.00042	0.00021
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<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	2.3	2.3	2.4	2.4	2.2	2.2	<2.0	<2.0	2.3	2.4	2.2	2.1	2.4	2.4	<2.0	<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	<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	0.000735	0.00245	0.00224	0.00149	0.00149	0.00135	0.00136	0.00123	0.00124	0.00160	0.00160	0.00180	0.00156	0.00155	0.00155	0.000850	0.00114	0.00109	0.000811
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	<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	0.117	2.20	1.83	1.32	1.21	0.626	0.632	0.465	0.468	1.35	1.37	1.25	1.18	1.36	1.36	0.251	0.450	0.391	0.236
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	3.4	30.5	30.2	32.5	32.7	31.4	31.0	12.4	12.3	34.2	35.1	34.3	33.1	33.4	33.7	4.1	13.0	13.1	4.1
Strontium (Sr)	mg/L		0.000050	0.0150	0.0429	0.0439	0.0401	0.0452	0.0373	0.0364	0.0187	0.0186	0.0471	0.0475	0.0396	0.0376	0.0496	0.0519	0.0184	0.0198	0.0196	0.0181
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	0.0000068	0.0000059	0.0000022	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000028	0.0000024	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000023	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000119	0.000216	0.000168	0.0000516	0.0000460	0.0000376	0.0000396	0.0000554	0.0000537	0.0000547	0.0000498	0.0000978	0.0000662	0.0000231	0.0000201	0.0000171	0.0000424	0.0000395	0.0000164
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<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	0.0283	0.0225	0.00238	0.00223	0.00199	0.00217	0.00327	0.00349	0.00294	0.00295	0.00764	0.00457	0.00132	0.00124	0.00036	0.00149	0.00125	0.00033
Tungsten (W)	mg/L		0.000010	<0.000010	0.000027	0.000022	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000016	0.000021	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000359	0.0000587	0.0000529	0.0000434	0.0000413	0.0000477	0.0000480	0.0000582	0.0000570	0.0000473	0.0000460	0.0000644	0.0000557	0.0000387	0.0000388	0.000110	0.000109	0.000107	0.0000998
Vanadium (V)	mg/L		0.000050	<0.000050	0.00140	0.00116	0.000252	0.000207	0.000164	0.000169	0.000239	0.000234	0.000213	0.000218	0.000467	0.000281	0.000148	0.000141	<0.000050	0.000125	0.000112	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000149	0.000169	0.000158	0.0000479	0.0000476	0.0000412	0.0000422	0.0000484	0.0000496	0.0000572	0.0000549	0.000109	0.0000647	0.0000293	0.0000294	0.0000293	0.0000448	0.0000437	0.0000268
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<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	0.000171	0.000153	0.000080	0.000091	0.000060	0.000064	0.000073	0.000077	0.000087	0.000083	0.000127	0.000095	<0.000050	<0.000050	0.000053	0.000071	0.000068	<0.000050
Radiochemistry																						
Radium-226	Bq/L		0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

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

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

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) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(\text{hardness})]-3.2\}}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(\text{hardness})]-1.465\}}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ / 1000. Lead guideline is a minimum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

Appendix A2-4b. Water Quality Data for AEMP Lakes, Doris North Project, 2010

Site ID:				Reference B	Reference B	Reference D	Reference D	Little Roberts	Little Roberts	Doris North	Doris North	Doris South	Doris South	Doris North	Doris North	Doris South	Doris South	Little Roberts	Reference D	Reference D	Reference B	Reference B
Depth Zone:				Surface	Mid	Surface	Surface	Surface	Surface	Surface	Deep	Surface	Surface	Surface	Deep	Surface	Mid	Surface	Surface	Surface	Surface	Mid
Depth (m):				1	4.3	1	1	1	1	1	11.5	1	1	1	12	1	3	1	1	1	1	3.5
Replicate:				1	1	1	2	1	2	1	1	1	2	1	1	1	1	1	1	2	1	1
Date Sampled:		**CCME Guideline for the Protection of**	**Realized Detection**	18-Apr-10	18-Apr-10	18-Apr-10	18-Apr-10	22-Apr-10	22-Apr-10	22-Apr-10	22-Apr-10	22-Apr-10	22-Apr-10	22-Apr-10	15-Jul-10	15-Jul-10	15-Jul-10	20-Jul-10	20-Jul-10	20-Jul-10	20-Jul-10	20-Jul-10
ALS Sample ID:	**Units**	**Aquatic Life[a]**	**Limit**	L879365-1	L879365-2	L879365-3	L879365-4	L880317-1	L880317-2	L880317-3	L880317-4	L880317-5	L880317-6	L909785-1	L909785-2	L909785-3	L909785-4	L911821-10	L911821-11	L911821-12	L911821-13	L911821-17
Physical Tests																						
Conductivity	µS/cm		2.0	65.0	62.3	153	155	570	574	317	319	339	339	268	270	269	268	239	86.4	86.4	40.6	40.8
Hardness (as $CaCO_3$)	mg/L		0.5 or 1.0	18.9	17.9	30.8	29.9	95.9	94.9	56.4	56.7	60.6	60.7	47.9	47.1	47.7	47.3	42.7	17.6	17.5	12.0	12.1
pH	pH	6.5-9.0	0.10	7.34	7.32	7.31	7.35	7.69	7.66	7.72	7.59	7.73	7.74	7.91	7.85	7.85	7.81	7.73	7.40	7.41	7.34	7.32
Total Suspended Solids	mg/L	dependent on background levels	3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.5	4.1	4.1	5.5	<3.0	<3.0	<3.0	<3.0	<3.0
Total Dissolved Solids	mg/L		10	38	41	94	85															
Turbidity	NTU	dependent on background levels	0.10	0.18	0.22	1.91	1.96	1.77	2.01	3.50	1.87	2.98	2.46	4.37	4.86	4.94	4.56	4.21	5.51	5.58	0.43	0.36
Anions and Nutrients																						
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	14.1	13.4	19.9	20.3	54.6	54.7	33.3	33.5	35.9	35.9	26.3	26.7	26.7	26.7	24.2	10.1	10.6	8.8	9.4
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0249	0.0255	<0.0050	<0.0050	0.0129	0.0172	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.005	<0.005	<0.005
Bromide (Br)	mg/L		0.050	<0.050	<0.050	0.069	0.071	0.296	0.298	0.149	0.150	0.158	0.157	0.120	0.123	0.120	0.122	0.129	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L		0.50	9.28	8.86	32.4	32.4	140	141	75.0	76.0	80.6	80.4	62.0	62.5	62.1	62.1	55.6	18.1	18.1	5.88	5.85
Fluoride (F)	mg/L		0.020	<0.020	<0.020	0.042	0.040	0.085	0.083	0.054	0.054	0.057	0.057	0.050	0.050	0.050	0.050	0.039	0.026	0.025	<0.020	<0.020
Nitrate (as N)	mg/L	2.935[u]	0.0050	0.0093	0.0124	0.0435	0.0471	<0.0050	<0.0050	<0.0050	0.107	<0.0050	<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	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[v]	0.0020	0.0043	0.0051	0.0086	0.0101	0.0214	0.0262	0.0228	0.0171	0.0122	0.0156	0.0263	0.0235	0.0228	0.0225	0.0174	0.0081	0.0076	0.0053	0.0044
Sulphate (SO_4)	mg/L		0.50	2.23	2.15	2.71	2.71	7.76	7.79	3.13	3.11	3.36	3.36	2.64	2.69	2.64	2.64	3.37	1.55	1.55	1.36	1.35
Cyanides																						
Total Cyanide	mg/L	0.005 (as free CN)	0.0010	0.0021	0.0022	0.0042	0.0042	0.0074	0.0076	0.0047	0.0044	0.0048	0.0048	0.0044	0.0041	0.0041	0.0043	0.0046	0.0032	0.0033	0.0023	0.0024
Organic Carbon																						
Total Organic Carbon	mg/L		0.20 or 0.50	2.76	2.77	5.02	5.01	8.29	8.46	5.79	5.58	6.02	6.09	5.92	5.62	6.01	5.85	5.04	3.35	3.26	3.42	2.50
Total Metals																						
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0057	0.0056	0.0819	0.0821	0.0248	0.0254	0.0055	0.0105	0.0363	0.0320	0.0588	0.0588	0.0810	0.0866	0.164	0.291	0.315	0.0113	0.0095
Antimony (Sb)	mg/L		0.000010	<0.000010	<0.000010	0.000013	0.000025	0.000036	0.000044	0.000016	0.000015	0.000022	0.000027	0.000019	0.000019	0.000017	0.000018	0.000014	<0.000010	<0.000010	<0.000010	<0.000010
Arsenic (As)	mg/L	0.005	0.000050	0.000101	0.000100	0.000175	0.000166	0.000411	0.000460	0.000266	0.000236	0.000307	0.000267	0.000233	0.000250	0.000248	0.000237	0.000260	0.000128	0.000126	0.000067	0.000062
Barium (Ba)	mg/L		0.00010	0.00241	0.00240	0.00373	0.00387	0.00727	0.00726	0.00296	0.00312	0.00313	0.00315	0.00330	0.00327	0.00354	0.00360	0.00424	0.00459	0.00459	0.00164	0.00157
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	0.0000176	0.0000118	0.0000060	0.0000084	0.0000140	<0.0000050	0.0000167	0.0000104	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000825	0.0000099	0.0000103	<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	<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	0.0050	0.0108	0.0110	0.0187	0.0194	0.0444	0.0447	0.0271	0.0270	0.0272	0.0280	0.0314	0.0306	0.0296	0.0322	0.0243	0.0161	0.0149	0.0099	0.0103
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050	0.0000095	0.0000122	<0.0000050	<0.0000050	<0.0000050	<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	4.47	4.17	4.69	4.64	14.5	14.3	9.51	9.56	10.2	10.2	8.30	8.20	8.27	8.26	7.18	2.75	2.71	2.89	2.90
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	0.0000050	0.0000053	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000078	0.0000172	0.0000176	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001 ; Cr(III): 0.0089[o]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00074	0.00072	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	0.000051	0.000063	0.000073	0.000069	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000052	0.000057	0.000080	0.000103	0.000104	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00097	0.00102	0.00275	0.00253	0.00292	0.00301	0.00285	0.00165	0.00272	0.00256	0.00172	0.00149	0.00151	0.00163	0.00592	0.00120	0.00123	0.00070	0.00069
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000091	0.000093	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	<0.030	<0.030	0.165	0.164	0.542	0.537	<0.030	<0.030	0.072	0.037	0.129	0.125	0.141	0.141	0.186	0.274	0.264	<0.030	<0.030
Lead (Pb)	mg/L	≥0.001[f]	0.000050	<0.000050	<0.000050	0.000052	0.000096	0.000088	0.000118	<0.000050	<0.000050	0.000080	0.000253	0.000107	0.000083	0.000064	0.000069	0.000077	0.000211	0.000191	0.000057	<0.000050
Lithium (Li)	mg/L		0.00020	0.00070	0.00070	0.00223	0.00219	0.00595	0.00577	0.00409	0.00407	0.00443	0.00436	0.00389	0.00400	0.00404	0.00409	0.00310	0.00156	0.00159	0.00040	0.00039
Magnesium (Mg)	mg/L		0.10	1.85	1.72	4.41	4.35	14.5	14.3	7.92	7.97	8.55	8.57	6.60	6.48	6.56	6.48	6.01	2.62	2.60	1.16	1.17
Manganese (Mn)	mg/L		0.00020	0.00130	0.00176	0.0119	0.0119	0.0607	0.0599	0.00318	0.0114	0.00465	0.00371	0.0215	0.0235	0.0226	0.0237	0.00975	0.00437	0.00454	0.00181	0.00170
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	<0.000050	<0.000050	0.000079	0.000084	0.000281	0.000294	0.000196	0.000156	0.000195	0.000190	0.000159	0.000167	0.000155	0.000167	0.000181	0.000075	0.000072	<0.000050	<0.000050
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	0.00024	0.00023	0.00065	0.00067	0.00100	0.00095	0.00053	0.00042	0.00054	0.00047	0.00066	0.00063	0.00059	0.00062	0.00072	0.00063	0.00063	0.00022	0.00022
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<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	<2.0	<2.0	5.0	5.0	2.9	2.9	3.1	3.1	2.4	2.3	2.4	2.4	2.0	<2.0	<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	<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	0.00103	0.00100	0.00157	0.00159	0.00288	0.00283	0.00167	0.00165	0.00188	0.00179	0.00151	0.00151	0.00158	0.00161	0.00147	0.00153	0.00154	0.000674	0.000654
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	<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	0.138	0.139	0.626	0.602	1.74	1.74	1.12	1.35	1.29	1.22	1.13	1.11	1.15	1.17	1.28	0.874	0.872	0.093	0.092
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	5.1	4.8	16.6	16.4	71.5	71.4	36.7	36.9	40.0	39.6	31.7	31.0	31.1	31.0	28.4	10.0	9.8	3.1	3.2
Strontium (Sr)	mg/L		0.000050	0.0216	0.0210	0.0278	0.0278	0.0864	0.0853	0.0484	0.0489	0.0517	0.0520	0.0415	0.0431	0.0438	0.0435	0.0364	0.0156	0.0167	0.0134	0.0126
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000022	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000020	0.0000036	0.0000035	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000133	0.0000111	0.0000565	0.0000559	0.0000337	0.0000343	0.0000120	0.0000108	0.0000360	0.0000210	0.0000312	0.0000302	0.0000376	0.0000396	0.0000687	0.000113	0.000116	0.0000100	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	<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	0.00313	0.00317	0.00052	0.00053	<0.00020	0.00029	0.00296	0.00128	0.00173	0.00166	0.00276	0.00299	0.00479	0.0109	0.0116	0.00023	<0.00020
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000012	<0.000010	0.000026	0.000025	0.000023	0.000021	0.000020	0.000021	0.000019	0.000020	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000384	0.0000365	0.0000413	0.0000401	0.0000582	0.0000566	0.0000362	0.0000323	0.0000409	0.0000389	0.0000337	0.0000334	0.0000352	0.0000364	0.0000428	0.0000526	0.0000526	0.0000295	0.0000281
Vanadium (V)	mg/L		0.000050	<0.000050	<0.000050	0.000185	0.000189	0.000169	0.000175	0.000070	0.000058	0.000199	0.000114	0.000146	0.000160	0.000201	0.000210	0.000301	0.000540	0.000541	<0.000050	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000145	0.0000146	0.0000599	0.0000580	0.0000559	0.0000572	0.0000172	0.0000194	0.0000374	0.0000254	0.0000298	0.0000310	0.0000350	0.0000358	0.0000626	0.0000808	0.0000822	0.0000129	0.0000117
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	0.0031	0.0034	<0.0030	<0.0030	<0.0030	<0.0030	<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	0.000080	<0.000050	0.000084	0.000091	0.000074	0.000072	<0.000050	<0.000050	0.000061	<0.000050	0.000059	0.000061	0.000065	0.000065	0.000100	0.000142	0.000157	<0.000050	<0.000050
Radiochemistry																						
Radium-226	Bq/L		0.005	<0.005	0.009	<0.005	0.006	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

Winter surface water quality samples were collected from 1 m below the ice.

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

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 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) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$ / 1000. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

Appendix A2-4b. Water Quality Data for AEMP Lakes, Doris North Project, 2010

Site ID:				Doris South	Doris North	Doris North	Doris North	Little Roberts	Reference D	Reference B	Reference B	Little Roberts	Doris North	Doris North	Doris North	Doris South	Reference B	Reference B	Reference D
Depth Zone:				Surface	Surface	Deep	Deep	Surface	Surface	Surface	Deep	Surface	Surface	Deep	Deep	Surface	Surface	Deep	Surface
Depth (m):				1	1	13	13	1	1	1	8.75	1	1	11	11	1	1	8.5	1
Replicate:				1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1
Date Sampled:		**CCME Guideline for the Protection of**	**Realized Detection**	08-Aug-10	09-Aug-10	09-Aug-10	09-Aug-10	10-Aug-10	21-Aug-10	24-Aug-10	24-Aug-10	12-Sep-10	12-Sep-10	12-Sep-10	12-Sep-10	12-Sep-10	17-Sep-10	17-Sep-10	25-Sep-10
ALS Sample ID:	**Units**	**Aquatic Life[a]**	**Limit**	L919821-2	L919821-3	L919821-4	L919821-5	L919821-6	L926333-6	L926334-1	L926334-2	L930857-1	L930857-2	L930857-3	L930857-4	L930857-5	L933534-1	L933534-2	L936328-1
Physical Tests																			
Conductivity	µS/cm		2.0	266	265	266	265	256	101	44.3	44.3	262	265	265	265	265	45.1	45.9	108
Hardness (as $CaCO_3$)	mg/L		0.5 or 1.0	48.6	48.7	47.3	48.7	45.0	19.3	13.2	13.3	48.1	50.1	49.8	50.1	50.6	12.8	12.9	20.1
pH	pH	6.5-9.0	0.10	7.55	7.60	7.57	7.56	7.57	7.92	7.99	7.99	7.64	7.69	7.70	7.67	7.69	7.77	6.92	7.30
Total Suspended Solids	mg/L	dependent on background levels	3.0	6.3	4.3	5.6	4.9	4.3	<3.0	<3.0	<3.0	4.0	8.0	<3.0	5.3	6.7	<3.0	<3.0	<3.0
Total Dissolved Solids	mg/L		10						60	23	22								
Turbidity	NTU	dependent on background levels	0.10	4.98	5.02	5.64	5.78	4.32	2.63	0.30	0.36	4.50	6.42	6.25	6.09	8.03	0.57	0.60	1.19
Anions and Nutrients																			
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	27.3	28.1	27.3	27.8	25.9	11.7	9.7	9.3	26.0	28.4	28.9	28.5	28.9	9.7	15.4	12.9
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0147	0.0247	<0.0050	0.0069	0.0053	0.0053	0.0056	0.0072	0.0068	0.0228
Bromide (Br)	mg/L		0.050	0.120	0.124	0.127	0.125	0.127	0.069	<0.050	<0.050	0.146	0.144	0.142	0.143	0.140	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L		0.50	61.9	61.9	62.0	62.0	59.7	20.4	6.00	5.98	62.7	63.4	63.4	63.4	63.4	6.13	6.11	21.5
Fluoride (F)	mg/L		0.020	0.048	0.049	0.047	0.047	0.045	0.028	<0.020	<0.020	0.046	0.049	0.049	0.050	0.052	<0.020	<0.020	0.030
Nitrate (as N)	mg/L	2.935[c]	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<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	<0.0010	<0.0010	<0.0010	<0.0010	0.0022	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0241	0.0272	0.0270	0.0284	0.0188	0.0070	0.0056	0.0030	0.0172	0.0309	0.0316	0.0266	0.0238	0.0048	0.0043	0.0066
Sulphate (SO_4)	mg/L		0.50	2.64	2.63	2.62	2.63	3.54	1.77	1.46	1.46	4.37	2.69	2.68	2.69	2.72	1.45	1.45	2.05
Cyanides																			
Total Cyanide	mg/L	0.005 (as free CN)	0.0010	0.0044	0.0044	0.0041	0.0038	0.0040	0.0036	0.0028	0.0030	0.0049	0.0055	0.0045	0.0051	0.0046	0.0025	0.0025	0.0033
Organic Carbon																			
Total Organic Carbon	mg/L		0.20 or 0.50	7.16	6.69	6.34	6.34	6.35	4.05	3.22	3.23	5.37	5.46	5.49	5.21	5.43	2.70	2.81	4.08
Total Metals																			
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0892	0.0531	0.0663	0.0733	0.113	0.112	0.0116	0.0099	0.0722	0.0365	0.0506	0.0535	0.0898	0.0160	0.0095	0.0600
Antimony (Sb)	mg/L		0.000010	0.000017	0.000016	0.000043	0.000014	0.000018	0.000021	0.000011	<0.000010	0.000014	0.000015	0.000015	0.000015	0.000018	<0.000010	<0.000010	<0.000010
Arsenic (As)	mg/L	0.005	0.000050	0.000267	0.000264	0.000306	0.000289	0.000284	0.000151	0.000086	0.000084	0.000264	0.000313	0.000304	0.000321	0.000329	0.000079	0.000071	0.000130
Barium (Ba)	mg/L		0.00010	0.00359	0.00332	0.00361	0.00360	0.00374	0.00253	0.00173	0.00167	0.00342	0.00304	0.00310	0.00313	0.00346	0.00154	0.00145	0.00215
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	<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	0.0050	0.0266	0.0279	0.0267	0.0280	0.0283	0.0162	0.0087	0.0091	0.0290	0.0289	0.0284	0.0282	0.0281	0.0101	0.0087	0.0164
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	0.000193	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	8.59	8.64	8.35	8.59	7.52	3.23	3.34	3.25	7.82	8.95	8.87	8.88	8.95	3.18	3.12	3.21
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000055	0.0000079	<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	<0.00050	<0.00050	<0.00050	0.00079	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000053	<0.000050	0.000053	0.000050	0.000066	0.000072	<0.000050	<0.000050	0.000050	<0.000050	<0.000050	<0.000050	0.000063	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00165	0.00155	0.00159	0.00161	0.00186	0.00121	0.00087	0.00080	0.00156	0.00154	0.00146	0.00147	0.00171	0.00085	0.00079	0.00127
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<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	0.150	0.132	0.165	0.179	0.202	0.170	<0.030	<0.030	0.149	0.092	0.106	0.105	0.130	<0.030	<0.030	0.085
Lead (Pb)	mg/L	≥0.001[f]	0.000050	0.000075	0.000098	0.000059	<0.000050	0.00145	0.000596	0.00264	0.000234	<0.000050	<0.000050	0.000144	0.000064	0.000086	0.000219	0.000180	0.000284
Lithium (Li)	mg/L		0.00020	0.00365	0.00380	0.00374	0.00381	0.00331	0.00157	0.00052	0.00048	0.00330	0.00378	0.00376	0.00380	0.00382	0.00047	0.00044	0.00146
Magnesium (Mg)	mg/L		0.10	6.60	6.58	6.42	6.61	6.36	2.98	1.34	1.30	6.94	6.75	6.72	6.78	6.85	1.28	1.26	3.13
Manganese (Mn)	mg/L		0.00020	0.0233	0.0253	0.0350	0.0384	0.0128	0.00772	0.00202	0.00200	0.00769	0.0229	0.0245	0.0240	0.0198	0.00138	0.00132	0.00278
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000175	0.000173	0.000216	0.000173	0.000197	0.000086	0.000053	0.000051	0.000222	0.000218	0.000233	0.000224	0.000240	<0.000050	<0.000050	0.000074
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	0.00060	0.00059	0.00060	0.00058	0.00071	0.00054	<0.00020	<0.00020	0.00066	0.00052	0.00057	0.00057	0.00073	0.00028	<0.00020	0.00043
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<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	2.4	2.4	2.3	2.4	2.2	<2.0	<2.0	<2.0	2.3	2.4	2.4	2.4	2.4	<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	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00147	0.00148	0.00146	0.00151	0.00142	0.00124	0.000736	0.000718	0.00148	0.00157	0.00159	0.00162	0.00168	0.000762	0.000748	0.00108
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	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.16	1.11	1.13	1.18	1.04	0.424	0.180	0.170	1.09	1.16	1.20	1.20	1.31	0.131	0.124	0.360
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	31.9	32.1	31.2	32.2	31.1	11.5	3.5	3.4	32.4	32.4	32.2	32.3	32.4	3.6	3.5	13.1
Strontium (Sr)	mg/L		0.000050	0.0414	0.0443	0.0428	0.0434	0.0411	0.0186	0.0153	0.0152	0.0433	0.0458	0.0462	0.0440	0.0441	0.0151	0.0157	0.0191
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	0.0000098	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000355	0.0000241	0.0000270	0.0000285	0.0000481	0.0000363	<0.0000050	<0.0000050	0.0000363	0.0000155	0.0000183	0.0000190	0.0000304	0.0000076	0.0000078	0.0000348
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	0.00029	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00296	0.00149	0.00177	0.00194	0.00309	0.00479	<0.00020	<0.00020	0.00175	0.00101	0.00143	0.00136	0.00272	0.00042	<0.00020	0.00126
Tungsten (W)	mg/L		0.000010	0.000022	0.000019	0.000020	0.000019	0.000011	<0.000010	<0.000010	<0.000010	<0.000010	0.000017	0.000018	0.000017	0.000018	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000374	0.0000352	0.0000355	0.0000360	0.0000425	0.0000468	0.0000341	0.0000330	0.0000462	0.0000366	0.0000375	0.0000383	0.0000407	0.0000368	0.0000355	0.0000573
Vanadium (V)	mg/L		0.000050	0.000227	0.000172	0.000211	0.000211	0.000241	0.000251	<0.000050	<0.000050	0.000167	0.000139	0.000156	0.000160	0.000222	<0.000050	<0.000050	0.000102
Yttrium (Y)	mg/L		0.0000050	0.0000320	0.0000244	0.0000282	0.0000292	0.0000474	0.0000545	0.0000117	0.0000111	0.0000411	0.0000200	0.0000213	0.0000209	0.0000292	0.0000112	0.0000110	0.0000379
Zinc (Zn)	mg/L	0.03	0.0030	0.0032	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<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	0.000070	0.000052	0.000188	0.000057	0.000076	0.000058	<0.000050	<0.000050	0.000069	<0.000050	<0.000050	<0.000050	0.000062	<0.000050	<0.000050	0.000059
Radiochemistry																			
Radium-226	Bq/L		0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

Winter surface water quality samples were collected from 1 m below the ice.

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

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 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) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(\text{hardness})]-3.2\}}$ / 1000.

*e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(\text{hardness})]-1.465\}}$ * 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ / 1000. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ / 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.

Appendix A2-4c. Water Quality Data for AEMP Marine Sites, Doris North Project, 2010

Site ID:				RBE	RBE	RBW	REF-Marine	RBE	RBE	RBW	RBW	RBE	RBE	RBW	RBW	REF-Marine	REF-Marine	RBE	RBE	RBW	REF-Marine
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Depth (m):				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Replicate:				1	2	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	1
Date Sampled:		CCME Guideline for the	Realized Detection	25-Apr-10	25-Apr-10	25-Apr-10	13-Jul-10	20-Jul-10	20-Jul-10	20-Jul-10	20-Jul-10	15-Aug-10	15-Aug-10	15-Aug-10	15-Aug-10	19-Aug-10	19-Aug-10	30-Sep-10	30-Sep-10	30-Sep-10	28-Sep-10
ALS Sample ID:	Units	Protection of Aquatic Life[a]	Limit	L880493-1	L880493-2	L880493-3	L909785-5	L911821-2	L911821-3	L911821-4	L911821-5	L921315-1	L921315-2	L921315-3	L921315-4	L923126-1	L923126-2	L939411-1	L939411-2	L939411-4	L938575-1
Physical Tests																					
Conductivity	µS/cm		2.0	-	-	-	32400	34000	33900	34200	34300	-	-	-	-	-	-	37000	37300	37600	37400
Hardness (as $CaCO_3$)	mg/L		0.86 to 4.3	4990	4990	5120	3870	4380	4210	4260	4220	762	727	4110	4110	3010	3000	4890	4860	4550	4630
pH	pH	7.0-8.7	0.10	7.75	7.72	7.73	7.92	7.84	7.90	7.87	7.88	7.73	7.73	7.90	7.90	7.83	7.88	7.78	7.82	7.86	7.86
Total Suspended Solids	mg/L	dependent on background levels	3.0	8.3	<3.0	10.3	10.8	5.6	6.9	<3.0	7.6	23.7	25.0	16.3	15.7	9.0	9.0	20.8	18.2	18.2	12.9
Turbidity	NTU	dependent on background levels	0.10	0.22	0.19	0.16	0.40	0.73	0.71	0.45	0.47	15.3	15.7	6.51	6.42	1.06	1.07	1.05	1.11	0.59	0.42
Salinity (EC)	g/L	<10% fluctuation[c]	1.0	26.7	26.5	26.6	-	21.9	21.8	22.1	22.0	4.2	4.3	21.2	21.0	17.0	17.0	-	-	-	-
Anions and Nutrients																					
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	120	119	118	96.3	104	96.2	103	98.8	36.5	35.8	103	105	49.9	49.5	106	118	114	111
Ammonia (as N)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	0.0090	0.0068	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		2.5 to 25	42.9	42.2	43.7	<25	34.3	34.2	35.5	35.0	5.0	5.7	31.1	32.7	27.8	24.9	36.6	36.9	36.3	39.5
Chloride (Cl)	mg/L		25 to 250	15200	15200	15200	11500	12700	12700	12700	12700	2280	2340	12000	11700	8580	8020	13600	13600	13800	13700
Fluoride (F)	mg/L		0.030 to 1.0	0.93	0.92	0.95	0.598	<0.75	<0.75	<0.75	0.92	<1.0	<1.0	<0.75	<0.75	<0.75	<0.75	0.690	0.689	0.690	0.661
Nitrate (as N)	mg/L	3.612[c]	0.0060 to 2.5	0.0252	0.0243	0.0318	<2.5	<0.0060	<0.0060	<0.0060	<0.0060	0.0159	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.50	<0.50	<0.50	<0.50
Nitrite (as N)	mg/L		0.0020 to 0.50				<0.50	<0.0020	<0.0020	<0.0020	<0.0020	0.0030	0.0034	<0.0020	<0.0020	<0.0020	<0.0020	<0.10	<0.10	<0.10	<0.10
Total Phosphorus	mg/L		0.0020	0.0371	0.0359	0.0379	0.0265	0.0275	0.0277	0.0270	0.0274	0.0385	0.0439	0.0324	0.0309	0.0177	0.0169	0.0277	0.0273	0.0276	0.0271
Sulphate (SO_4)	mg/L		25 to 250	2080	2080	2080	1500	1750	1740	1750	1750	295	303	1670	1610	1170	1080	1890	1900	1910	1910
Cyanides																					
Total Cyanide	mg/L		0.0010 or 0.0050	<0.0050	<0.0050	<0.0050	0.0013	0.0012	0.0014	0.0011	0.0022	0.0047	0.0048	0.0014	0.0019	0.0023	0.0023	0.0014	0.0015	0.0014	0.0017
Organic / Inorganic Carbon																					
Total Organic Carbon	mg/L		0.50 or 1.0	1.2	1.1	1.2	1.80	1.61	1.44	1.33	1.36	4.93	4.98	2.04	1.99	2.29	2.24	1.67	1.62	1.57	1.76
Total Metals																					
Aluminum (Al)	mg/L		0.0050 or 0.010	0.018	<0.010	<0.010	0.029	0.0302	0.0248	0.0151	0.0226	0.562	0.511	0.319	0.288	0.0342	0.0302	0.0275	0.0259	0.0169	0.0091
Antimony (Sb)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)	mg/L	0.0125[b]	0.0004 or 0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.00111	0.00113	0.00119
Barium (Ba)	mg/L		0.0010	0.0115	0.0115	0.0112	0.0105	0.0112	0.0115	0.0114	0.0111	0.0085	0.0073	0.0114	0.0118	0.0077	0.0080	0.0091	0.0091	0.0093	0.0099
Beryllium (Be)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L		0.10	3.77	3.73	3.81	2.80	2.96	2.95	3.01	3.07	0.56	0.57	2.93	3.27	2.30	2.41	3.34	3.47	3.46	3.37
Cadmium (Cd)	mg/L	0.00012	0.000020 or 0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	<0.00012	0.000040	0.000043	0.000042
Calcium (Ca)	mg/L		0.10 or 0.50	320	321	331	242	288	263	285	263	52.1	49.8	266	267	199	193	338	336	311	312
Cesium (Cs)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Chromium (Cr)	mg/L	Cr(VI): 0.0015; Cr(III): 0.056[c]	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0012	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt (Co)	mg/L		0.000050 or 0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.000070	0.000056	<0.000050
Copper (Cu)	mg/L		0.000050 or 0.0010	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	<0.0010	<0.0010	0.0023	0.0023	0.0011	0.0012	<0.0010	<0.0010	<0.0010	0.000953	0.000665	0.000537
Gallium (Ga)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)	mg/L		0.010 to 0.30	<0.050	<0.050	<0.050	<0.30	<0.050	<0.050	<0.050	<0.050	0.649	0.616	0.353	0.343	0.067	0.066	<0.050	0.064	0.045	0.022
Lead (Pb)	mg/L		0.000050 or 0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.000052	<0.000050	<0.000050
Lithium (Li)	mg/L		0.020	0.161	0.158	0.162	0.124	0.133	0.136	0.138	0.131	0.025	0.025	0.120	0.134	0.096	0.100	0.135	0.135	0.133	0.133
Magnesium (Mg)	mg/L		0.20 or 1.0	1020	1020	1040	793	888	862	863	865	153	146	838	836	611	612	982	976	917	935
Manganese (Mn)	mg/L		0.000050 or 0.00050	0.00233	0.00147	0.00145	0.00247	0.00267	0.00270	0.00225	0.00225	0.0154	0.0166	0.00764	0.00823	0.00278	0.00289	0.00252	0.00302	0.00275	0.00254
Mercury (Hg)	mg/L	Inorganic Hg: 0.000016[c]	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)	mg/L		0.0020	0.0087	0.0082	0.0095	0.0073	0.0078	0.0078	0.0081	0.0078	<0.0020	<0.0020	0.0064	0.0070	0.0052	0.0054	0.0075	0.0080	0.0081	0.0075
Nickel (Ni)	mg/L		0.000050 or 0.00050	<0.00050	<0.00050	<0.00050	0.00118	0.00067	0.00056	0.00055	0.00055	0.00129	0.00124	0.00096	0.00086	<0.00050	<0.00050	<0.00050	0.000663	0.000659	0.000596
Phosphorus (P)	mg/L		1.0 or 3.0	<1.0	<1.0	<1.0	<3.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Potassium (K)	mg/L		4.0 or 20	340	339	337	235	269	259	264	258	48.2	45.9	254	256	189	183	310	306	286	287
Rhenium (Re)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	mg/L		0.0050	0.0885	0.0877	0.0879	0.0680	0.0766	0.0774	0.0805	0.0785	0.0142	0.0148	0.0663	0.0711	0.0514	0.0528	0.0816	0.0818	0.0825	0.0808
Selenium (Se)	mg/L		0.00040 or 0.002	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.00040	<0.00040	<0.00040
Silicon (Si)	mg/L		0.10 or 0.50	0.52	<0.50	0.70	<0.50	<0.50	<0.50	<0.50	<0.50	2.34	1.97	1.12	0.99	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Sodium (Na)	mg/L		4.0 or 20	7760	7720	7690	6300	7640	7340	7500	7260	1240	1180	7090	7140	5010	4870	9010	8890	8280	8220
Strontium (Sr)	mg/L		0.000050 or 0.050	5.73	5.71	5.69	4.54	5.27	5.05	5.18	5.00	0.911	0.869	4.95	4.96	3.70	3.53	5.26	5.49	5.39	5.31
Tellurium (Te)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thorium (Th)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0294	0.0262	0.0175	0.0167	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)	mg/L		0.000050 or 0.00050	0.00247	0.00253	0.00253	0.00196	0.00215	0.00214	0.00217	0.00215	<0.00050	<0.00050	0.00187	0.00199	0.00143	0.00148	0.00219	0.00194	0.00193	0.00189
Vanadium (V)	mg/L		0.00050	0.00081	0.00083	0.00074	0.00067	0.00073	0.00070	0.00070	0.00069	0.00153	0.00141	0.00123	0.00132	0.00051	0.00053	0.00069	0.00075	0.00076	0.00071
Yttrium (Y)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	mg/L		0.00080 to 0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0069	0.0053	<0.0050	0.0065	<0.0050	<0.0050	<0.0050	<0.0013	0.00276	<0.00080
Zirconium (Zr)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Radiochemistry																					
Radium-226	Bq/L		0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

Winter surface water quality samples were collected from 1 m below the ice.

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

a) Canadian water quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

Appendix A2-5

QA/QC Blank Data for AEMP Water Quality Sampling, Doris North Project, 2010

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Appendix A2-5. QA/QC Blank Data for AEMP Water Quality Sampling, Doris North Project, 2010

Blank Type:		Realized	Equipment Blank	Equipment Blank	Equipment Blank	Travel Blank	Travel Blank	Travel Blank	Travel Blank	Travel Blank	Travel Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank
Date Sampled:		Detection	18-Apr-10	11-Jul-10	08-Aug-10	18-Apr-10	17-Jun-10	15-Jul-10	24-Aug-10	12-Sep-10	15-Sep-10	22-Apr-10	18-Jun-10	20-Jul-10	10-Aug-10	13-Aug-10	24-Aug-10	15-Sep-10	30-Sep-10
ALS Sample ID:	**Units**	Limit	L879380-1	L909785-7	L919821-1	L879380-2	L899505-5	L909785-8	L926334-4	L930857-6	L932990-10	L880317-7	L900033-3	L911821-1	L919821-7	L921162-7	L926334-3	L932990-9	L939411-5
Physical Tests																			
Conductivity	µS/cm	2.0	<2.0	**2.5**	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	**2.0**
Hardness (as $CaCO_3$)	mg/L	0.50 or 1.0	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
pH	pH	0.10	5.83	6.19	5.65	5.69	5.98	5.54	5.76	5.43	5.57	5.90	5.62	5.56	5.64	5.92	5.67	5.75	5.64
Total Suspended Solids	mg/L	3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Total Dissolved Solids	mg/L	10	<10	-	-	<10	-	-	<10	-	-	-	-	-	-	-	<10	-	-
Turbidity	NTU	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Anions and Nutrients																			
Alkalinity, Total (as $CaCO_3$)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ammonia (as N)	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.0050	<0.0050	-	<0.0050	<0.0050	<0.005	<0.005	<0.0050	<0.0050	**0.0186**	<0.0050	**0.0161**
Bromide (Br)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<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	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.20	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<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	<0.0050	<0.0050	<0.0050	<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	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulphate (SO_4)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Cyanides																			
Total Cyanide	mg/L	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon																			
Total Organic Carbon	mg/L	0.50	**0.34**	<0.50	<0.50	**0.28**	<0.50	<0.50	<0.50	-	**0.26**	<0.20	<0.50	<0.50	<0.50	-	<0.50	<0.50	**0.77**
Total Metals																			
Aluminum (Al)	mg/L	0.0030	<0.0030	**0.0238**	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Antimony (Sb)	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Arsenic (As)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Barium (Ba)	mg/L	0.00010	<0.00010	**0.00046**	**0.00012**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Beryllium (Be)	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cadmium (Cd)	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cesium (Cs)	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	<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	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Gallium (Ga)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<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	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)	mg/L	0.000050	<0.000050	**0.000078**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Magnesium (Mg)	mg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)	mg/L	0.00020	<0.00020	**0.00076**	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Mercury (Hg)	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000050	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Nickel (Ni)	mg/L	0.00020	<0.00020	**0.0212**	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<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	<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	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<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	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Selenium (Se)	mg/L	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<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	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Silver (Ag)	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<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	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)	mg/L	0.000050	<0.000050	**0.000054**	**0.000273**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Tellurium (Te)	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Tin (Sn)	mg/L	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<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	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tungsten (W)	mg/L	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Vanadium (V)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Yttrium (Y)	mg/L	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Zinc (Zn)	mg/L	0.0030	<0.0030	**0.0040**	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<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	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry																			
Radium-226	Bq/L	0.005 or 0.007	<0.007	<0.005	<0.005	<0.007	-	-	-	-	-	**0.008**	-	-	-	-	-	-	<0.005

Note:

Bold values represent concentrations that are higher than analytical detection limits.

Appendix A2-6

Sediment Quality Data for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A2-6a. Sediment Quality Data for AEMP Streams, Doris North Project, 2010

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Doris OF 1	Doris OF 2	Doris OF 3	Little Roberts OF 1	Little Roberts OF 2	Little Roberts OF 3	Roberts OF 1	Roberts OF 2	Roberts OF 3
Replicate:													
Date Sampled:					20-Aug-10	20-Aug-10	20-Aug-10	12-Aug-10	12-Aug-10	12-Aug-10	13-Aug-10	13-Aug-10	13-Aug-10
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L923760-13	L923760-14	L923760-15	L920950-22	L920950-23	L920950-24	L920950-25	L920950-26	L920950-27
Physical Tests													
Moisture	%			0.10	16.9	31.9	8.30	45.7	41.8	43.4	50.6	22.9	29.7
pH	pH			0.10	6.65	6.29	6.94	6.15	5.68	6.07	6.08	8.50	8.06
Particle Size													
% Gravel (>2 mm)	%			0.10	3.75	37.8	22.8	<0.10	<0.10	<0.10	10.8	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	81.4	43.8	68.1	46.6	63.1	62.2	60.8	46.8	35.9
% Silt (0.063 mm - 4 µm)	%			0.10	9.87	14.9	6.96	44.7	25.5	25.2	16.7	25.8	36.0
% Clay (<4 µm)	%			0.10	4.95	3.54	2.17	8.68	11.3	12.6	11.7	27.4	28.1
Leachable Anions & Nutrients													
Total Nitrogen	%			0.020	0.080	0.193	0.136	0.162	0.109	0.119	0.066	<0.020	0.024
Organic / Inorganic Carbon													
Total Organic Carbon	%			0.10	0.26	1.79	0.79	2.75	1.32	1.73	0.94	0.12	0.24
Plant Available Nutrients													
Available Ammonium-N	mg/kg			0.80-2.4	1.23	2.4	2.27	5.6	5.7	6.2	3.7	<1.5	1.6
Available Nitrate-N	mg/kg			2.0-7.5	<2.0	<3.0	<2.0	<5.0	<5.0	<5.0	<3.8	2.7	<3.0
Nitrite-N	mg/kg			0.40-1.5	<0.40	<0.60	<0.40	<1.0	<1.0	<1.0	<0.75	<0.40	<0.60
Available Phosphate-P	mg/kg			2.0	2.5	2.5	4.3	4.8	5.3	5.8	5.0	2.2	3.1
Metals													
Aluminum (Al)	mg/kg			50	6230	10400	6560	12000	9900	8850	11800	14100	17700
Antimony (Sb)	mg/kg			10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic (As)	mg/kg	5.9	17	0.050	0.570	9.97	0.542	2.52	1.52	1.34	2.64	3.30	2.27
Barium (Ba)	mg/kg			1.0	24.9	46.6	14.1	56.0	45.5	39.8	63.1	75.9	103
Beryllium (Be)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.57
Bismuth (Bi)	mg/kg			20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	mg/kg	0.6	3.5	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Calcium (Ca)	mg/kg			50	2520	3390	1920	4160	3080	2980	3520	5080	6250
Chromium (Cr)	mg/kg	37.3	90	2.0	17.9	26.7	16.5	33.9	27.7	25.3	34.0	39.7	50.6
Cobalt (Co)	mg/kg			2.0	4.8	5.9	5.0	6.9	5.7	5.1	7.9	10.0	12.0
Copper (Cu)	mg/kg	35.7	197	1.0	13.8	19.6	6.8	14.7	12.0	11.2	20.1	24.4	28.4
Iron (Fe)	mg/kg			50	12700	17000	12900	16800	15000	13000	17900	22200	27400
Lead (Pb)	mg/kg	35	91.3	2.0	2.2	3.5	<2.0	4.9	3.8	3.4	4.8	5.3	6.7
Lithium (Li)	mg/kg			2.0	12.5	17.5	11.3	21.4	18.2	16.3	22.4	26.4	32.7
Magnesium (Mg)	mg/kg			50	4650	6650	5100	8430	7080	6450	8800	10800	13700
Manganese (Mn)	mg/kg			1.0	151	165	163	203	184	175	191	286	386
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0052	0.0131	<0.0050	0.0142	0.0078	0.0078	0.0080	<0.0050	<0.0050
Molybdenum (Mo)	mg/kg			0.20	<0.20	0.35	0.75	0.90	0.66	0.89	0.46	0.47	0.52
Nickel (Ni)	mg/kg			5.0	10.2	15.1	10.8	17.3	14.0	12.8	18.7	21.5	26.8
Phosphorus (P)	mg/kg			50	311	444	302	483	433	415	439	493	628
Potassium (K)	mg/kg			200	1220	2020	660	2520	2020	1750	2800	3980	5110
Selenium (Se)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.12
Sodium (Na)	mg/kg			200	350	460	<200	540	410	360	480	1070	1410
Strontium (Sr)	mg/kg			0.50	11.8	18.0	9.86	23.0	16.4	15.4	19.7	27.9	35.1
Sulphur (S)	mg/kg			100-500	2300	2400	2500	650	410	500	440	210	410
Thallium (Tl)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin (Sn)	mg/kg			5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	mg/kg			1.0	498	729	404	910	731	680	837	1070	1350
Uranium (U)	mg/kg			0.10	0.624	0.881	0.331	1.19	1.01	0.878	1.18	1.12	1.51
Vanadium (V)	mg/kg			2.0	27.4	36.4	26.7	40.9	33.6	30.1	42.7	48.4	59.6
Zinc (Zn)	mg/kg	123	315	1.0	20.5	36.4	23.0	43.9	34.5	30.7	42.3	44.2	55.4

Notes:

Shaded cells indicate values that exceed CCME guidelines

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A2-6a. Sediment Quality Data for AEMP Streams, Doris North Project, 2010

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Reference B OF 1	Reference B OF 2	Reference B OF 3	Reference D OF 1	Reference D OF 2	Reference D OF 3
Replicate:										
Date Sampled:					09-Aug-10	09-Aug-10	09-Aug-10	13-Aug-10	13-Aug-10	13-Aug-10
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L920950-16	L920950-17	L920950-18	L920950-28	L920950-29	L920950-30
Physical Tests										
Moisture	%			0.10	15.5	7.56	29.3	15.5	6.93	16.8
pH	pH			0.10	7.25	7.11	6.97	7.04	6.98	6.92
Particle Size										
% Gravel (>2 mm)	%			0.10	31.6	11.5	21.1	34.3	72.1	10.9
% Sand (2.0 mm - 0.063 mm)	%			0.10	64.5	86.8	77.0	64.4	27.6	88.2
% Silt (0.063 mm - 4 µm)	%			0.10	3.25	0.90	1.44	0.60	<0.10	0.13
% Clay (<4 µm)	%			0.10	0.63	0.80	0.40	0.66	0.27	0.77
Leachable Anions & Nutrients										
Total Nitrogen	%			0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Organic / Inorganic Carbon										
Total Organic Carbon	%			0.10	0.14	<0.10	<0.10	<0.10	<0.10	<0.10
Plant Available Nutrients										
Available Ammonium-N	mg/kg			0.80-2.4	2.4	1.4	1.7	1.21	1.5	1.16
Available Nitrate-N	mg/kg			2.0-7.5	<3.0	<3.0	<3.0	<2.7	<7.5	<2.7
Nitrite-N	mg/kg			0.40-1.5	<0.60	<0.60	<0.60	<0.55	<1.5	<0.55
Available Phosphate-P	mg/kg			2.0	2.3	<2.0	<2.0	2.1	<2.0	<2.0
Metals										
Aluminum (Al)	mg/kg			50	16500	5400	4910	5950	5900	5630
Antimony (Sb)	mg/kg			10	<10	<10	<10	<10	<10	<10
Arsenic (As)	mg/kg	5.9	17	0.050	1.72	0.465	0.416	0.319	0.307	0.473
Barium (Ba)	mg/kg			1.0	63.4	18.7	13.5	15.9	14.0	13.5
Beryllium (Be)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bismuth (Bi)	mg/kg			20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	mg/kg	0.6	3.5	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Calcium (Ca)	mg/kg			50	5450	1530	1290	1840	1670	1730
Chromium (Cr)	mg/kg	37.3	90	2.0	41.2	9.9	8.0	9.6	9.1	8.4
Cobalt (Co)	mg/kg			2.0	9.8	4.0	4.0	4.4	5.6	3.8
Copper (Cu)	mg/kg	35.7	197	1.0	14.2	2.5	4.4	6.7	10.0	9.7
Iron (Fe)	mg/kg			50	26700	10200	9950	12000	11200	10400
Lead (Pb)	mg/kg	35	91.3	2.0	5.6	<2.0	<2.0	<2.0	<2.0	<2.0
Lithium (Li)	mg/kg			2.0	33.1	11.8	10.8	14.8	15.7	16.3
Magnesium (Mg)	mg/kg			50	10300	4870	4530	5320	6040	5560
Manganese (Mn)	mg/kg			1.0	401	171	143	241	294	143
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0172	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum (Mo)	mg/kg			0.20	0.43	<0.20	<0.20	<0.20	0.39	0.38
Nickel (Ni)	mg/kg			5.0	21.4	7.7	6.2	8.4	9.8	7.4
Phosphorus (P)	mg/kg			50	855	342	266	379	379	329
Potassium (K)	mg/kg			200	2170	820	690	690	650	740
Selenium (Se)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			200	440	<200	<200	<200	<200	<200
Strontium (Sr)	mg/kg			0.50	27.0	5.98	5.81	8.97	6.23	8.18
Sulphur (S)	mg/kg			100-500	170	100	160	210	160	180
Thallium (Tl)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin (Sn)	mg/kg			5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	mg/kg			1.0	907	272	265	281	247	291
Uranium (U)	mg/kg			0.10	1.65	0.451	0.345	0.620	0.381	0.744
Vanadium (V)	mg/kg			2.0	47.0	17.3	16.5	21.1	17.3	17.1
Zinc (Zn)	mg/kg	123	315	1.0	54.5	19.8	19.9	22.6	22.9	19.9

Notes:

Shaded cells indicate values that exceed CCME guidelines

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A2-6b. Sediment Quality Data for AEMP Lakes, Doris North Project, 2010

Site ID:					Doris North	Doris North	Doris North	Doris South	Doris South	Doris South	Little Roberts	Little Roberts	Little Roberts	Reference B
Depth (m):					14	14	14	3.5	3.75	4	2.75	2.75	2.75	10.75
Replicate:		CCME Guidelines for the		Realized	1	2	3	1	2	3	1	2	3	1
Date Sampled:		Protection of Aquatic Life[a]		Detection	08-Aug-10	08-Aug-10	08-Aug-10	09-Aug-10	09-Aug-10	09-Aug-10	10-Aug-10	10-Aug-10	10-Aug-10	25-Aug-10
ALS Sample ID:	Units	ISQG[b]	PEL[c]	Limit	L923760-1	L923760-2	L923760-3	L923760-4	L923760-5	L923760-6	L923760-7	L923760-8	L923760-9	L930638-1
Physical Tests														
Moisture	%			0.10	75.9	77.7	77.0	62.3	68.7	68.2	65.0	65.7	61.1	44.2
pH	pH			0.10	5.55	5.47	5.47	5.92	5.73	5.77	6.24	5.21	5.34	5.37
Particle Size														
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	2.43
% Sand (2.0 mm - 0.063 mm)	%			0.10	0.66	0.27	2.18	5.35	4.59	6.02	12.4	3.85	8.56	7.91
% Silt (0.063 mm - 4 µm)	%			0.10	84.9	90.8	89.8	75.7	75.0	76.4	75.0	79.5	77.5	57.9
% Clay (<4 µm)	%			0.10	14.4	8.92	8.03	19.0	20.4	17.6	12.6	16.6	13.9	31.8
Leachable Anions & Nutrients														
Total Nitrogen	%			0.020	0.410	0.425	0.403	0.326	0.314	0.336	0.318	0.373	0.274	0.069
Organic / Inorganic Carbon														
Total Organic Carbon	%			0.10	3.01	3.16	3.04	2.21	2.07	2.18	2.23	2.92	1.95	0.42
Plant Available Nutrients														
Available Ammonium-N	mg/kg			0.80-2.4	10.1	14.7	16.9	6.0	5.4	6.4	10.3	39.6	20.1	4.42
Available Nitrate-N	mg/kg			2.0-7.5	<3.8	<3.8	<3.8	<3.8	<3.8	<3.0	<3.8	<3.0	<3.0	<3.0
Nitrite-N	mg/kg			0.40-1.5	<0.75	<0.75	<0.75	<0.75	<0.75	<0.60	<0.75	<0.60	<0.60	<0.60
Available Phosphate-P	mg/kg			2.0	2.0	<2.0	2.2	<2.0	<2.0	<2.0	2.5	<2.0	<2.0	<2.0
Metals														
Aluminum (Al)	mg/kg			50	30600	28600	28200	23000	21200	21000	16100	21500	18300	16500
Antimony (Sb)	mg/kg			10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic (As)	mg/kg	5.9	17	0.050	4.39	12.2	21.0	3.15	3.77	2.95	2.11	3.04	2.27	5.32
Barium (Ba)	mg/kg			1.0	174	167	187	128	122	119	87.9	120	98.6	93.6
Beryllium (Be)	mg/kg			0.50	0.98	0.96	0.97	0.73	0.69	0.69	<0.50	0.64	0.54	0.57
Bismuth (Bi)	mg/kg			20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	mg/kg	0.6	3.5	0.10	0.11	0.11	0.11	<0.10	<0.10	<0.10	0.10	0.11	0.11	0.23
Calcium (Ca)	mg/kg			50	7030	6600	6580	5950	5500	5490	5580	6200	5520	4280
Chromium (Cr)	mg/kg	37.3	90	2.0	83.1	78.8	77.1	65.0	61.8	59.9	45.9	60.6	52.5	45.5
Cobalt (Co)	mg/kg			2.0	15.6	15.1	16.1	12.7	12.0	11.6	9.6	12.2	11.1	16.2
Copper (Cu)	mg/kg	35.7	197	1.0	45.2	43.9	47.0	29.7	26.9	26.7	22.6	32.4	26.9	21.7
Iron (Fe)	mg/kg			50	47500	55200	67200	31400	33800	31300	23500	33400	27300	31500
Lead (Pb)	mg/kg	35	91.3	2.0	12.0	10.7	10.3	7.8	8.2	8.3	7.5	7.4	6.5	7.4
Lithium (Li)	mg/kg			2.0	52.4	48.3	46.5	40.7	37.9	37.4	28.2	37.7	31.9	30.4
Magnesium (Mg)	mg/kg			50	17500	16200	15600	13600	13100	12800	9860	12900	11200	9620
Manganese (Mn)	mg/kg			1.0	643	761	1660	511	617	554	324	424	330	262
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0807	0.0776	0.0623	0.0281	0.0388	0.0343	0.0152	0.0218	0.0188	0.0060
Molybdenum (Mo)	mg/kg			0.20	1.13	1.08	1.62	1.67	0.98	1.23	1.13	1.56	1.26	2.49
Nickel (Ni)	mg/kg			5.0	49.3	46.6	48.3	36.3	34.2	34.1	24.2	32.3	28.0	26.2
Phosphorus (P)	mg/kg			50	1120	1480	1650	806	955	871	769	873	763	645
Potassium (K)	mg/kg			200	7520	6970	6740	5680	5260	5190	3960	5410	4500	4090
Selenium (Se)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/kg			0.10	0.29	0.27	0.53	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.14
Sodium (Na)	mg/kg			200	1740	1650	1710	1180	1070	1090	850	1130	920	510
Strontium (Sr)	mg/kg			0.50	47.1	44.5	44.4	35.6	32.2	32.7	29.3	34.4	29.4	25.4
Sulphur (S)	mg/kg			100-500	2000	2000	2300	1800	1900	1900	2100	2800	2600	2160
Thallium (Tl)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin (Sn)	mg/kg			5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	mg/kg			1.0	1720	1580	1490	1490	1290	1340	1150	1490	1280	1070
Uranium (U)	mg/kg			0.10	2.23	2.22	2.03	1.61	1.65	1.68	1.30	1.75	1.49	1.99
Vanadium (V)	mg/kg			2.0	86.6	85.4	88.6	69.9	65.7	64.4	51.6	69.1	58.3	49.7
Zinc (Zn)	mg/kg	123	315	1.0	107	102	103	78.5	76.2	74.6	56.4	76.0	65.7	59.5

Notes:

Shaded cells indicate values that exceed CCME guidelines

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A2-6b. Sediment Quality Data for AEMP Lakes, Doris North Project, 2010

Site ID:					Reference B	Reference B	Reference D	Reference D	Reference D
Depth (m):					11	11.25	3	3	3
Replicate:		CCME Guidelines for the		Realized	2	3	1	2	3
Date Sampled:		Protection of Aquatic Life[a]		Detection	25-Aug-10	25-Aug-10	11-Aug-10	11-Aug-10	11-Aug-10
ALS Sample ID:	Units	ISQG[b]	PEL[c]	Limit	L930638-2	L930638-3	L923760-10	L923760-11	L923760-12
Physical Tests									
Moisture	%			0.10	39.3	41.5	45.4	40.1	67.5
pH	pH			0.10	5.44	5.15	5.66	5.61	5.40
Particle Size									
% Gravel (>2 mm)	%			0.10	0.35	<0.10	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	9.01	5.42	59.9	55.7	11.1
% Silt (0.063 mm - 4 µm)	%			0.10	61.6	59.1	37.6	40.7	81.5
% Clay (<4 µm)	%			0.10	29.1	35.5	2.51	3.57	7.37
Leachable Anions & Nutrients									
Total Nitrogen	%			0.020	0.107	0.072	0.172	0.201	0.438
Organic / Inorganic Carbon									
Total Organic Carbon	%			0.10	0.74	0.48	1.20	1.47	3.99
Plant Available Nutrients									
Available Ammonium-N	mg/kg			0.80-2.4	6.0	3.5	12.1	11.0	23.3
Available Nitrate-N	mg/kg			2.0-7.5	<3.0	<3.0	<2.0	<2.5	<4.3
Nitrite-N	mg/kg			0.40-1.5	<0.60	<0.60	<0.40	<0.50	<0.86
Available Phosphate-P	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	2.1
Metals									
Aluminum (Al)	mg/kg			50	17000	16800	8020	7850	16000
Antimony (Sb)	mg/kg			10	<10	<10	<10	<10	<10
Arsenic (As)	mg/kg	5.9	17	0.050	5.47	4.80	0.855	0.894	1.89
Barium (Ba)	mg/kg			1.0	95.6	90.4	41.8	41.2	90.7
Beryllium (Be)	mg/kg			0.50	0.61	0.57	<0.50	<0.50	0.54
Bismuth (Bi)	mg/kg			20	<20	<20	<20	<20	<20
Cadmium (Cd)	mg/kg	0.6	3.5	0.10	0.19	0.30	<0.10	<0.10	0.12
Calcium (Ca)	mg/kg			50	4200	3710	2710	2420	5730
Chromium (Cr)	mg/kg	37.3	90	2.0	47.6	47.0	19.4	19.4	45.6
Cobalt (Co)	mg/kg			2.0	18.1	14.9	4.5	4.4	8.1
Copper (Cu)	mg/kg	35.7	197	1.0	21.3	19.2	10.3	10.2	26.1
Iron (Fe)	mg/kg			50	27100	35900	13300	12300	23400
Lead (Pb)	mg/kg	35	91.3	2.0	7.2	6.9	3.6	3.1	7.7
Lithium (Li)	mg/kg			2.0	31.3	29.9	15.2	15.0	27.6
Magnesium (Mg)	mg/kg			50	9960	9080	4990	4940	9300
Manganese (Mn)	mg/kg			1.0	255	237	150	123	305
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0060	0.0061	0.0099	0.0077	0.0224
Molybdenum (Mo)	mg/kg			0.20	1.87	2.42	0.53	0.52	1.08
Nickel (Ni)	mg/kg			5.0	29.3	24.4	11.2	11.4	24.1
Phosphorus (P)	mg/kg			50	642	702	529	498	864
Potassium (K)	mg/kg			200	4260	3790	1670	1640	3680
Selenium (Se)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/kg			0.10	0.12	0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			200	540	390	360	360	740
Strontium (Sr)	mg/kg			0.50	26.1	23.4	14.3	13.0	30.8
Sulphur (S)	mg/kg			100-500	1950	1910	1700	2100	2800
Thallium (Tl)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin (Sn)	mg/kg			5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	mg/kg			1.0	1090	1050	567	558	1160
Uranium (U)	mg/kg			0.10	1.83	2.06	1.02	1.00	2.29
Vanadium (V)	mg/kg			2.0	50.6	51.7	25.5	25.2	52.6
Zinc (Zn)	mg/kg	123	315	1.0	58.3	62.3	29.8	29.9	59.5

Notes:

Shaded cells indicate values that exceed CCME guidelines

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A2-6c. Sediment Quality Data for AEMP Marine Sites, Doris North Project, 2010

Site ID:					RBE	RBE	RBE	RBW	RBW	RBW	REF-Marine	REF-Marine	REF-Marine
Depth (m):					4.7	4.7	4.7	3.9	3.9	3.9	7	7	7
Replicate:		CCME Guidelines for the		Realized	1	2	3	1	2	3	1	2	3
Date Sampled:		Protection of Aquatic Life[a]		Detection	15-Aug-10	15-Aug-10	15-Aug-10	17-Aug-10	17-Aug-10	17-Aug-10	19-Aug-10	19-Aug-10	19-Aug-10
ALS Sample ID:	Units	ISQG[b]	PEL[c]	Limit	L921370-2	L921370-3	L921370-5	L923230-2	L923230-3	L923230-6	L923230-8	L923230-10	L923230-11
Physical Tests													
Moisture	%			0.10	18.5	18.5	19.1	22.3	32.8	34.0	31.4	32.3	37.3
pH	pH			0.10	6.95	7.09	7.02	7.73	7.42	7.84	7.72	7.20	7.52
Particle Size													
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	90.7	91.4	96.4	72.8	67.6	68.8	56.9	61.3	54.2
% Silt (0.063 mm - 4 µm)	%			0.10	7.03	8.17	2.78	23.0	27.2	27.3	39.3	35.4	41.9
% Clay (<4 µm)	%			0.10	2.30	0.45	0.82	4.17	5.24	3.87	3.85	3.28	3.94
Leachable Anions & Nutrients													
Total Nitrogen	%			0.020	<0.020	<0.020	<0.020	0.052	0.052	0.054	0.073	0.064	0.090
Organic / Inorganic Carbon													
Total Organic Carbon	%			0.10	0.17	<0.10	<0.10	0.37	0.40	0.50	0.51	0.48	0.68
Plant Available Nutrients													
Available Ammonium-N	mg/kg			0.80-1.2	0.95	1.16	1.12	5.82	3.58	9.86	7.48	5.31	7.64
Available Nitrate-N	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Nitrite-N	mg/kg			0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Available Phosphate-P	mg/kg			2.0	4.4	4.3	3.9	13.5	17.2	11.1	14.2	16.4	18.3
Metals													
Aluminum (Al)	mg/kg			50	4720	3670	3580	6330	7270	6840	6190	6310	6860
Antimony (Sb)	mg/kg			10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic (As)	mg/kg	7.24	41.6	0.10	1.18	1.00	1.50	2.51	3.28	2.82	2.13	2.11	2.40
Barium (Ba)	mg/kg			1.0	15.2	8.8	9.0	26.5	30.6	29.1	25.4	26.7	29.4
Beryllium (Be)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bismuth (Bi)	mg/kg			20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium (Cd)	mg/kg	0.7	4.2	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Calcium (Ca)	mg/kg			50	2140	2000	1850	3030	3200	3180	3080	3060	3170
Chromium (Cr)	mg/kg	52.3	160	2.0	14.7	12.4	11.4	22.1	23.7	23.6	15.1	15.9	17.8
Cobalt (Co)	mg/kg			2.0	4.3	3.9	4.0	4.6	5.2	5.2	3.4	3.5	3.7
Copper (Cu)	mg/kg	18.7	108	1.0	11.2	11.1	13.1	12.5	13.6	13.7	7.1	7.8	9.3
Iron (Fe)	mg/kg			50	10100	9510	8440	13400	13800	14400	9240	9460	10400
Lead (Pb)	mg/kg	30.2	112	2.0	<2.0	<2.0	<2.0	2.4	2.8	2.8	2.3	2.3	2.6
Lithium (Li)	mg/kg			2.0	9.0	7.3	7.2	11.3	13.1	12.5	12.2	12.7	14.1
Magnesium (Mg)	mg/kg			50	3830	2980	3010	5260	6020	5880	4800	4950	5500
Manganese (Mn)	mg/kg			1.0	90.9	79.6	76.3	118	131	127	98.7	101	109
Mercury (Hg)	mg/kg	0.13	0.70	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum (Mo)	mg/kg			0.20	0.23	<0.20	<0.20	0.68	0.69	0.84	0.70	0.75	1.08
Nickel (Ni)	mg/kg			5.0	8.2	6.6	6.9	10.7	11.9	12.1	7.7	8.0	9.3
Phosphorus (P)	mg/kg			50	294	316	293	574	524	576	588	579	612
Potassium (K)	mg/kg			200	960	540	540	1530	1830	1770	1600	1660	1890
Selenium (Se)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			200	2130	970	1000	2810	3700	3770	3520	3660	4140
Strontium (Sr)	mg/kg			0.50	11.6	8.65	7.93	16.9	18.7	18.3	19.1	18.9	20.3
Sulphur (S)	mg/kg			100	590	540	570	670	750	1030	1210	1170	1560
Thallium (Tl)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin (Sn)	mg/kg			5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	mg/kg			1.0	440	356	326	533	579	561	541	547	566
Uranium (U)	mg/kg			0.10	0.467	0.949	0.433	0.542	0.590	0.577	0.727	0.722	0.787
Vanadium (V)	mg/kg			2.0	23.6	22.7	19.0	30.0	31.5	31.8	22.6	23.5	25.3
Zinc (Zn)	mg/kg	124	271	1.0	16.0	12.3	11.3	20.5	24.2	22.6	19.4	20.3	22.3

Notes:

Shaded cells indicate values that exceed CCME guidelines

a) Canadian sediment quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A2-7

Primary Production Data for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A2-7a. Periphyton Biomass Data for AEMP Streams, Doris North Project, 2010

Site	Replicate	Date Sampled	Detection Limit ($\mu g/cm^2$)	Chlorophyll *a* ($\mu g/cm^2$)
Doris OF	1	17-Jul-10	0.1	0.106
Doris OF	2	17-Jul-10	0.1	0.139
Doris OF	3	17-Jul-10	0.01	0.023
Doris OF	1	19-Aug-10	0.1	0.123
Doris OF	2	20-Aug-10	0.1	0.216
Doris OF	3	20-Aug-10	0.1	0.229
Doris OF	1	20-Sep-10	0.1	0.185
Doris OF	2	20-Sep-10	0.1	0.113
Doris OF	3	20-Sep-10	0.1	0.080
Little Roberts OF	1	17-Jul-10	0.01	0.024
Little Roberts OF	2	17-Jul-10	0.1	0.069
Little Roberts OF	3	17-Jul-10	0.1	0.202
Little Roberts OF	1	19-Aug-10	0.1	2.560
Little Roberts OF	2	19-Aug-10	0.1	0.488
Little Roberts OF	3	19-Aug-10	0.1	0.848
Little Roberts OF	1	20-Sep-10	0.1	0.356
Little Roberts OF	2	20-Sep-10	0.1	0.372
Little Roberts OF	3	20-Sep-10	0.1	0.150
Roberts OF	1	17-Jul-10	0.1	0.496
Roberts OF	2	17-Jul-10	NC - too much sediment on plate	
Roberts OF	3	17-Jul-10	0.1	0.068
Roberts OF	1	19-Aug-10	0.1	0.118
Roberts OF	2	19-Aug-10	0.1	0.401
Roberts OF	3	19-Aug-10	0.1	0.100
Roberts OF	1	20-Sep-10	0.1	0.167
Roberts OF	2	20-Sep-10	0.1	0.148
Roberts OF	3	20-Sep-10	0.01	0.014
Reference B OF	1	18-Jul-10	0.01	0.015
Reference B OF	2	18-Jul-10	0.01	0.008
Reference B OF	3	18-Jul-10	0.1	0.070
Reference B OF	1	19-Aug-10	0.1	0.212
Reference B OF	2	19-Aug-10	0.1	0.128
Reference B OF	3	19-Aug-10	0.1	0.156
Reference B OF	1	20-Sep-10	0.1	0.068
Reference B OF	2	20-Sep-10	0.1	0.187
Reference B OF	3	20-Sep-10	0.1	0.049
Reference D OF	1	18-Jul-10	0.1	0.128
Reference D OF	2	18-Jul-10	0.1	0.143
Reference D OF	3	18-Jul-10	0.1	0.138
Reference D OF	1	19-Aug-10	0.1	0.386
Reference D OF	2	19-Aug-10	0.1	0.040
Reference D OF	3	19-Aug-10	0.1	0.105
Reference D OF	1	20-Sep-10	0.1	0.545
Reference D OF	2	20-Sep-10	0.1	0.135
Reference D OF	3	20-Sep-10	0.01	0.017

NC = Not collected

Plates were installed for approximately one month.

Appendix A2-7b. Phytoplankton Biomass Data for AEMP Lakes, Doris North Project, 2010

Site	Replicate	Date Sampled	Detection Limit (µg/L)	Chlorophyll *a* (µg/L)
Doris South	1	22-Apr-10	0.02	10.10
Doris South	2	22-Apr-10	0.02	4.49
Doris South	3	22-Apr-10	0.04	4.76
Doris South	1	15-Jul-10	0.04	7.68
Doris South	2	15-Jul-10	0.04	8.86
Doris South	3	15-Jul-10	0.04	8.45
Doris South	1	8-Aug-10	0.04	11.90
Doris South	2	8-Aug-10	0.04	8.22
Doris South	3	8-Aug-10	0.04	12.00
Doris South	1	12-Sep-10	0.1	43.60
Doris South	2	12-Sep-10	0.1	25.90
Doris South	3	12-Sep-10	0.01	8.74
Doris North	1	22-Apr-10	0.02	16.90
Doris North	2	22-Apr-10	0.02	6.98
Doris North	3	22-Apr-10	0.02	0.77
Doris North	1	12-Jul-10	0.04	9.40
Doris North	2	12-Jul-10	0.04	8.80
Doris North	3	12-Jul-10	0.04	9.01
Doris North	1	9-Aug-10	0.04	12.40
Doris North	2	9-Aug-10	0.04	13.80
Doris North	3	9-Aug-10	0.04	10.80
Doris North	1	12-Sep-10	0.1	24.80
Doris North	2	12-Sep-10	0.01	4.16
Doris North	3	12-Sep-10	0.01	5.88
Little Roberts	1	22-Apr-10	0.04	2.74
Little Roberts	2	22-Apr-10	0.04	3.32
Little Roberts	3	22-Apr-10	0.04	2.81
Little Roberts	1	19-Jul-10	0.04	4.85
Little Roberts	2	19-Jul-10	0.04	5.12
Little Roberts	3	19-Jul-10	0.04	5.38
Little Roberts	1	10-Aug-10	0.04	1.11
Little Roberts	2	10-Aug-10	0.04	6.14
Little Roberts	3	10-Aug-10	0.04	6.58
Little Roberts	1	12-Sep-10	0.01	3.07
Little Roberts	2	12-Sep-10	0.01	7.65
Little Roberts	3	12-Sep-10	0.01	9.29
Reference B	1	19-Apr-10	0.01	0.89
Reference B	2	19-Apr-10	0.01	1.05
Reference B	3	19-Apr-10	0.01	0.95
Reference B	1	18-Jul-10	0.02	0.89
Reference B	2	18-Jul-10	0.02	0.89
Reference B	3	18-Jul-10	0.02	0.61
Reference B	1	24-Aug-10	0.01	0.43
Reference B	2	24-Aug-10	0.01	0.26
Reference B	3	24-Aug-10	0.01	0.21
Reference B	1	17-Sep-10	0.01	0.45
Reference B	2	17-Sep-10	0.01	0.37
Reference B	3	17-Sep-10	0.01	0.16
Reference D	1	19-Apr-10	0.01	0.69
Reference D	2	19-Apr-10	0.01	0.40
Reference D	3	19-Apr-10	0.01	0.52
Reference D	1	18-Jul-10	0.02	0.75
Reference D	2	18-Jul-10	0.02	0.80
Reference D	3	18-Jul-10	0.02	0.64
Reference D	1	11-Aug-10	0.04	0.87
Reference D	2	11-Aug-10	0.04	0.93
Reference D	3	11-Aug-10	0.04	0.88
Reference D	1	25-Sep-10	0.01	0.67
Reference D	2	25-Sep-10	0.01	0.69
Reference D	3	25-Sep-10	0.01	0.75

Appendix A2-7c. Phytoplankton Biomass Data for AEMP Marine Sites, Doris North Project, 2010

Site	Replicate	Date Sampled	Detection Limit (µg/L)	Chlorophyll *a* (µg/L)
RBW	1	24-Apr-10	0.01	0.92
RBW	2	24-Apr-10	0.01	0.51
RBW	3	24-Apr-10	0.01	0.36
RBW	1	20-Jul-10	0.01	0.20
RBW	2	20-Jul-10	0.01	0.19
RBW	3	20-Jul-10	0.01	0.18
RBW	1	17-Aug-10	0.01	1.21
RBW	2	17-Aug-10	0.01	1.37
RBW	3	17-Aug-10	0.01	1.30
RBW	1	30-Sep-10	0.01	0.30
RBW	2	30-Sep-10	0.01	0.33
RBW	3	30-Sep-10	0.01	0.21
RBE	1	24-Apr-10	0.01	0.41
RBE	2	24-Apr-10	0.01	0.71
RBE	3	24-Apr-10	0.01	0.17
RBE	1	20-Jul-10	0.01	0.25
RBE	2	20-Jul-10	0.01	0.20
RBE	3	20-Jul-10	0.01	0.15
RBE	1	17-Aug-10	0.1	5.58
RBE	2	17-Aug-10	0.1	5.33
RBE	3	17-Aug-10	0.1	10.00
RBE	1	30-Sep-10	0.01	0.78
RBE	2	30-Sep-10	0.01	0.11
RBE	3	30-Sep-10	0.01	0.62
REF-Marine	1	April	NC - due to melting ice	
REF-Marine	2	April	NC - due to melting ice	
REF-Marine	3	April	NC - due to melting ice	
REF-Marine	1	13-Jul-10	0.01	0.19
REF-Marine	2	13-Jul-10	0.01	0.16
REF-Marine	3	13-Jul-10	0.01	0.17
REF-Marine	1	19-Aug-10	0.01	0.36
REF-Marine	2	19-Aug-10	0.01	0.51
REF-Marine	3	19-Aug-10	0.01	0.57
REF-Marine	1	28-Sep-10	0.01	0.20
REF-Marine	2	28-Sep-10	0.01	0.21
REF-Marine	3	28-Sep-10	0.01	0.07

NC = Not collected

Appendix A2-8

Benthos Taxonomy Data for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A2-8a. Benthos Taxonomy Data for AEMP Streams, Doris North Project, 2010

Taxonomic Identification			Doris OF					Little Roberts OF					Roberts OF					Reference B OF					Reference D OF				
Major Group	**Family**	**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**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
Coelenterata	Hydridae	*Hydra*	48	385	648	144	688		24	36	15	21	1981	312	531	426	193			1		4	40	55	1	5	10
Microturbellaria	Typhloplanidae	*Mesostoma*	1	4	22	34	34										5			13		16				1	
Nematoda	-	-	2	64	31	19	228	10	69	10	49	14	141	95	65	73	56	16	11	3	33	4	20	16	8	36	18
Hirudinea	Piscicolidae	*Piscicola punctata*						1																			
Oligochaeta	-	(i/d)						16																			
	Enchytraeidae	-	48	160	497	1	129		5	2	16	13	10	8	1	242	35	28				13	39		16		
	Lumbriculidae	-	1	1	8	36	10	12	5	4	14	19	3		4	29	1	27	17	1	50	6	16	23	7	8	24
	Naididae	-	6	8	24		32		8		2	4	90	16	24	8	1	8	10	6		8	28	1	40	73	15
	Tubificidae	-	10	52	9	66	5	41	18	5	23	7	8	1	29	107	3	55	10	1	13	4	9	44	4		88
Gastropoda	Physidae	*Physa*																	5	58	105	19					
	Valvatidae	*Valvata sincera*	1															1	1		6	4	7	65	38	11	35
Pelecypoda	Sphaeriidae	(i/d)																7	1								
		Sphaerium																									
		Pisidium																3									
Hydracarina	-	-	77	410	238	26	497	8	27	12	25	23	19	54	47	17	35		2	5	10	9	24	6	10	54	7
Copepoda - Calanoida	-	-	37	48	48	8	16					1			16		10										
Copepoda - Cyclopoida	Cyclopidae	*Acanthocyclops*	1					24		1		1	10					32	10	5	20			45	64	15	30
Ostracoda	-	-	5	88	64	520	32	168	12			2	111		8	56		104	17	19	84	68	12	90	232	70	150
Cladocera	Chydoridae	*Eurycercus*						144	8									95	3		17			3	3	1	10
	Macrothricidae	-																									
Amphipoda	Epimeriidae	*Epimeria loricata*																									
	Gammaridae	*Gammarus lacustris*																							1		
Malacostraca	Mysidae	*Mysis relicta*			2																						
Isopoda	Chaetiliidae	*Saduria entomon*											4			2											
Ephemeroptera	Baetidae	*Baetis*	3	12	16		52		3	5	11	6				2	5			4	1		2		6	8	2
	Ephemerellidae	*Ephemerella*		1																2		2					
Plecoptera	Nemouridae	(i/d)																						5			
		Nemoura	33	160	142	12	87		15	29	39	25	7	22	13	12	1		2	5	4	8	54	2	6	30	5
Trichoptera	Apataniidae	*Apatania*								2	5																
	Brachycentridae	*Brachycentrus*																		6							
	Limnephilidae	*Grensia praeterica*			2			5				1									5			5	2		1
Coleoptera	Dytiscidae	*Oreodytes*																6		1	1						2
Diptera	Chironomidae	(pupa)	14	66	46	1	212		12	1	2	5					2			4		8	4				1
		(i/d)						8							1			8	2	1		1					
		Ablabesmyia																						5	4		
		Thienemannimyia group	10	33	45	16	101	54	34	6	19	33	2		9		6	116	42	33	206	115	26	4	14	30	25
		Procladius						12					1					12			4			30	8		48
		Diamesa	29	125	106	17	129		14		37	4	155	246	404	135	142			1			28				6
		Potthastia longimana group					1																				
		Protanypus																						2	1		1
		Monodiamesa																									
		(i/d)				1		9	4			1															
		Abyskomyia						16					1														
		Bryophaenocladius ?																	1								
		Cricotopus/Orthocladius		33			16	1		1	29	18	55	82	103	112	52			2		13		5	8	31	
		Corynoneura						8																			
		Doncricotopus											1														
		Eukiefferiella	4	8											8					1			4			5	
		Euryhapsis		11	3		6				1	3	1							1		5	41	2		6	5
		Heterotanytarsus																	1								
		Paracladius																									
		Parakiefferiella		16	8	8	16	40			5	5											4				
		Psectrocladius						17										258	30	4	19	8		28	21	24	31
		Pseudosmittia																			4						
		Tvetenia	35	135	149	1	589		34	16	55	41	13	13	28	14	46			2						5	
		Zalutschia																56									15
		(i/d)																						1			
		Chironomus		1				8													1						

Appendix A2-8a. Benthos Taxonomy Data for AEMP Streams, Doris North Project, 2010

Taxonomic Identification			Doris OF					Little Roberts OF					Roberts OF					Reference B OF					Reference D OF				
Major Group	**Family**	**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**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
Diptera	Chironomidae	*Cladopelma*																									
		Cryptochironomus						1	1										2		5			3			
		Demicryptochironomus																								1	
		Dicrotendipes																	8	3	2		1	15	78	79	12
		Parachironomus																									
		Polypedilum						1								8		4									
		Sergenta			8	265		174	4				5					4						80	16	6	42
		Stictochironomus		3	1	47		22			24		48		2	2		28	13		7		1	64	63	38	105
		Cladotanytarsus	1	8		8		8	16		8			8		1	6								8		
		Corynocera						16																			
		Micropsectra					16				1	3					5					16		1	33	15	18
		Micropsectra/Tanytarsus																									
		Paratanytarsus									8	3			1			185	24	10	32	2	19	5	1	1	8
		Stempellina											5								8			5			5
		Tanytarsus						170	8		4	2	5	1				156	1		4						5
	Empididae	(pupa)			1																						
		Chelifera																						2	1		
		Clinocera																		1	1	1					
	Simulidae	*Simulium*											1	6	6	11	1			6							
		Simulium - pupa							4		2		19	67	116	35	22			1							
	Tipulidae	*Tipula*	20	56	39	62	24	12	14	6	6	5	42	6	18	27	11	10	10	5	68	10	18	32	28	8	22
Terrestrial	-	-	7	4	1		1		2									3		1	1	2					5
Fish	Salmonidae	*Salvelinus alpinus* (Arctic Char)																				1					
Fish	Gasterosteidae	*Pungitius pungitius* (Ninespine Stickleback)							3				2											2	1		1
TOTAL number of individuals			393	1892	2158	1292	2921	1006	344	136	400	260	2740	937	1434	1319	638	1222	223	206	711	347	397	646	723	561	752

Note:

i/d = immature or damaged individuals

Appendix A2-8b. Benthos Taxonomy Data for AEMP Lakes, Doris North Project, 2010

Taxonomic Identification			Doris South					Doris North					Little Roberts					Reference B					Reference D				
Major Group	**Family**	**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**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
Coelenterata	Hydridae	*Hydra*																								
Microturbellaria	Typhloplanidae	*Mesostoma*																								
Nematoda	-	-		5							1	3	2	26	8		35	61	129	218	229	131	40	45	56	123	20
Hirudinea	Piscicolidae	*Piscicola punctata*																								
Oligochaeta	-	(i/d)																								
	Enchytraeidae	-																								
	Lumbriculidae	-											1		2	2	3					1		5			4
	Naididae	-																				2					
	Tubificidae	-	3	1	15	11	2	12	8	71	19	17			1			78	38	76	66	19	1	25	16	3	8
Gastropoda	Physidae	*Physa*																								
	Valvatidae	*Valvata sincera*																					17	8	47	52	48
Pelecypoda	Sphaeriidae	(i/d)								1	1	3	18	33	26	8		9	20	108	67	19	116	54	157	167	180
		Sphaerium																		1		1			23	21	8
		Pisidium						1	4	4	4	4	28	21	19	19	5	9	2	20	15	12	51	14	8	61	52
Hydracarina	-	-											72	34	4	40	4						8			1	28
Copepoda - Calanoida	-	-					2	3	1	1	6	11										2					
Copepoda - Cyclopoida	Cyclopidae	*Acanthocyclops*		2									12		16		8						8				20
Ostracoda	-	-	108	85	26	40	33	12		5	2	2	96	24	80	144	88			5	1	6	64	12	248	16	100
Cladocera	Chydoridae	*Eurycercus*																1									
	Bosminidae	*Bosmina*																	1								
	Daphnidae	*Daphnia*																	1								
	Macrothricidae	-	1	7			2																				
Amphipoda	Epimeriidae	*Epimeria loricata*								1															1		
	Gammaridae	*Gammarus lacustris*																	1								
Malacostraca	Mysidae	*Mysis relicta*																		2		1					
Isopoda	Chaetiliidae	*Saduria entomon*					1																				
Ephemeroptera	Baetidae	*Baetis*																									
	Ephemerellidae	*Ephemerella*																									
Plecoptera	Nemouridae	(i/d)																									
		Nemoura															1										
Trichoptera	Apataniidae	*Apatania*																									
	Brachycentridae	*Brachycentrus*																									
	Limnephilidae	*Grensia praeterica*													3	1									7	4	4
Coleoptera	Dytiscidae	*Oreodytes*																									
Diptera	Chironomidae	(pupa)	2	5	2	1		4	5	1		5	4														
		(i/d)												1										7	8	24	
		Ablabesmyia																							5	8	4
		Thienemannimyia group												1													
		Procladius	51	45	28	16	43	4		8	6		100	34	139	93	40		1	6	1	4	19	6	46	55	24
		Diamesa																									
		Potthastia longimana group														1											
		Protanypus																2	2	12		5					
		Monodiamesa	7	6	3	1	7					1						1	1			2					
		(i/d)																					8	10			
		Abyskomyia																									
		Bryophaenocladius ?																									
		Cricotopus/Orthocladius													33	34	1							5			
		Corynoneura																						5			
		Doncricotopus																									
		Eukiefferiella																									
		Euryhapsis																									
		Heterotanytarsus																									
		Heterotrissocladius																1	3	56	28	18					
		Heterotrissocladius/Hydrobaenus																									
		Mesocricotopus																1	1			2					
		Paracladius		6	2	3	1														1						

Appendix A2-8b. Benthos Taxonomy Data for AEMP Lakes, Doris North Project, 2010

Taxonomic Identification			Doris South					Doris North					Little Roberts					Reference B					Reference D				
Major Group	**Family**	**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**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
Diptera	Chironomidae	*Parakiefferiella*																									
		Psectrocladius																	1	1	1						
		Pseudosmittia																									
		Tvetenia																									
		Zalutschia														1		2	1	12		24					
		(i/d)																					8	10			
		Chironomus	6	8	7	7	4	136	124	36	122	80	2	17	13	19	35						1	61	16	6	20
		Cladopelma																						5			4
		Cryptochironomus																						2			
		Demicryptochironomus																									
		Dicrotendipes												1													
		Parachironomus																					8				
		Polypedilum																									
		Sergenta											8		2	3	4						214	177	222	137	272
		Stictochironomus	17	12	5	10	5						1									4					
		Cladotanytarsus																									
		Corynocera																					1	299	23	101	24
		Micropsectra	1																								
		Micropsectra/Tanytarsus																					8	25	8		
		Paratanytarsus											327	1048	250	693	489						34	67	8	50	24
		Stempellina																									
		Tanytarsus		1	2		1						231	65	305	20		23	20	115	69	29	103	87	72	64	48
	Empididae	(pupa)																									
		Chelifera																									
		Clinocera																									
	Simulidae	*Simulium*																									
		Simulium - pupa																									
	Tipulidae	*Tipula*																									
Terrestrial	-	-																									
Fish	Salmonidae	*Salvelinus alpinus* (Arctic Char)																									
Fish	Gasterosteidae	*Pungitius pungitius* (Ninespine Stickleback)																									
TOTAL number of individuals			196	183	90	89	101	172	142	128	161	126	902	1305	901	1078	713	188	222	632	478	282	709	929	971	893	892

Note:

i/d = immature or damaged individuals

Appendix A2-8c. Benthos Taxonomy Data for AEMP Marine Sites, Doris North Project, 2010

Taxonomic Identification			Roberts Bay West (RBW)										Roberts Bay East (RBE)									
Major Group	**Family**	**Genus**	**Rep-1**	**Rep-1**	**Rep-2**	**Rep-2**	**Rep-3**	**Rep-3**	**Rep-4**	**Rep-4**	**Rep-5**	**Rep-5**	**Rep-1**	**Rep-1**	**Rep-2**	**Rep-2**	**Rep-3**	**Rep-3**	**Rep-4**	**Rep-4**	**Rep-5**	**Rep-5**
			A	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**
ANNELIDA																						
Polychaeta Errantia	Phyllodocidae	*Eteone longa*													3		1		1			
		Phyllodoce groenlandica	1		2						1											
	Polynoidae	*Harmothoe imbricata Cmplx.*									2											
	Hesionidae	*Hesionidae Indet.*					1															
	Nephtyidae	*Nephtys* sp.	186	27	221	33	316	63	254	26	301	81	1									
	Pholoidae	*Pholoe* sp.			1	2	1		1		1											
		Pholoides asperus	1				10		5		2											
Polychaeta Sedentaria	Paraonidae	*Aricidea sp.*					2		2		1											
		Paraonidae Indet.							1													
	Maldanidae	*Axiothella sp.*	1								1											
	Orbiniidae	*Leitoscoloplos sp.*	8	7	12	2	23	5	20	2	18	7										
	Capitellidae	*Mediomastus sp.*	1		1		7		6		3											
		Notomastus sp.			3																	
		Capitella capitata Cmplx.																				
	Pectinariidae	*Pectinaria granulata*	2		4		3		2		8											
		Pectinaria sp.	11		15		14		7		11											
	Spionidae	*Prionospio sp.*					1															
		Spio sp.	2				1				4											
		Marenzelleria arctia	1				1						1	6		5	2	13	6	10	2	4
Oligochaeta	Enchytraeidae	*Enchytraeidae Indet.*	2										1									
ARTHROPODA																						
Amphipoda	Lysianassidae	*Boeckosimus affinis*																				
		Lysianassidae Indet.			1																	
	Gammaracanthidae	*Gammaracanthus loricatus*			1																	
	Pontoporeiidae	*Pontoporeia femorata*	1					1														
Copepoda		*Harpacticoida*							1				2				1		2			
Ostracoda		*Ostracoda Indet.*			1																	
Cumacea	Leuconidae	*Eudorella pacifica*																				
Isopoda	Chaetiliidae	*Saduria entomon*			1	1	2	4	1	1	3	1										
Decapoda	Decopoda (Order)	*Natantia megalops*				1		1				1										
MOLLUSCA																						
Gastropoda	Cylichnidae	*Cylichna sp.*	5		3		23	3	15		11	1										
Bivalvia	Astartidae	*Astarte borealis*	1						2		1											
	Thyasiridae	*Axinopsida orbiculata*																				
	Tellinidae	*Macoma balthica*	1	1	2	8	6	17	2	9		5										
		Macoma sp.																				
	Mytilidae	*Musculus niger*					1															
UROCHORDATA																						
Ascidiacea	Molgulidae	*Rhizomolgula globularis*									1											
Nematoda			1						1				4		8		5		13		9	
TOTAL number of individuals			225	35	268	47	412	94	320	38	369	96	9	6	11	5	9	13	22	10	11	4

J = juvenile

A = adult

Appendix A2-8c. Benthos Taxonomy Data for AEMP Marine Sites, Doris North Project, 2010

Taxonomic Identification			Reference Bay (REF-Marine)									
Major Group	**Family**	**Genus**	**Rep-1**	**Rep-1**	**Rep-2**	**Rep-2**	**Rep-3**	**Rep-3**	**Rep-4**	**Rep-4**	**Rep-5**	**Rep-5**
			A	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**
ANNELIDA												
Polychaeta Errantia	Phyllodocidae	*Eteone longa*			4				1			
		Phyllodoce groenlandica										
	Polynoidae	*Harmothoe imbricata Cmplx.*										
	Hesionidae	*Hesionidae Indet.*										
	Nephtyidae	*Nephtys* sp.	1									
	Pholoidae	*Pholoe* sp.										
		Pholoides asperus										
Polychaeta Sedentaria	Paraonidae	*Aricidea sp.*										
		Paraonidae Indet.										
	Maldanidae	*Axiothella sp.*										
	Orbiniidae	*Leitoscoloplos sp.*										
	Capitellidae	*Mediomastus sp.*										
		Notomastus sp.										
		Capitella capitata Cmplx.	1									
	Pectinariidae	*Pectinaria granulata*										
		Pectinaria sp.										
	Spionidae	*Prionospio sp.*										
		Spio sp.										
		Marenzelleria arctia	8	5	11	8	1	7	10	1	3	
Oligochaeta	Enchytraeidae	*Enchytraeidae Indet.*			3		1		1		1	
ARTHROPODA												
Amphipoda	Lysianassidae	*Boeckosimus affinis*			3		2					
		Lysianassidae Indet.										
	Gammaracanthidae	*Gammaracanthus loricatus*										
	Pontoporeiidae	*Pontoporeia femorata*										
Copepoda		*Harpacticoida*										
Ostracoda		*Ostracoda Indet.*										
Cumacea	Leuconidae	*Eudorella pacifica*			1							
Isopoda	Chaetiliidae	*Saduria entomon*			4							
Decapoda	Decopoda (Order)	*Natantia megalops*										
MOLLUSCA												
Gastropoda	Cylichnidae	*Cylichna sp.*										
Bivalvia	Astartidae	*Astarte borealis*										
	Thyasiridae	*Axinopsida orbiculata*		1		1				3		2
	Tellinidae	*Macoma balthica*	2	52	4	86	12	93	12	17	2	15
		Macoma sp.	1									
	Mytilidae	*Musculus niger*										
UROCHORDATA												
Ascidiacea	Molgulidae	*Rhizomolgula globularis*										
Nematoda					4				1		1	
TOTAL number of individuals			13	58	34	95	16	100	25	21	7	17

J = juvenile

A = adult

Appendix A2-9

Results of Benthos QA/QC Sorting Efficiencies, Doris North Project, 2010

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Appendix A2-9. Results of Benthos QA/QC Sorting Efficiencies, Doris North Project, 2010

Sample ID	# from First Sort	QAQC Re-sort # Found	Initial Sort Efficiency (%)	Re-sort Required?	Final Efficiency (%)
Freshwater					
Reference B OF 2	223	4	98.2	N	98.2
Little Roberts Lake 5	713	10	98.6	N	98.6
Doris Lake South 4	89	1	98.9	N	98.9
Doris Lake North 1	172	3	98.3	N	98.3
Reference D OF 1	393	6	98.5	N	98.5
Marine					
REF-Marine 1	71	0	100	N	100
REF-Marine 2	125	0	100	N	100
REF-Marine 3	116	0	100	N	100
REF-Marine 4	45	0	100	N	100
REF-Marine 5	23	0	100	N	100
RBE 1	11	0	100	N	100
RBE 2	8	0	100	N	100
RBE 3	17	0	100	N	100
RBE 4	19	0	100	N	100
RBE 5	6	0	100	N	100
RBW 1	259	0	100	N	100
RBW 2	315	0	100	N	100
RBW 3	506	0	100	N	100
RBW 4	357	0	100	N	100
RBW 5	465	0	100	N	100

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/AC re-sort / (# first sort + # QA/QC resort))]*100*

Appendix A3

2010 Aquatic Resources Summary Statistics, Doris North Project

Appendix A3-1. Sediment Quality Summary Statistics for AEMP Aquatic Sites, Doris North Project, 2010

Appendix A3-2. Primary Production Summary Statistics for AEMP Aquatic Sites, Doris North Project, 2010

Appendix A3-3. Benthos Summary Statistics for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A3-1

Sediment Quality Summary Statistics for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A3-1a. Sediment Quality Summary Statistics for AEMP Streams, Doris North Project, 2010

Stream	Units	CCME Guidelines for the Protection of Aquatic Life[a]		Doris Outflow						Little Roberts Outflow						Roberts Outflow					
		ISQG[b]	PEL[c]	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE
Physical Tests																					
Moisture	%			8.30	31.90	16.90	19.03	11.94	6.90	41.80	45.70	43.40	43.63	1.96	1.13	22.90	50.60	29.70	34.40	14.44	8.33
pH	pH			6.29	6.94	6.65	6.63	0.33	0.19	5.68	6.15	6.07	5.97	0.25	0.15	6.08	8.50	8.06	7.55	1.29	0.74
Particle Size																					
% Gravel (>2 mm)	%			3.75	37.80	22.80	21.45	17.07	9.85	<0.1	<0.1	-	-	-	-	<0.1	10.80	<0.1	3.63	6.21	3.58
% Sand (2.0 mm - 0.063 mm)	%			43.8	81.4	68.1	64.4	19.1	11.0	46.6	63.1	62.2	57.3	9.3	5.4	35.9	60.8	46.8	47.8	12.5	7.2
% Silt (0.063 mm - 4 µm)	%			6.96	14.90	9.87	10.58	4.02	2.32	25.20	44.70	25.50	31.80	11.17	6.45	16.70	36.00	25.80	26.17	9.66	5.57
% Clay (<4 µm)	%			2.2	5.0	3.5	3.6	1.4	0.8	8.7	12.6	11.3	10.9	2.0	1.2	11.7	28.1	27.4	22.4	9.3	5.4
Leachable Anions & Nutrients																					
Total Nitrogen	%			0.080	0.193	0.136	0.136	0.057	0.033	0.109	0.162	0.119	0.130	0.028	0.016	<0.02	0.066	0.024	0.033	0.029	0.017
Organic / Inorganic Carbon																					
Total Organic Carbon	%			0.26	1.79	0.79	0.95	0.78	0.45	1.32	2.75	1.73	1.93	0.74	0.43	0.12	0.94	0.24	0.43	0.44	0.26
Plant Available Nutrients																					
Available Ammonium-N	mg/kg			1.23	2.40	2.27	1.97	0.64	0.37	5.60	6.20	5.70	5.83	0.32	0.19	<1.5	3.70	1.60	2.02	1.52	0.88
Available Nitrate-N	mg/kg			<2	<3	-	-	-	-	<5	<5	-	-	-	-	<3	<3.8	-	-	-	-
Nitrite-N	mg/kg			<0.4	<0.6	-	-	-	-	<1	<1	-	-	-	-	<0.4	<0.75	-	-	-	-
Available Phosphate-P	mg/kg			2.5	4.3	2.5	3.1	1.0	0.6	4.8	5.8	5.3	5.3	0.5	0.3	2.2	5.0	3.1	3.4	1.4	0.8
Metals																					
Aluminum (Al)	mg/kg			6230	10400	6560	7730	2318	1338	8850	12000	9900	10250	1604	926	11800	17700	14100	14533	2974	1717
Antimony (Sb)	mg/kg			<10	<10	-	-	-	-	<10	<10	-	-	-	-	<10	<10	-	-	-	-
Arsenic (As)	mg/kg	5.9	17	0.542	9.970	0.570	3.694	5.435	3.138	1.340	2.520	1.520	1.793	0.636	0.367	2.270	3.300	2.640	2.737	0.522	0.301
Barium (Ba)	mg/kg			14.1	46.6	24.9	28.5	16.6	09.6	39.8	56.0	45.5	47.1	08.2	04.7	63.1	103.0	75.9	80.7	20.4	11.8
Beryllium (Be)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	0.57	<0.5	0.36	0.18	0.11
Bismuth (Bi)	mg/kg			<20	<20	-	-	-	-	<20	<20	-	-	-	-	<20	<20	-	-	-	-
Cadmium (Cd)	mg/kg	0.6	3.5	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-
Calcium (Ca)	mg/kg			1920	3390	2520	2610	739	427	2980	4160	3080	3407	654	378	3520	6250	5080	4950	1370	791
Chromium (Cr)	mg/kg	37.3	90	16.5	26.7	17.9	20.4	5.5	3.2	25.3	33.9	27.7	29.0	4.4	2.6	34.0	50.6	39.7	41.4	8.4	4.9
Cobalt (Co)	mg/kg			4.8	5.9	5.0	5.2	0.6	0.3	5.1	6.9	5.7	5.9	0.9	0.5	7.9	12.0	10.0	10.0	2.1	1.2
Copper (Cu)	mg/kg	35.7	197	6.8	19.6	13.8	13.4	6.4	3.7	11.2	14.7	12.0	12.6	1.8	1.1	20.1	28.4	24.4	24.3	4.2	2.4
Iron (Fe)	mg/kg			12700	17000	12900	14200	2427	1401	13000	16800	15000	14933	1901	1097	17900	27400	22200	22500	4757	2747
Lead (Pb)	mg/kg	35	91.3	<2	3.5	2.2	2.2	1.3	0.7	3.4	4.9	3.8	4.0	0.8	0.4	4.8	6.7	5.3	5.6	1.0	0.6
Lithium (Li)	mg/kg			11.3	17.5	12.5	13.8	3.3	1.9	16.3	21.4	18.2	18.6	2.6	1.5	22.4	32.7	26.4	27.2	5.2	3.0
Magnesium (Mg)	mg/kg			4650	6650	5100	5467	1049	606	6450	8430	7080	7320	1012	584	8800	13700	10800	11100	2464	1422
Manganese (Mn)	mg/kg			151	165	163	160	8	4	175	203	184	187	14	8	191	386	286	288	98	56
Mercury (Hg)	mg/kg	0.17	0.486	<0.005	0.0131	0.0052	0.0069	0.0055	0.0032	0.0078	0.0142	0.0078	0.0099	0.0037	0.0021	0.0025	0.0080	0.0025	0.0043	0.0032	0.0018
Molybdenum (Mo)	mg/kg			<0.2	0.75	0.35	0.40	0.33	0.19	0.66	0.90	0.89	0.82	0.14	0.08	0.46	0.52	0.47	0.48	0.03	0.02
Nickel (Ni)	mg/kg			10.2	15.1	10.8	12.0	2.7	1.5	12.8	17.3	14.0	14.7	2.3	1.3	18.7	26.8	21.5	22.3	4.1	2.4
Phosphorus (P)	mg/kg			302	444	311	352	80	46	415	483	433	444	35	20	439	628	493	520	97	56
Potassium (K)	mg/kg			660	2020	1220	1300	684	395	1750	2520	2020	2097	391	226	2800	5110	3980	3963	1155	667
Selenium (Se)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Silver (Ag)	mg/kg			<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-	<0.1	0.12	<0.1	0.07	0.04	0.02
Sodium (Na)	mg/kg			<200	460	350	303	184	107	360	540	410	437	93	54	480	1410	1070	987	471	272
Strontium (Sr)	mg/kg			9.86	18.00	11.80	13.22	4.25	2.45	15.40	23.00	16.40	18.27	4.13	2.38	19.70	35.10	27.90	27.57	7.71	4.45
Sulphur (S)	mg/kg			2300	2500	2400	2400	100	58	410	650	500	520	121	70	210	440	410	353	125	72
Thallium (Tl)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Tin (Sn)	mg/kg			<5	<5	-	-	-	-	<5	<5	-	-	-	-	<5	<5	-	-	-	-
Titanium (Ti)	mg/kg			404	729	498	544	167	97	680	910	731	774	121	70	837	1350	1070	1086	257	148
Uranium (U)	mg/kg			0.331	0.881	0.624	0.612	0.275	0.159	0.878	1.190	1.010	1.026	0.157	0.090	1.120	1.510	1.180	1.270	0.210	0.121
Vanadium (V)	mg/kg			26.7	36.4	27.4	30.2	5.4	3.1	30.1	40.9	33.6	34.9	5.5	3.2	42.7	59.6	48.4	50.2	8.6	5.0
Zinc (Zn)	mg/kg	123	315	20.5	36.4	23.0	26.6	8.6	4.9	30.7	43.9	34.5	36.4	6.8	3.9	42.3	55.4	44.2	47.3	7.1	4.1

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A3-1a. Sediment Quality Summary Statistics for AEMP Streams, Doris North Project, 2010

Stream	Units	CCME Guidelines for the Protection of Aquatic Life[a]		Reference B Outflow						Reference D Outflow					
		ISQG[b]	PEL[c]	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE
Physical Tests															
Moisture	%			7.56	29.30	15.50	17.45	11.00	6.35	6.93	16.80	15.50	13.08	5.36	3.10
pH	pH			6.97	7.25	7.11	7.11	0.14	0.08	6.92	7.04	6.98	6.98	0.06	0.03
Particle Size															
% Gravel (>2 mm)	%			11.50	31.60	21.10	21.40	10.05	5.80	10.90	72.10	34.30	39.10	30.88	17.83
% Sand (2.0 mm - 0.063 mm)	%			64.5	86.8	77.0	76.1	11.2	6.5	27.6	88.2	64.4	60.1	30.5	17.6
% Silt (0.063 mm - 4 µm)	%			0.90	3.25	1.44	1.86	1.23	0.71	<0.1	0.60	0.13	0.26	0.30	0.17
% Clay (<4 µm)	%			0.4	0.8	0.6	0.6	0.2	0.1	0.3	0.8	0.7	0.6	0.3	0.2
Leachable Anions & Nutrients															
Total Nitrogen	%			<0.02	<0.02	-	-	-	-	<0.02	<0.02	-	-	-	-
Organic / Inorganic Carbon															
Total Organic Carbon	%			<0.1	0.14	<0.1	0.08	0.05	0.03	<0.1	<0.1	-	-	-	-
Plant Available Nutrients															
Available Ammonium-N	mg/kg			1.40	2.40	1.70	1.83	0.51	0.30	1.16	1.50	1.21	1.29	0.18	0.11
Available Nitrate-N	mg/kg			<3	<3	-	-	-	-	<2.7	<7.5	-	-	-	-
Nitrite-N	mg/kg			<0.6	<0.6	-	-	-	-	<0.55	<1.5	-	-	-	-
Available Phosphate-P	mg/kg			<2	2.3	<2	1.4	0.8	0.4	<2	2.1	<2	1.4	0.6	0.4
Metals															
Aluminum (Al)	mg/kg			4910	16500	5400	8937	6555	3784	5630	5950	5900	5827	172	99
Antimony (Sb)	mg/kg			<10	<10	-	-	-	-	<10	<10	-	-	-	-
Arsenic (As)	mg/kg	5.9	17	0.416	1.720	0.465	0.867	0.739	0.427	0.307	0.473	0.319	0.366	0.093	0.053
Barium (Ba)	mg/kg			13.5	63.4	18.7	31.9	27.4	15.8	13.5	15.9	14.0	14.5	01.3	00.7
Beryllium (Be)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Bismuth (Bi)	mg/kg			<20	<20	-	-	-	-	<20	<20	-	-	-	-
Cadmium (Cd)	mg/kg	0.6	3.5	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-
Calcium (Ca)	mg/kg			1290	5450	1530	2757	2336	1348	1670	1840	1730	1747	86	50
Chromium (Cr)	mg/kg	37.3	90	8.0	41.2	9.9	19.7	18.6	10.8	8.4	9.6	9.1	9.0	0.6	0.3
Cobalt (Co)	mg/kg			4.0	9.8	4.0	5.9	3.3	1.9	3.8	5.6	4.4	4.6	0.9	0.5
Copper (Cu)	mg/kg	35.7	197	2.5	14.2	4.4	7.0	6.3	3.6	6.7	10.0	9.7	8.8	1.8	1.1
Iron (Fe)	mg/kg			9950	26700	10200	15617	9599	5542	10400	12000	11200	11200	800	462
Lead (Pb)	mg/kg	35	91.3	<2	5.6	<2	2.5	2.7	1.5	<2	<2	-	-	-	-
Lithium (Li)	mg/kg			10.8	33.1	11.8	18.6	12.6	7.3	14.8	16.3	15.7	15.6	0.8	0.4
Magnesium (Mg)	mg/kg			4530	10300	4870	6567	3238	1869	5320	6040	5560	5640	367	212
Manganese (Mn)	mg/kg			143	401	171	238	142	82	143	294	241	226	77	44
Mercury (Hg)	mg/kg	0.17	0.486	0.0025	0.0172	0.0025	0.0074	0.0085	0.0049	0.0025	0.0025	0.0025	0.0025	0.0000	0.0000
Molybdenum (Mo)	mg/kg			<0.2	0.43	<0.2	0.21	0.19	0.11	<0.2	0.39	0.38	0.29	0.16	0.10
Nickel (Ni)	mg/kg			6.2	21.4	7.7	11.8	8.4	4.8	7.4	9.8	8.4	8.5	1.2	0.7
Phosphorus (P)	mg/kg			266	855	342	488	320	185	329	379	379	362	29	17
Potassium (K)	mg/kg			690	2170	820	1227	820	473	650	740	690	693	45	26
Selenium (Se)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Silver (Ag)	mg/kg			<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-
Sodium (Na)	mg/kg			<200	440	<200	213	196	113	<200	<200	-	-	-	-
Strontium (Sr)	mg/kg			5.81	27.00	5.98	12.93	12.19	7.04	6.23	8.97	8.18	7.79	1.41	0.81
Sulphur (S)	mg/kg			100	170	160	143	38	22	160	210	180	183	25	15
Thallium (Tl)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Tin (Sn)	mg/kg			<5	<5	-	-	-	-	<5	<5	-	-	-	-
Titanium (Ti)	mg/kg			265	907	272	481	369	213	247	291	281	273	23	13
Uranium (U)	mg/kg			0.345	1.650	0.451	0.815	0.725	0.418	0.381	0.744	0.620	0.582	0.185	0.107
Vanadium (V)	mg/kg			16.5	47.0	17.3	26.9	17.4	10.0	17.1	21.1	17.3	18.5	2.3	1.3
Zinc (Zn)	mg/kg	123	315	19.8	54.5	19.9	31.4	20.0	11.6	19.9	22.9	22.6	21.8	1.7	1.0

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A3-1b. Sediment Quality Summary Statistics for AEMP Lakes, Doris North Project, 2010

Lake		CCME Guidelines for the Protection of Aquatic Life[a]		Doris Lake South						Doris Lake North						Little Roberts Lake					
	Units	ISQG[b]	PEL[c]	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE
Physical Tests																					
Moisture	%			62.30	68.70	68.20	66.40	3.56	2.06	75.90	77.70	77.00	76.87	0.91	0.52	61.10	65.70	65.00	63.93	2.48	1.43
pH	pH			5.73	5.92	5.77	5.81	0.10	0.06	5.47	5.55	5.47	5.50	0.05	0.03	5.21	6.24	5.34	5.60	0.56	0.32
Particle Size																					
% Gravel (>2 mm)	%			<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-
% Sand (2.0 mm - 0.063 mm)	%			4.6	6.0	5.4	5.3	0.7	0.4	0.3	2.2	0.7	1.0	1.0	0.6	3.9	12.4	8.6	8.3	4.3	2.5
% Silt (0.063 mm - 4 µm)	%			75.0	76.4	75.7	75.7	0.7	0.4	84.9	90.8	89.8	88.5	3.2	1.8	75.0	79.5	77.5	77.3	2.3	1.3
% Clay (<4 µm)	%			17.6	20.4	19.0	19.0	1.4	0.8	8.0	14.4	8.9	10.5	3.4	2.0	12.6	16.6	13.9	14.4	2.0	1.2
Leachable Anions & Nutrients																					
Total Nitrogen	%			0.314	0.336	0.326	0.325	0.011	0.006	0.403	0.425	0.410	0.413	0.011	0.006	0.274	0.373	0.318	0.322	0.050	0.029
Organic / Inorganic Carbon																					
Total Organic Carbon	%			2.07	2.21	2.18	2.15	0.07	0.04	3.01	3.16	3.04	3.07	0.08	0.05	1.95	2.92	2.23	2.37	0.50	0.29
Plant Available Nutrients																					
Available Ammonium-N	mg/kg			5.40	6.40	6.00	5.93	0.50	0.29	10.10	16.90	14.70	13.9	3.47	2.00	10.30	39.60	20.10	23.3	14.92	8.61
Available Nitrate-N	mg/kg			<3	<3.8	-	-	-	-	<3.8	<3.8	-	-	-	-	<3	<3.8	-	-	-	-
Nitrite-N	mg/kg			<0.6	<0.75	-	-	-	-	<0.75	<0.75	-	-	-	-	<0.6	<0.75	-	-	-	-
Available Phosphate-P	mg/kg			<2	<2	-	-	-	-	<2	2.2	2.0	1.7	0.6	0.4	<2	2.5	<2	1.5	0.9	0.5
Metals																					
Aluminum (Al)	mg/kg			21000	23000	21200	21733	1102	636	28200	30600	28600	29133	1286	742	16100	21500	18300	18633	2715	1568
Antimony (Sb)	mg/kg			<10	<10	-	-	-	-	<10	<10	-	-	-	-	<10	<10	-	-	-	-
Arsenic (As)	mg/kg	5.9	17	2.95	3.77	3.15	3.29	0.43	0.25	4.39	21.00	12.20	12.53	8.31	4.80	2.11	3.04	2.27	2.47	0.50	0.29
Barium (Ba)	mg/kg			119	128	122	123	5	3	167	187	174	176	10	6	88	120	99	102	16	9
Beryllium (Be)	mg/kg			0.69	0.73	0.69	0.70	0.02	0.01	0.96	0.98	0.97	0.97	0.01	0.01	<0.5	0.64	0.54	0.48	0.20	0.12
Bismuth (Bi)	mg/kg			<20	<20	-	-	-	-	<20	<20	-	-	-	-	<20	<20	-	-	-	-
Cadmium (Cd)	mg/kg	0.6	3.5	<0.1	<0.1	-	-	-	-	0.110	0.110	0.110	0.110	0.000	0.000	0.10	0.11	0.11	0.1	0.01	0.00
Calcium (Ca)	mg/kg			5490	5950	5500	5647	263	152	6580	7030	6600	6737	254	147	5520	6200	5580	5767	376	217
Chromium (Cr)	mg/kg	37.3	90	59.9	65.0	61.8	62.2	2.6	1.5	77.1	83.1	78.8	79.7	3.1	1.8	45.9	60.6	52.5	53.0	7.4	4.3
Cobalt (Co)	mg/kg			11.6	12.7	12.0	12.1	0.6	0.3	15.1	16.1	15.6	15.6	0.5	0.3	9.6	12.2	11.1	11.0	1.3	0.8
Copper (Cu)	mg/kg	35.7	197	26.7	29.7	26.9	27.8	1.7	1.0	43.9	47.0	45.2	45.4	1.6	0.9	22.6	32.4	26.9	27.3	4.9	2.8
Iron (Fe)	mg/kg			31300	33800	31400	32167	1415	817	47500	67200	55200	56633	9928	5732	23500	33400	27300	28067	4994	2883
Lead (Pb)	mg/kg	35	91.3	7.8	8.3	8.2	8.1	0.3	0.2	10.3	12.0	10.7	11.0	0.9	0.5	6.5	7.5	7.4	7.1	0.6	0.3
Lithium (Li)	mg/kg			37.4	40.7	37.9	38.7	1.8	1.0	46.5	52.4	48.3	49.1	3.0	1.7	28.2	37.7	31.9	32.6	4.8	2.8
Magnesium (Mg)	mg/kg			12800	13600	13100	13167	404	233	15600	17500	16200	16433	971	561	9860	12900	11200	11320	1524	880
Manganese (Mn)	mg/kg			511	617	554	561	53	31	643	1660	761	1021	556	321	324	424	330	359	56	32
Mercury (Hg)	mg/kg	0.17	0.486	0.0281	0.0388	0.0343	0.0337	0.0054	0.0031	0.0623	0.0807	0.0776	0.0735	0.0099	0.0057	0.0152	0.0218	0.0188	0.0186	0.0033	0.0019
Molybdenum (Mo)	mg/kg			0.98	1.67	1.23	1	0.35	0.20	1.08	1.62	1.13	1.28	0.30	0.17	1.13	1.56	1.26	1.32	0.22	0.13
Nickel (Ni)	mg/kg			34.1	36.3	34.2	34.9	1.2	0.7	46.6	49.3	48.3	48.1	1.4	0.8	24.2	32.3	28.0	28.2	4.1	2.3
Phosphorus (P)	mg/kg			806	955	871	877	75	43	1120	1650	1480	1417	271	156	763	873	769	802	62	36
Potassium (K)	mg/kg			5190	5680	5260	5377	265	153	6740	7520	6970	7077	401	231	3960	5410	4500	4623	733	423
Selenium (Se)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Silver (Ag)	mg/kg			<0.1	<0.1	-	-	-	-	0.27	0.53	0.29	0.36	0.14	0.08	<0.1	<0.1	-	-	-	-
Sodium (Na)	mg/kg			1070	1180	1090	1113	59	34	1650	1740	1710	1700	46	26	850	1130	920	967	146	84
Strontium (Sr)	mg/kg			32.2	35.6	32.7	34	1.84	1.06	44.4	47.1	44.5	45	1.53	0.88	29.3	34.4	29.40	31.0	2.92	1.68
Sulphur (S)	mg/kg			1800	1900	1900	1867	58	33	2000	2300	2000	2100	173	100	2100	2800	2600	2500	361	208
Thallium (Tl)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Tin (Sn)	mg/kg			<5	<5	-	-	-	-	<5	<5	-	-	-	-	<5	<5	-	-	-	-
Titanium (Ti)	mg/kg			1290	1490	1340	1373	104	60	1490	1720	1580	1597	116	67	1150	1490	1280	1307	172	99
Uranium (U)	mg/kg			1.610	1.680	1.650	2	0.035	0.020	2.030	2.230	2.220	2.16	0.113	0.065	1.30	1.75	1.49	1.51	0.23	0.13
Vanadium (V)	mg/kg			64.4	69.9	65.7	67	2.9	1.7	85.4	88.6	86.6	87	1.6	0.9	51.6	69.1	58.3	60	8.8	5.1
Zinc (Zn)	mg/kg	123	315	74.6	78.5	76.2	76.4	2.0	1.1	102	107	103	104	2.6	1.5	56.4	76.0	65.7	66.0	9.8	5.7

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A3-1b. Sediment Quality Summary Statistics for AEMP Lakes, Doris North Project, 2010

Lake		CCME Guidelines for the Protection of Aquatic Life[a]		Reference Lake B						Reference Lake D					
	Units	ISQG[b]	PEL[c]	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE
Physical Tests															
Moisture	%			39.3	44.2	41.5	41.7	2.5	1.4	40.1	67.5	45.4	51.0	14.5	8.4
pH	pH			5.15	5.44	5.37	5.32	0.15	0.09	5.40	5.66	5.61	5.56	0.14	0.08
Particle Size															
% Gravel (>2 mm)	%			<0.10	2.4	0.4	0.9	1.3	0.7	<0.1	<0.1	-	-	-	-
% Sand (2.0 mm - 0.063 mm)	%			5.4	9.0	7.9	7.4	1.8	1.1	11.1	59.9	55.7	42.2	27.0	15.6
% Silt (0.063 mm - 4 µm)	%			57.9	61.6	59.1	59.5	1.9	1.1	37.6	81.5	40.7	53.3	24.5	14.1
% Clay (<4 µm)	%			29.1	35.5	31.8	32.1	3.2	1.9	2.5	7.4	3.6	4.5	2.6	1.5
Leachable Anions & Nutrients															
Total Nitrogen	%			0.069	0.107	0.072	0.083	0.021	0.012	0.172	0.438	0.201	0.27	0.146	0.084
Organic / Inorganic Carbon															
Total Organic Carbon	%			0.420	0.740	0.480	0.547	0.170	0.098	1.20	3.99	1.47	2.22	1.54	0.89
Plant Available Nutrients															
Available Ammonium-N	mg/kg			3.50	6.00	4.42	4.64	1.26	0.73	11.00	23.30	12.10	15.47	6.81	3.93
Available Nitrate-N	mg/kg			<3.0	<3.0	-	-	-	-	<2	<4.3	-	-	-	-
Nitrite-N	mg/kg			<0.60	<0.60	-	-	-	-	<0.4	<0.86	-	-	-	-
Available Phosphate-P	mg/kg			<2.0	<2.0	-	-	-	-	<2	2.10	1.00	1.37	0.64	0.37
Metals															
Aluminum (Al)	mg/kg			16500	17000	16800	16767	252	145	7850	16000	8020	10623	4657	2689
Antimony (Sb)	mg/kg			<10	<10	-	-	-	-	<10	<10	-	-	-	-
Arsenic (As)	mg/kg	5.9	17	4.80	5.47	5.32	5.20	0.35	0.20	0.86	1.89	0.89	1.21	0.59	0.34
Barium (Ba)	mg/kg			90.4	95.6	93.6	93.2	2.6	1.5	41.2	90.7	41.8	57.9	28.4	16.4
Beryllium (Be)	mg/kg			0.570	0.610	0.570	0.583	0.023	0.013	<0.5	0.54	<0.5	0.35	0.17	0.10
Bismuth (Bi)	mg/kg			<20	<20	-	-	-	-	<20	<20	-	-	-	-
Cadmium (Cd)	mg/kg	0.6	3.5	0.190	0.300	0.230	0.240	0.056	0.032	<0.1	0.12	<0.1	0.07	0.04	0.02
Calcium (Ca)	mg/kg			3710	4280	4200	4063	309	178	2420	5730	2710	3620	1833	1058
Chromium (Cr)	mg/kg	37.3	90	45.5	47.6	47.0	46.7	1.1	0.6	19.4	45.6	19.4	28.1	15.1	8.7
Cobalt (Co)	mg/kg			14.9	18.1	16.2	16.4	1.6	0.9	4.40	8.10	4.50	5.67	2.11	1.22
Copper (Cu)	mg/kg	35.7	197	19.2	21.7	21.3	20.7	1.3	0.8	10.2	26.1	10.3	15.5	9.2	5.3
Iron (Fe)	mg/kg			27100	35900	31500	31500	4400	2540	12300	23400	13300	16333	6140	3545
Lead (Pb)	mg/kg	35	91.3	6.90	7.40	7.20	7.17	0.25	0.15	3.10	7.70	3.60	4.80	2.52	1.46
Lithium (Li)	mg/kg			29.9	31.3	30.4	30.5	0.7	0.4	15.0	27.6	15.2	19.3	7.2	4.2
Magnesium (Mg)	mg/kg			9080	9960	9620	9553	444	256	4940	9300	4990	6410	2503	1445
Manganese (Mn)	mg/kg			237	262	255	251	13	7	123	305	150	193	98	57
Mercury (Hg)	mg/kg	0.17	0.486	0.00600	0.00610	0.00600	0.00603	0.00006	0.00003	0.0077	0.0224	0.0099	0.0133	0.0079	0.0046
Molybdenum (Mo)	mg/kg			1.87	2.49	2.42	2.26	0.34	0.20	0.52	1.08	0.53	0.71	0.32	0.19
Nickel (Ni)	mg/kg			24.4	29.3	26.2	26.6	2.5	1.4	11.2	24.1	11.4	15.6	7.4	4.3
Phosphorus (P)	mg/kg			642	702	645	663	34	20	498	864	529	630	203	117
Potassium (K)	mg/kg			3790	4260	4090	4047	238	137	1640	3680	1670	2330	1169	675
Selenium (Se)	mg/kg			<0.50	<0.50	-	-	-	-	<0.5	<0.5	-	-	-	-
Silver (Ag)	mg/kg			0.100	0.140	0.120	0.120	0.020	0.012	<0.1	<0.1	-	-	-	-
Sodium (Na)	mg/kg			390	540	510	480	79	46	360	740	360	486.7	219	127
Strontium (Sr)	mg/kg			23.4	26.1	25.4	25.0	1.4	0.8	13.0	30.8	14.3	19.4	9.9	5.7
Sulphur (S)	mg/kg			1910	2160	1950	2007	134	78	1700	2800	2100	2200	557	321
Thallium (Tl)	mg/kg			<0.50	<0.50	-	-	-	-	<0.50	<0.50	-	-	-	-
Tin (Sn)	mg/kg			<5.0	<5.0	-	-	-	-	<5	<5	-	-	-	-
Titanium (Ti)	mg/kg			1050	1090	1070	1070	20.0	11.5	558	1160	567	762	345	199
Uranium (U)	mg/kg			1.83	2.06	1.99	1.96	0.12	0.07	1.00	2.29	1.02	1.44	0.74	0.43
Vanadium (V)	mg/kg			49.7	51.7	50.6	50.7	1.0	0.6	25.2	52.6	25.5	34.4	15.7	9.1
Zinc (Zn)	mg/kg	123	315	58.3	62.3	59.5	60.0	2.1	1.2	29.8	59.5	29.9	40	17.1	9.9

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A3-1c. Sediment Quality Summary Statistics for AEMP Marine Sites, Doris North Project, 2010

Marine		CCME Guidelines for the Protection of Aquatic Life[a]		Roberts Bay West (RBW)						Roberts Bay East (RBE)						Reference Bay (REF-Marine)					
	Units	ISQG[b]	PEL[c]	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE	Min	Max	Median	Mean	SD	SE
Physical Tests																					
Moisture	%			22.30	34.00	32.80	29.70	6.44	3.72	18.50	19.10	18.50	18.70	0.35	0.20	31.40	37.30	32.30	33.67	3.18	1.84
pH	pH			7.42	7.84	7.73	7.66	0.22	0.13	6.95	7.09	7.02	7.02	0.07	0.04	7.20	7.72	7.52	7.48	0.26	0.15
Particle Size																					
% Gravel (>2 mm)	%			<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-
% Sand (2.0 mm - 0.063 mm)	%			67.6	72.8	68.8	69.7	2.7	1.6	90.7	96.4	91.4	92.8	3.1	1.8	54.2	61.3	56.9	57.5	3.6	2.1
% Silt (0.063 mm - 4 µm)	%			23.00	27.30	27.20	25.83	2.45	1.42	2.78	8.17	7.03	5.99	2.84	1.64	35.40	41.90	39.30	38.87	3.27	1.89
% Clay (<4 µm)	%			3.9	5.2	4.2	4.4	0.7	0.4	0.5	2.3	0.8	1.2	1.0	0.6	3.3	3.9	3.9	3.7	0.4	0.2
Leachable Anions & Nutrients																					
Total Nitrogen	%			0.052	0.054	0.052	0.053	0.001	0.001	<0.02	<0.02	-	-	-	-	0.064	0.090	0.073	0.076	0.013	0.008
Organic / Inorganic Carbon																					
Total Organic Carbon	%			0.37	0.50	0.40	0.42	0.07	0.04	<0.10	0.17	<0.10	-	-	-	0.48	0.68	0.51	0.56	0.11	0.06
Plant Available Nutrients																					
Available Ammonium-N	mg/kg			3.58	9.86	5.82	6.42	3.18	1.84	0.95	1.16	1.12	1.08	0.11	0.06	5.31	7.64	7.48	6.81	1.30	0.75
Available Nitrate-N	mg/kg			<2	<2	-	-	-	-	<2	<2	-	-	-	-	<2	<2	-	-	-	-
Nitrite-N	mg/kg			<0.4	<0.4	-	-	-	-	<0.4	<0.4	-	-	-	-	<0.4	<0.4	-	-	-	-
Available Phosphate-P	mg/kg			11.1	17.2	13.5	13.9	3.1	1.8	3.9	4.4	4.3	4.2	0.3	0.2	14.2	18.3	16.4	16.3	2.1	1.2
Metals																					
Aluminum (Al)	mg/kg			6330	7270	6840	6813	471	272	3580	4720	3670	3990	634	366	6190	6860	6310	6453	357	206
Antimony (Sb)	mg/kg			<10	<10	-	-	-	-	<10	<10	-	-	-	-	<10	<10	-	-	-	-
Arsenic (As)	mg/kg	7.24	41.6	2.51	3.28	2.82	2.87	0.39	0.22	1.0	1.5	1.18	1.23	0.25	0.15	2.11	2.4	2.13	2.21	0.16	0.09
Barium (Ba)	mg/kg			26.5	30.6	29.1	28.73	2.07	1.2	8.8	15.2	9	11	3.64	2.1	25.40	29.4	26.7	27.17	2.04	1.18
Beryllium (Be)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Bismuth (Bi)	mg/kg			<20	<20	-	-	-	-	<20	<20	-	-	-	-	<20	<20	-	-	-	-
Cadmium (Cd)	mg/kg	0.7	4.2	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-
Calcium (Ca)	mg/kg			3030	3200	3180	3137	93	54	1850	2140	2000	1997	145	84	3060	3170	3080	3103	59	34
Chromium (Cr)	mg/kg	52.3	160	22.1	23.7	23.6	23.1	0.9	0.5	11.4	14.7	12.4	12.8	1.7	1.0	15.1	17.8	15.9	16.3	1.4	0.8
Cobalt (Co)	mg/kg			4.6	5.2	5.2	5.0	0.3	0.2	3.9	4.3	4.0	4.1	0.2	0.1	3.4	3.7	3.5	3.5	0.2	0.1
Copper (Cu)	mg/kg	18.7	108	12.5	13.7	13.6	13.3	0.7	0.4	11.1	13.1	11.2	11.8	1.1	0.7	7.1	9.3	7.8	8.1	1.1	0.6
Iron (Fe)	mg/kg			13400	14400	13800	13867	503	291	8440	10100	9510	9350	841	486	9240	10400	9460	9700	616	356
Lead (Pb)	mg/kg	30.2	112	2.4	2.8	2.8	2.7	0.2	0.1	<2	<2	-	-	-	-	2.3	2.6	2.3	2.4	0.2	0.1
Lithium (Li)	mg/kg			11.3	13.1	12.5	12.3	0.9	0.5	7.2	9.0	7.3	7.8	1.0	0.6	12.2	14.1	12.7	13.0	1.0	0.6
Magnesium (Mg)	mg/kg			5260	6020	5880	5720	404	234	2980	3830	3010	3273	482	278	4800	5500	4950	5083	369	213
Manganese (Mn)	mg/kg			118	131	127	125	7	4	76	91	80	82	8	4	99	109	101	103	5	3
Mercury (Hg)	mg/kg	0.13	0.7	<0.005	<0.005	-	-	-	-	<0.005	<0.005	-	-	-	-	<0.005	<0.005	-	-	-	-
Molybdenum (Mo)	mg/kg			0.68	0.84	0.69	0.74	0.09	0.05	<0.2	0.23	<0.2	0.14	0.08	0.04	0.70	1.08	0.75	0.84	0.21	0.12
Nickel (Ni)	mg/kg			10.7	12.1	11.9	11.6	0.8	0.4	6.6	8.2	6.9	7.2	0.9	0.5	7.7	9.3	8.0	8.3	0.9	0.5
Phosphorus (P)	mg/kg			524	576	574	558	29	17	293	316	294	301	13	8	579	612	588	593	17	10
Potassium (K)	mg/kg			1530	1830	1770	1710	159	92	540	960	540	680	242	140	1600	1890	1660	1717	153	88
Selenium (Se)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Silver (Ag)	mg/kg			<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-	<0.1	<0.1	-	-	-	-
Sodium (Na)	mg/kg			2810	3770	3700	3427	535	309	970	2130	1000	1367	661	382	3520	4140	3660	3773	325	188
Strontium (Sr)	mg/kg			16.90	18.70	18.30	17.97	0.95	0.55	7.93	11.60	8.65	9.39	1.94	1.12	18.90	20.30	19.10	19.43	0.76	0.44
Sulphur (S)	mg/kg			670	1030	750	817	189	109	540	590	570	567	25	15	1170	1560	1210	1313	215	124
Thallium (Tl)	mg/kg			<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-	<0.5	<0.5	-	-	-	-
Tin (Sn)	mg/kg			<5	<5	-	-	-	-	<5	<5	-	-	-	-	<5	<5	-	-	-	-
Titanium (Ti)	mg/kg			533	579	561	558	23	13	326	440	356	374	59	34	541	566	547	551	13	8
Uranium (U)	mg/kg			0.542	0.590	0.577	0.570	0.025	0.014	0.433	0.949	0.467	0.616	0.289	0.167	0.722	0.787	0.727	0.745	0.036	0.021
Vanadium (V)	mg/kg			30.0	31.8	31.5	31.1	1.0	0.6	19.0	23.6	22.7	21.8	2.4	1.4	22.6	25.3	23.5	23.8	1.4	0.8
Zinc (Zn)	mg/kg	124.0	271.0	20.5	24.2	22.6	22.4	1.9	1.1	11.3	16.0	12.3	13.2	2.5	1.4	19.4	22.3	20.3	20.7	1.5	0.9

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

a) Canadian sediment quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Appendix A3-2

Primary Production Summary Statistics for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A3-2a. Periphyton Biomass Summary Statistics for AEMP Streams, Doris North Project, 2010

Site	Date Sampled	Summary Statistics (µg/cm2)					
		Min	Max	Median	Mean	SD	SE
Doris OF	July 17 to September 20, 2010	0.023	0.229	0.123	0.135	0.066	0.022
Little Roberts OF	July 17 to September 20, 2010	0.024	2.560	0.356	0.563	0.790	0.263
Roberts OF	July 17 to September 20, 2010	0.014	0.496	0.133	0.189	0.169	0.060
Reference B OF	July 18 to September 20, 2010	0.008	0.212	0.070	0.099	0.074	0.025
Reference D OF	July 18 to September 20, 2010	0.017	0.545	0.135	0.182	0.172	0.057

SD = Standard deviation of the mean

SE = Standard error of the mean

Plates were installed for approximately one month.

Appendix A3-2b. Phytoplankton Biomass Summary Statistics for AEMP Lakes, Doris North Project, 2010

Site	Date Sampled	Summary Statistics (µg/L)					
		Min	Max	Median	Mean	SD	SE
Doris South	April 22 to September 12, 2010	4.49	43.60	8.80	12.89	11.12	3.21
Doris North	April 22 to September 12, 2010	0.77	24.80	9.21	10.31	6.29	1.81
Little Roberts	April 22 to September 12, 2010	1.11	9.29	4.99	4.84	2.35	0.68
Reference B	April 19 to September 17, 2010	0.16	1.05	0.53	0.60	0.32	0.09
Reference D	April 19 to September 25, 2010	0.40	0.93	0.72	0.72	0.15	0.04

SD = Standard deviation of the mean

SE = Standard error of the mean

Appendix A3-2c. Phytoplankton Biomass Summary Statistics for AEMP Marine Sites, Doris North Project, 2010

Site	Date Sampled	Summary Statistics (µg/L)					
		Min	Max	Median	Mean	SD	SE
RBW	April 24 to September 30, 2010	0.18	1.37	0.34	0.59	0.47	0.14
RBE	April 24 to September 30, 2010	0.11	10.00	0.52	2.03	3.19	0.92
REF-Marine	July 13 to September 29, 2010*	0.07	0.57	0.20	0.27	0.17	0.06

** Not collected in April due to melting ice*

SD = Standard deviation of the mean

SE = Standard error of the mean

Appendix A3-3

Benthos Summary Statistics for AEMP Aquatic Sites, Doris North Project, 2010

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Appendix A3-3a. Benthos Summary Statistics for AEMP Streams, Doris North Project, 2010

	Doris OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1205	9292	6167	5654	3054	1366
Family Richness	10.0	15.0	13.0	12.8	1.9	0.9
Simpson's Diversity	0.73	0.83	0.80	0.78	0.05	0.02
Simpson's Evenness	0.31	0.42	0.37	0.37	0.05	0.02
Bray-Curtis Dissimilarity	0.60	0.84	0.74	0.72	0.10	0.04

	Little Roberts OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	438	3458	938	1381	1195	534
Family Richness	11.0	13.0	12.0	12.0	1.0	0.4
Simpson's Diversity	0.63	0.81	0.73	0.72	0.07	0.03
Simpson's Evenness	0.24	0.49	0.29	0.32	0.10	0.05
Bray-Curtis Dissimilarity	0.58	0.81	0.67	0.69	0.09	0.04

	Roberts OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1986	9017	4326	4590	2704	1209
Family Richness	9.0	13.0	12.0	11.6	1.7	0.7
Simpson's Diversity	0.40	0.79	0.67	0.64	0.14	0.06
Simpson's Evenness	0.13	0.36	0.27	0.27	0.09	0.04
Bray-Curtis Dissimilarity	0.41	0.78	0.47	0.53	0.15	0.07

	Reference B OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	701	4177	1181	1829	1472	658
Family Richness	12.0	18.0	15.0	14.6	2.3	1.0
Simpson's Diversity	0.51	0.81	0.71	0.68	0.12	0.05
Simpson's Evenness	0.17	0.29	0.23	0.23	0.05	0.02
Bray-Curtis Dissimilarity	0.12	0.61	0.37	0.37	0.20	0.09

	Reference D OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1309	2528	2181	2064	507	227
Family Richness	12.0	17.0	14.0	14.2	1.9	0.9
Simpson's Diversity	0.73	0.83	0.75	0.77	0.04	0.02
Simpson's Evenness	0.24	0.48	0.29	0.32	0.10	0.04
Bray-Curtis Dissimilarity	0.16	0.44	0.20	0.25	0.11	0.05

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

Appendix A3-3b. Benthos Summary Statistics for AEMP Lakes, Doris North Project, 2010

	Doris South					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	1290	2841	1435	1884	750	335
Family Richness	3.0	5.0	4.0	3.8	0.8	0.4
Simpson's Diversity	0.51	0.60	0.54	0.55	0.04	0.02
Simpson's Evenness	0.41	0.84	0.55	0.62	0.19	0.09
Bray-Curtis Dissimilarity	0.18	0.22	0.21	0.20	0.02	0.01

	Doris North					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	1623	2449	2043	2038	323	145
Family Richness	3.0	5.0	4.0	4.0	0.7	0.3
Simpson's Diversity	0.16	0.56	0.29	0.33	0.15	0.07
Simpson's Evenness	0.34	0.45	0.40	0.39	0.05	0.02
Bray-Curtis Dissimilarity	0.09	0.17	0.13	0.13	0.03	0.02

	Little Roberts					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	9710	18536	12870	13890	3335	1492
Family Richness	4.0	7.0	6.0	5.6	1.1	0.5
Simpson's Diversity	0.16	0.40	0.27	0.29	0.09	0.04
Simpson's Evenness	0.20	0.34	0.25	0.26	0.06	0.03
Bray-Curtis Dissimilarity	0.06	0.20	0.10	0.11	0.06	0.02

	Reference B					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	1319	6000	2159	2986	1887	844
Family Richness	4.0	7.0	4.0	4.8	1.3	0.6
Simpson's Diversity	0.55	0.66	0.63	0.62	0.05	0.02
Simpson's Evenness	0.35	0.74	0.55	0.58	0.16	0.07
Bray-Curtis Dissimilarity	0.30	0.50	0.34	0.38	0.08	0.04

	Reference D					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	9580	13261	12348	11832	1483	663
Family Richness	6.0	8.0	7.0	6.8	0.8	0.4
Simpson's Diversity	0.24	0.68	0.56	0.54	0.18	0.08
Simpson's Evenness	0.22	0.45	0.37	0.35	0.08	0.04
Bray-Curtis Dissimilarity	0.06	0.36	0.10	0.14	0.12	0.06

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

Appendix A3-3c. Benthos Summary Statistics for AEMP Marine Sites, Doris North Project, 2010

	Roberts Bay West (RBW)					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	20348	39753	28047	29886	8098	3621
Family Richness	11.0	16.0	13.0	13.4	1.8	0.8
Simpson's Diversity	0.32	0.43	0.34	0.36	0.05	0.02
Simpson's Evenness	0.09	0.15	0.12	0.12	0.02	0.01
Bray-Curtis Dissimilarity	0.91	0.97	0.95	0.95	0.02	0.01

	Roberts Bay East (RBE)					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	471	1493	864	958	442	198
Family Richness	1.0	4.0	3.0	2.6	1.1	0.5
Simpson's Diversity	0.00	0.55	0.28	0.30	0.22	0.10
Simpson's Evenness	0.42	1.00	0.55	0.68	0.27	0.12
Bray-Curtis Dissimilarity	0.74	0.87	0.80	0.80	0.06	0.02

	Reference Bay (REF-Marine)					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	1807	9820	5578	5971	3468	1551
Family Richness	4.0	8.0	5.0	5.2	1.6	0.7
Simpson's Diversity	0.18	0.52	0.43	0.39	0.13	0.06
Simpson's Evenness	0.23	0.44	0.32	0.34	0.09	0.04
Bray-Curtis Dissimilarity	0.04	0.52	0.30	0.28	0.17	0.08

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

Appendix B
2010 Fish Results

Appendix B1. 2010 Fish Data Report, Doris North Project

Appendix B2. 2010 Fish Raw Data, Doris North Project

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Appendix B1

2010 Fish Data Report, Doris North Project

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APPENDIX B1
2010 FISH DATA REPORT, DORIS NORTH PROJECT

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B1. 2010 Fish Data Report, Doris North Project

B1.1 INTRODUCTION

Metal Mining Effluent Regulations (MMER) stipulate that mines are required to conduct Environmental Effects Monitoring (EEM) if effluent discharge rates exceed 50 m^3 per day and/or deleterious substances are discharged into any water body as per subsection 36(3) of the *Fisheries Act* (DFO 1986). The 2010 Fish Data Collection incorporated the requirements of the MMER, though to date no effluent has been discharged. Results from the 2010 Fish Data Collection were analyzed and reported such that the information will be readily available once the EEM monitoring is initiated.

This data report documents the results of the fish component of the 2010 Aquatic Effects Monitoring Program (AEMP) for the Doris North Project. Previous to 2010, baseline fish data were collected on species that were not included in the AEMP.

B1.2 RESULTS

The raw data collected as well as the results of the tissue metal analyses can be found in Appendix B2.

B1.2.1 Lakes

B1.2.1.1 Population

A total of 2,192 ninespine stickleback were captured through extensive sampling via minnow traps in five lake sites (1,014.5 hours; Appendix B2-1). No other fish species were captured. CPUE was highest in Reference Lakes B and D, and lowest in Doris Lake North (Table B1.2-1; Figure B1.2-1).

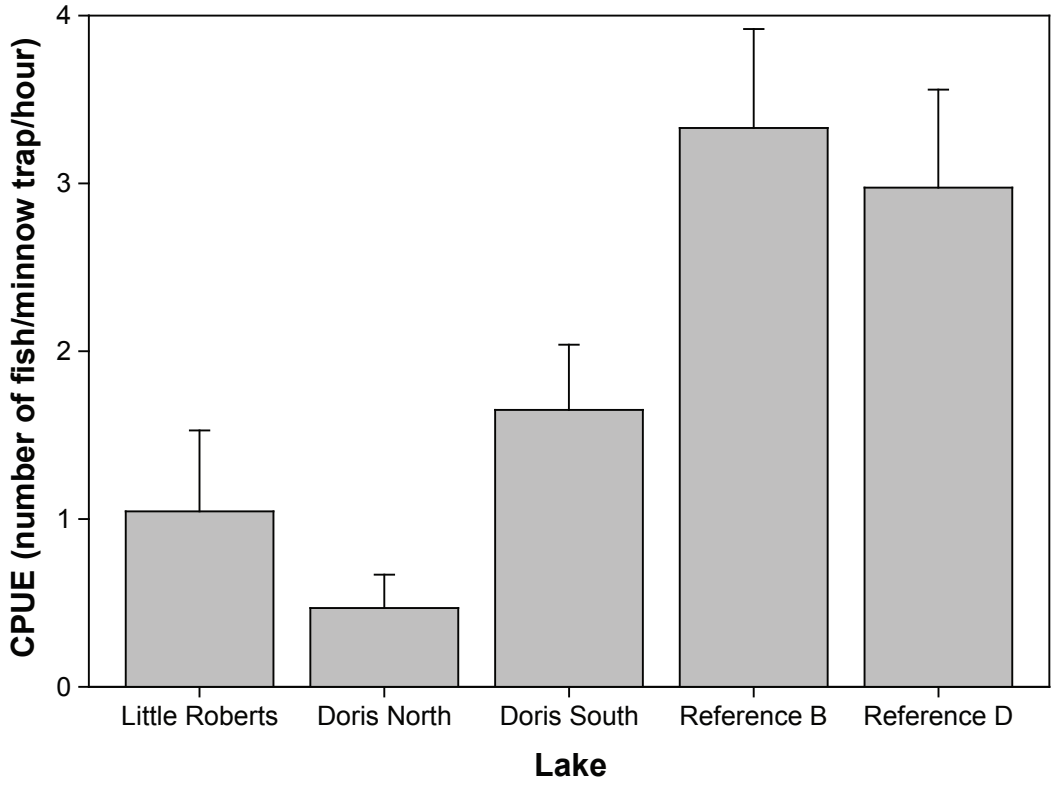
Table B1.2-1. Minnow Traps, Catch, Effort and CPUE, Doris North Project, 2010

Site	Number of Minnow Traps Set	Total Number of Stickleback Captured	Mean CPUE (fish per hr per trap)	SE	SD
Little Roberts Lake	5	128	1.04	0.48	1.08
Doris Lake North	5	54	0.47	0.20	0.44
Doris Lake South	12	480	1.65	0.39	1.35
Reference Lake B	12	959	3.33	0.59	2.04
Reference Lake D	8	571	2.97	0.58	1.65

B1.2.1.2 Biology

Energy Use

Table B1.2-2 summarizes the length, weight, age, condition, gonadosomatic index and hepatosomatic index of ninespine stickleback captured at five lakes in the Doris North Project area in 2010. Doris Lake contained the largest fish (40 – 86 mm FL), while the smallest fish were found in the Reference Lake B (33 – 64 mm FL) and Reference Lake D (29 – 76 mm FL) (Figure B1.2-2). Sexually immature fish were smaller than adult males or females. Length frequency distributions of ninespine stickleback are illustrated in Figure B1.2-3.



Note: Error bars represent standard error of the mean

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Mean CPUE of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-1

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Table B1.2-2. Biological Attributes of Ninespine Stickleback, Doris North Project, 2010

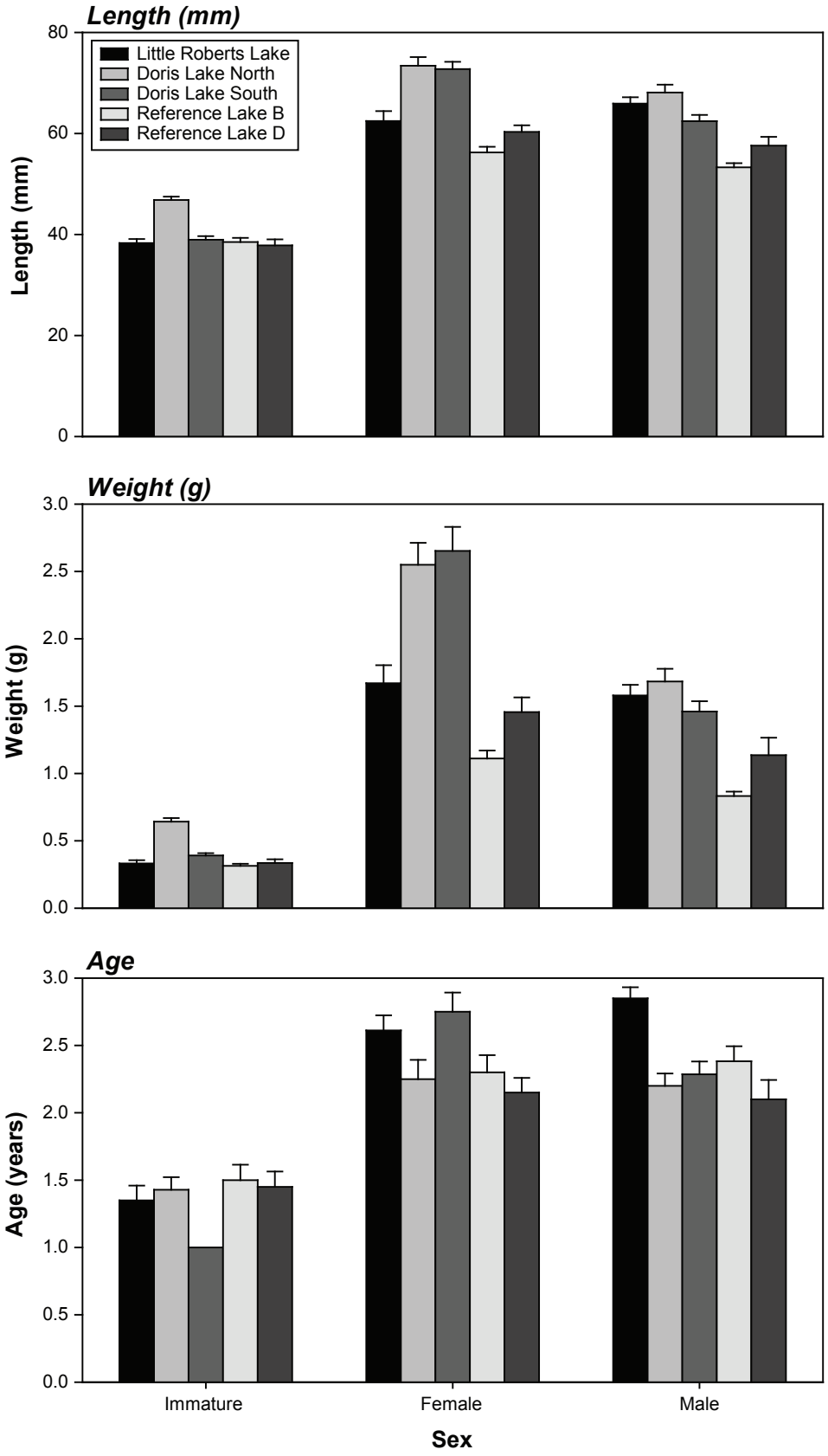
Lake	Sex	n	Length (mm)					Weight (g)					Age (years)*					Condition (g/mm^3)				
			Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD
Little Roberts	Female	20	45 - 76	62	63	2	9	0.80 - 2.54	1.67	1.61	0.13	0.60	2 - 3	3	3	0.1	0.5	0.51 - 0.87	0.67	0.68	0.02	0.08
	Male	20	57 - 77	66	66	1	6	1.06 - 2.42	1.58	1.60	0.08	0.35	2 - 3	3	3	0.1	0.4	0.44 - 0.64	0.55	0.55	0.01	0.05
	Immature	20	33 - 48	38	39	1	4	0.20 - 0.70	0.33	0.32	0.02	0.11	1 - 2	1	1	0.1	0.5	0.45 - 0.69	0.58	0.58	0.01	0.07
Doris North	Female	20	60 - 85	73	74	2	8	1.51 - 4.04	2.55	2.48	0.16	0.73	1 - 4	2	2	0.1	0.6	0.51 - 0.77	0.63	0.62	0.02	0.07
	Male	20	57 - 85	68	68	2	7	0.96 - 2.74	1.68	1.70	0.09	0.42	2 - 3	2	2	0.1	0.4	0.45 - 0.64	0.53	0.53	0.01	0.05
	Immature	29	40 - 58	47	47	1	4	0.41 - 1.11	0.64	0.64	0.03	0.14	1 - 2	1	1	0.1	0.5	0.54 - 0.71	0.62	0.60	0.01	0.05
Doris South	Female	20	62 - 86	73	74	1	6	1.65 - 4.69	2.65	2.64	0.18	0.80	2 - 4	3	3	0.1	0.6	0.57 - 0.75	0.67	0.68	0.01	0.05
	Male	36	53 - 85	62	60	1	7	0.91 - 2.88	1.46	1.28	0.08	0.46	2 - 4	2	2	0.1	0.6	0.36 - 0.70	0.59	0.60	0.01	0.06
	Immature	20	34 - 45	39	39	1	3	0.27 - 0.45	0.39	0.39	0.02	0.08	-	1	1	0.0	0.0	0.53 - 0.77	0.66	0.66	0.01	0.06
Reference B	Female	20	46 - 64	56	57	1	5	0.61 - 1.75	1.11	1.11	0.06	0.26	2 - 4	2	2	0.1	0.6	0.55 - 0.78	0.62	0.61	0.01	0.05
	Male	34	46 - 63	53	53	1	5	0.58 - 1.31	0.83	0.77	0.03	0.19	2 - 4	2	2	0.1	0.7	0.43 - 0.71	0.55	0.55	0.01	0.06
	Immature	20	33 - 44	39	39	1	4	0.23 - 0.47	0.31	0.31	0.01	0.07	1 - 2	2	2	0.1	0.5	0.49 - 0.71	0.55	0.54	0.02	0.08
Reference D	Female	20	53 - 76	60	59	1	6	0.91 - 2.78	1.46	1.33	0.11	0.49	2 - 4	2	2	0.1	0.5	0.5 - 0.8	0.65	0.63	0.01	0.06
	Male	20	45 - 81	58	57	2	8	0.50 - 2.96	1.14	0.97	0.13	0.58	1 - 4	2	2	0.1	0.6	0.4 - 0.7	0.56	0.55	0.02	0.07
	Immature	20	29 - 45	38	37	1	5	0.16 - 0.52	0.34	0.30	0.03	0.12	1 - 2	1	1	0.1	0.5	0.5 - 0.7	0.60	0.58	0.01	0.06

Lake	Sex	n	Gonadosomatic Index (%)					Hepatosomatic Index (%)				
			Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD
Little Roberts	Female	20	8.31 - 28.89	16.78	15.85	1.33	5.93	4.37 - 13.38	9.49	9.60	0.47	2.10
	Male	20	3.98 - 10.96	6.83	7.03	0.42	1.89	6.80 - 13.19	8.82	8.84	0.34	1.51
	Immature	20	-	-	-	-	-	2.71 - 7.16	3.90	3.48	0.26	1.16
Doris North	Female	20	14.80 - 32.33	21.90	22.22	1.16	5.20	6.92 - 10.67	9.19	9.48	0.24	1.07
	Male	20	1.90 - 8.15	5.67	5.77	0.37	1.66	2.51 - 10.43	7.82	8.29	0.46	2.04
	Immature	29	-	-	-	-	-	2.62 - 5.89	4.05	4.12	0.16	0.85
Doris South	Female	20	11.15 - 28.84	19.42	17.59	1.16	5.21	8.68 - 13.46	11.20	11.06	0.24	1.06
	Male	36	0.26 - 11.52	2.80	1.08	0.54	3.25	2.30 - 11.23	5.13	3.69	0.52	3.15
	Immature	20	-	-	-	-	-	2.67 - 13.10	4.38	3.66	0.57	2.54
Reference B	Female	20	10.74 - 32.14	18.70	16.80	1.33	5.95	6.84 - 12.94	9.59	9.56	0.39	1.76
	Male	34	0.28 - 12.02	2.30	1.38	0.46	2.71	1.67 - 0.98	3.64	3.28	0.28	1.65
	Immature	20	-	-	-	-	-	0.84 - 3.96	2.83	2.95	0.19	0.84
Reference D	Female	20	1.65 - 3.81	2.37	2.26	0.12	0.54	7.28 - 13.74	10.62	10.26	0.39	1.75
	Male	20	1.10 - 3.66	1.90	1.77	0.14	0.62	1.66 - 12.44	5.60	4.75	0.67	2.99
	Immature	20	-	-	-	-	-	1.79 - 8.86	5.09	5.42	0.41	1.81

SE = standard error of the mean, SD = standard deviation of the mean

Dashes (-) indicate data was not collected

** n = 18 for female stickleback in Little Roberts Lake*



Note: Error bars represent standard error of the mean

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Mean Length, Weight and Age of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-2

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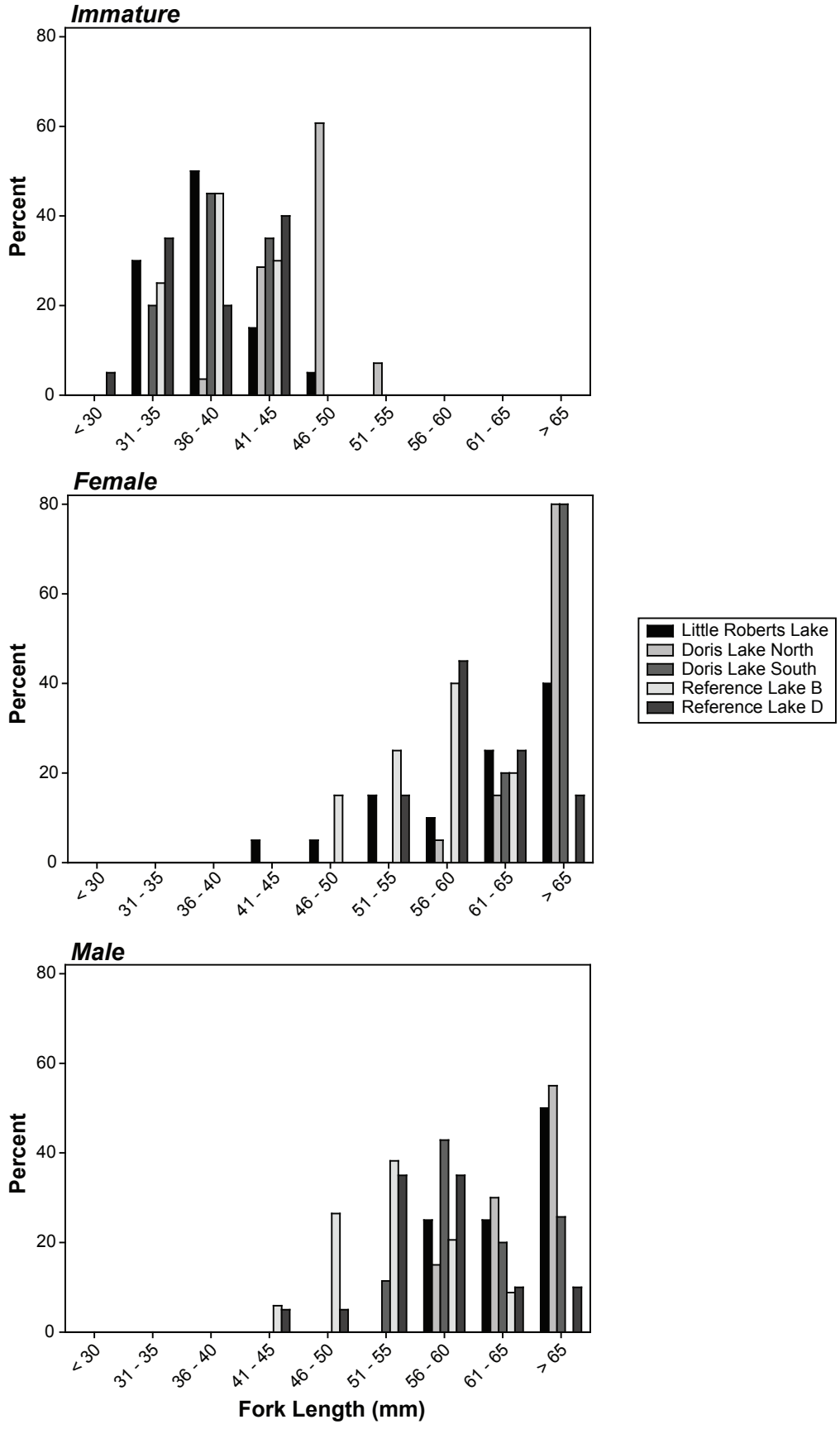

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Length Distributions of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-3

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The mean weight of immature stickleback ranged from 0.16 g to 1.11 g. Mean weight of adult males ranged from 0.50 g to 2.96 g, while adult females ranged from 0.61 to 4.69 g. Mean weight of female ninespine stickleback was greater than that of males in all five lakes.

Although size-at-age in fisheries biology is generally expressed as length-at-age, the MMER/EEM Guidelines specify weight-at-age as the appropriate effect endpoint. Figure B1.2-4 illustrates the weight at age for ninespine stickleback in five lakes within the Doris North Project area. As expected, weight increased with age in most lakes, although the short life span of ninespine stickleback (4 years) tended to obscure the pattern of growth over time.

Mean gonadosomatic indices for female stickleback ranged from 17 (Little Roberts Lake) to 22% (Doris Lake North; Figure B1.2-5, Table B1.2-2). The mean gonadosomatic indices for male ninespine stickleback ranged from 2% in Reference Lake B to 7% in Little Roberts Lake (Figure B1.2-5). Figure B1.2-6 shows the developmental stage of ninespine stickleback eggs. The majority of the eggs collected were immature and between 0.5 and 1.0 mm (65% in Doris Lake to 77% in both Little Roberts Lake and Reference Lake D; and Table B1.2-2). Immature eggs of the size range 1.0–1.5 mm comprised between 0% (all lake sites) and 47% (Reference Lake B) of the samples collected. Mature eggs comprised between 9% of the sample in Reference Lake D to 29% of the sample in Doris Lake.

The number of eggs per female as a function of body weight is shown in Figure B1.2-7. The rate of increase in egg number with an increase in body weight of females did not differ greatly among lakes. The mean number of eggs per female was higher in the Doris Lake sites (North = 742 ± 64, South = 891 ± 56) compared to the Reference Lake sites (D = 573 ± 58; B = 389 ± 30) or Little Roberts Lake (434 ± 32).

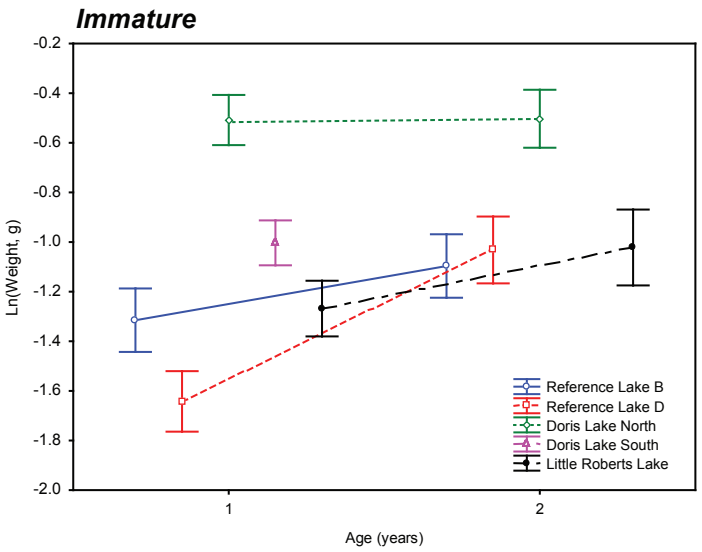
The rate of growth (measured by weight) of the male ninespine stickleback gonads appeared to be much greater in Little Roberts Lake and Doris Lake North than the other sites (Figure B1.2-8). This may reflect greater habitat suitability and/or food production, as both Little Roberts Lake and Doris Lake North are shallow, densely vegetated areas typically preferred by ninespine stickleback.

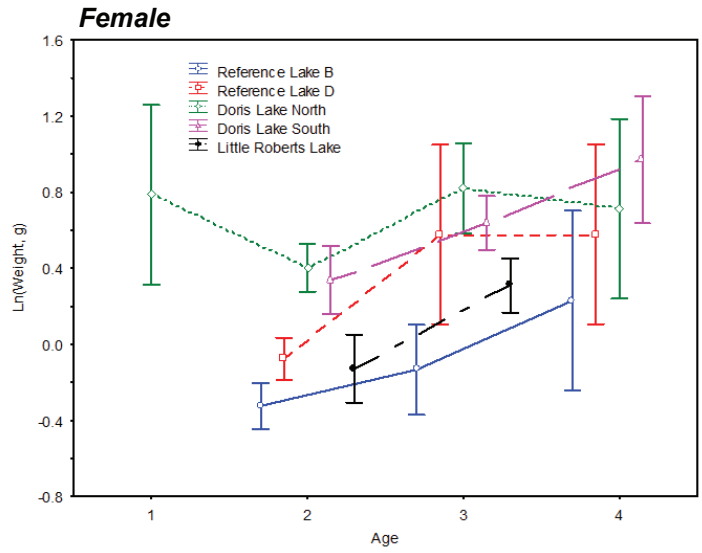
Energy Storage

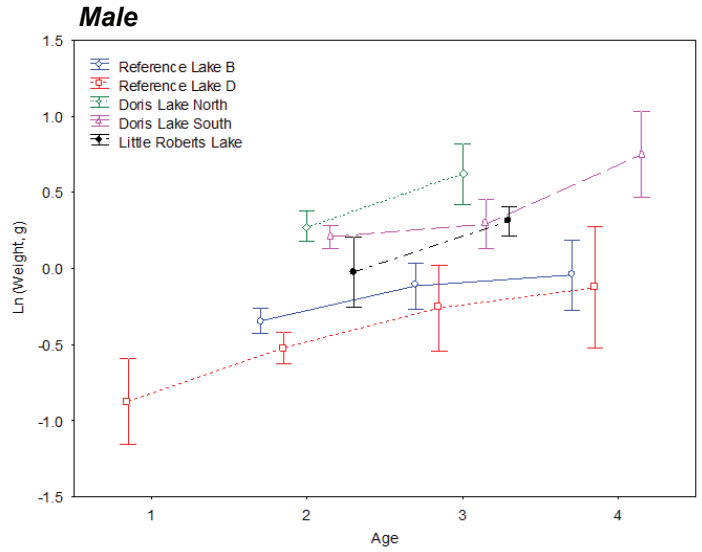
Figure B1.2-9 illustrates a positive relationship between length and weight for immature ninespine stickleback at all five lake sites. Weight-length relationships for female ninespine stickleback are shown in Figure B1.2-10. Females from Little Roberts Lake increased in weight with increasing length faster than females from Reference Lake D (Figure B1.2-10). There was some variability in growth rate among lake sites, with female fish in Doris Lake South having the highest growth rate. Weight-length relationships for male ninespine stickleback are shown in Figure B1.2-11. The slope of the weight-length relationship for male fish showed little variation among sites.

Condition factor (Fulton's *K*) of ninespine stickleback in the Doris North Project area is summarized in Table B1.2-2 and Figure B1.2-12. Mean condition varied from 0.53 to 0.67 and was generally similar between lakes and between sex and maturity classification.

Hepatosomatic indices are summarized in Table B1.2-2 and Figure B1.2-13. Mean hepatosomatic indices were highest in female ninespine stickleback (mean = 10.1%), followed by males (mean = 6.2%) and immature stickleback (mean = 4.1%). Mean HSIs of immature stickleback ranged from 3% in Reference Lake B to 5% in Reference Lake D, while the HSI of female stickleback ranged from 9% in both Little Roberts Lake and Doris Lake North to 11% in both Doris Lake South and Reference Lake D. Mean HSI for male ninespine stickleback ranged from 4% in Reference Lake B to 9% in Little Roberts Lake.







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Size at Age of Immature, Female, and Male Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-4

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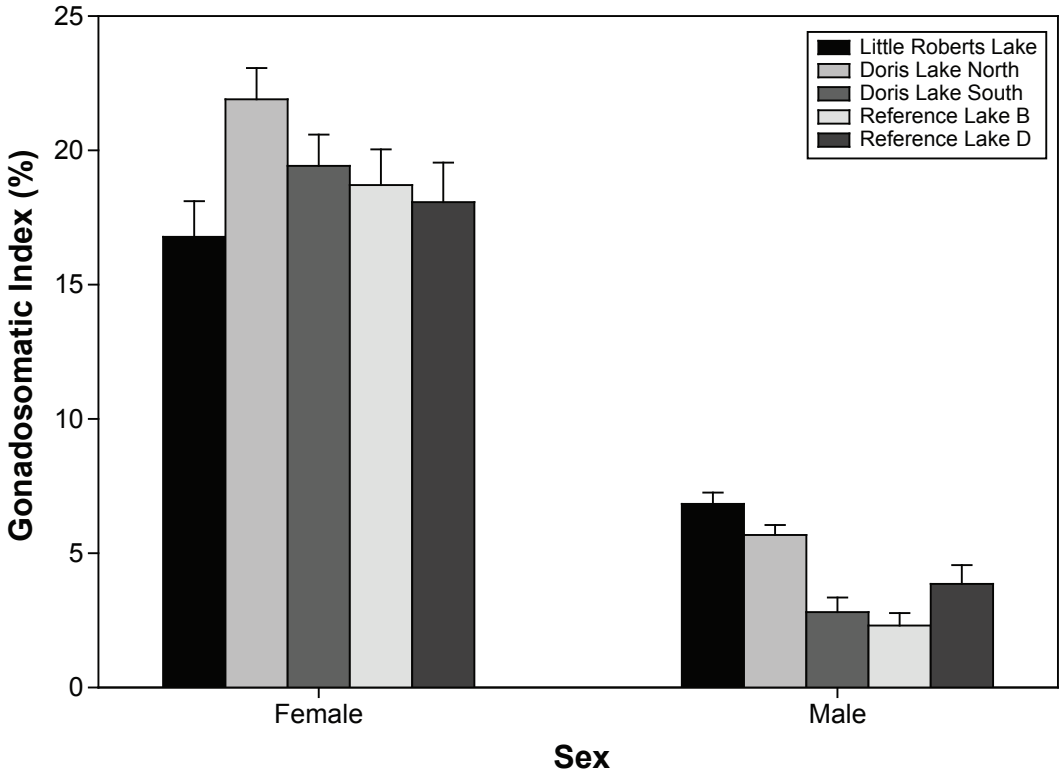

Note: Error bars represent standard error of the mean

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Gonadosomatic Indices of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-5

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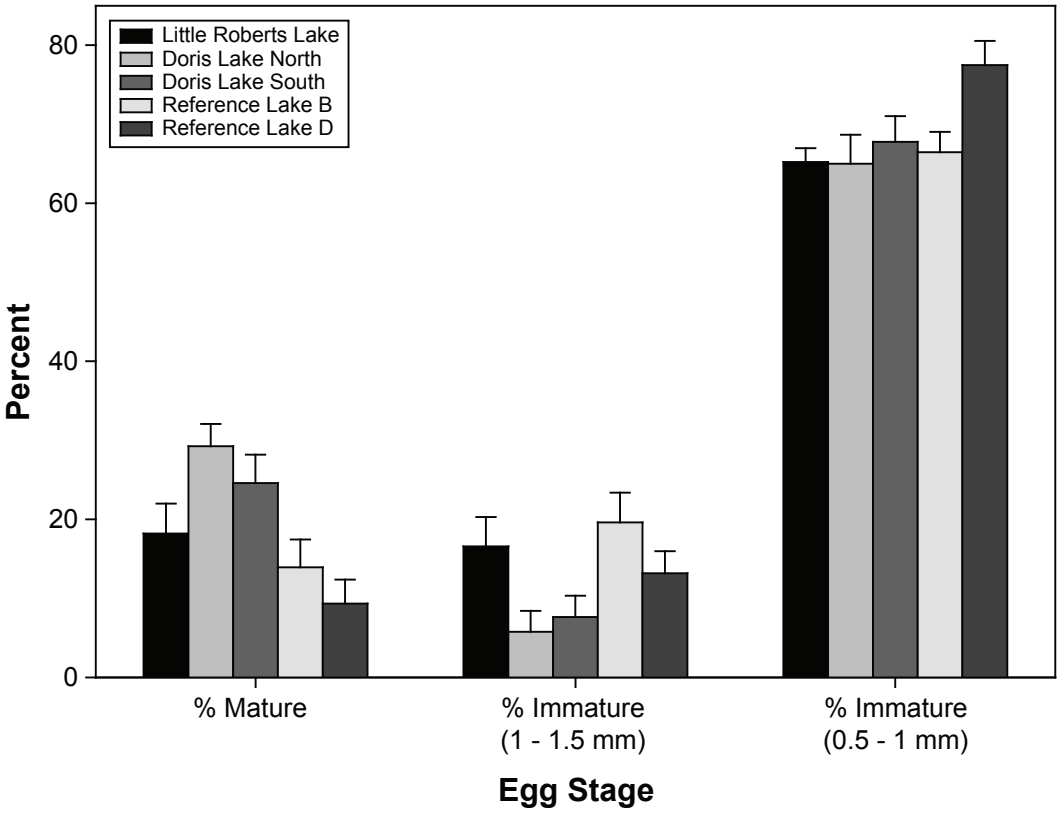

Note: Error bars represent standard error of the mean

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Egg Stage of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-6

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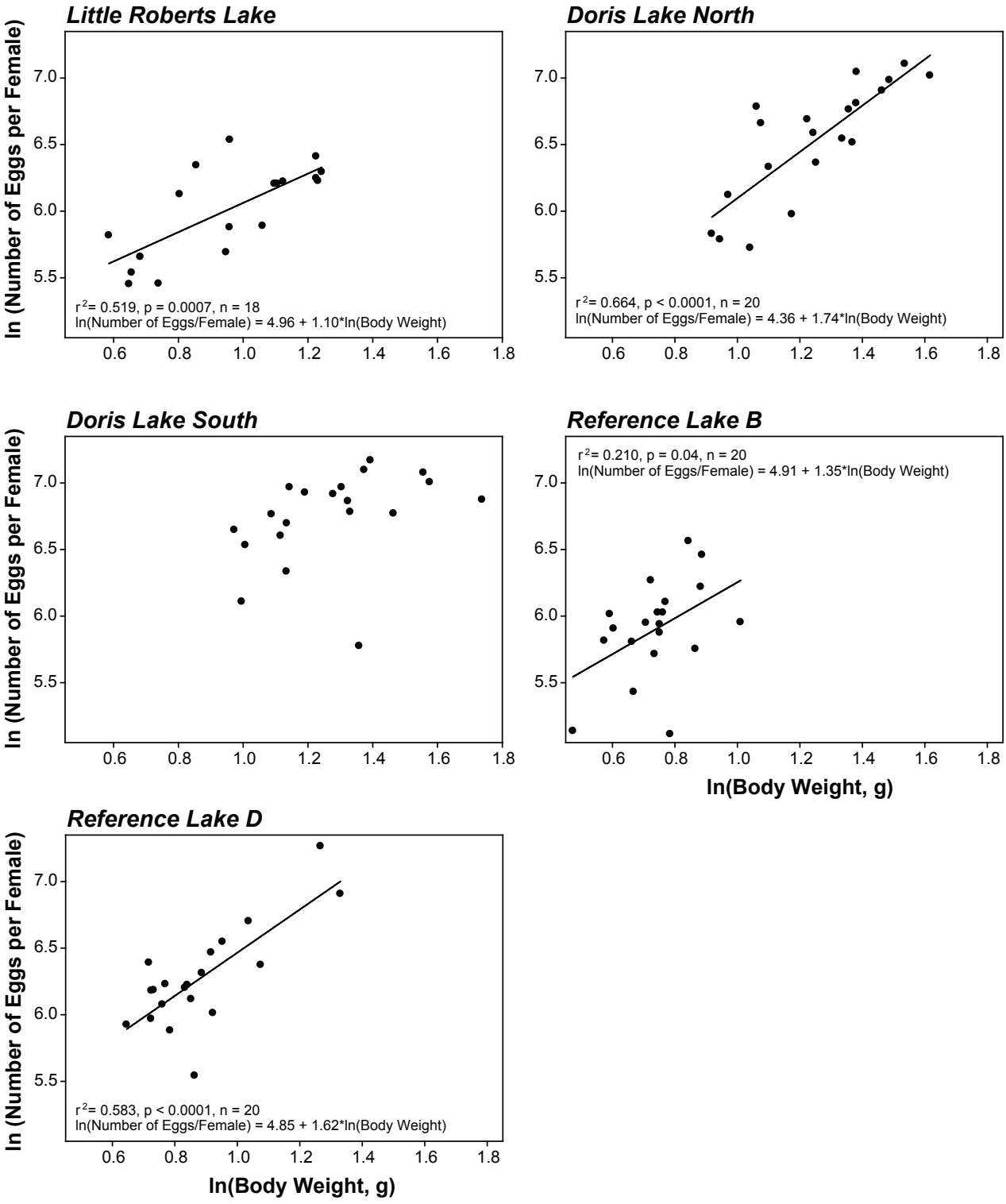

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Body Weight - Number of Eggs/Female Relationships, Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-7

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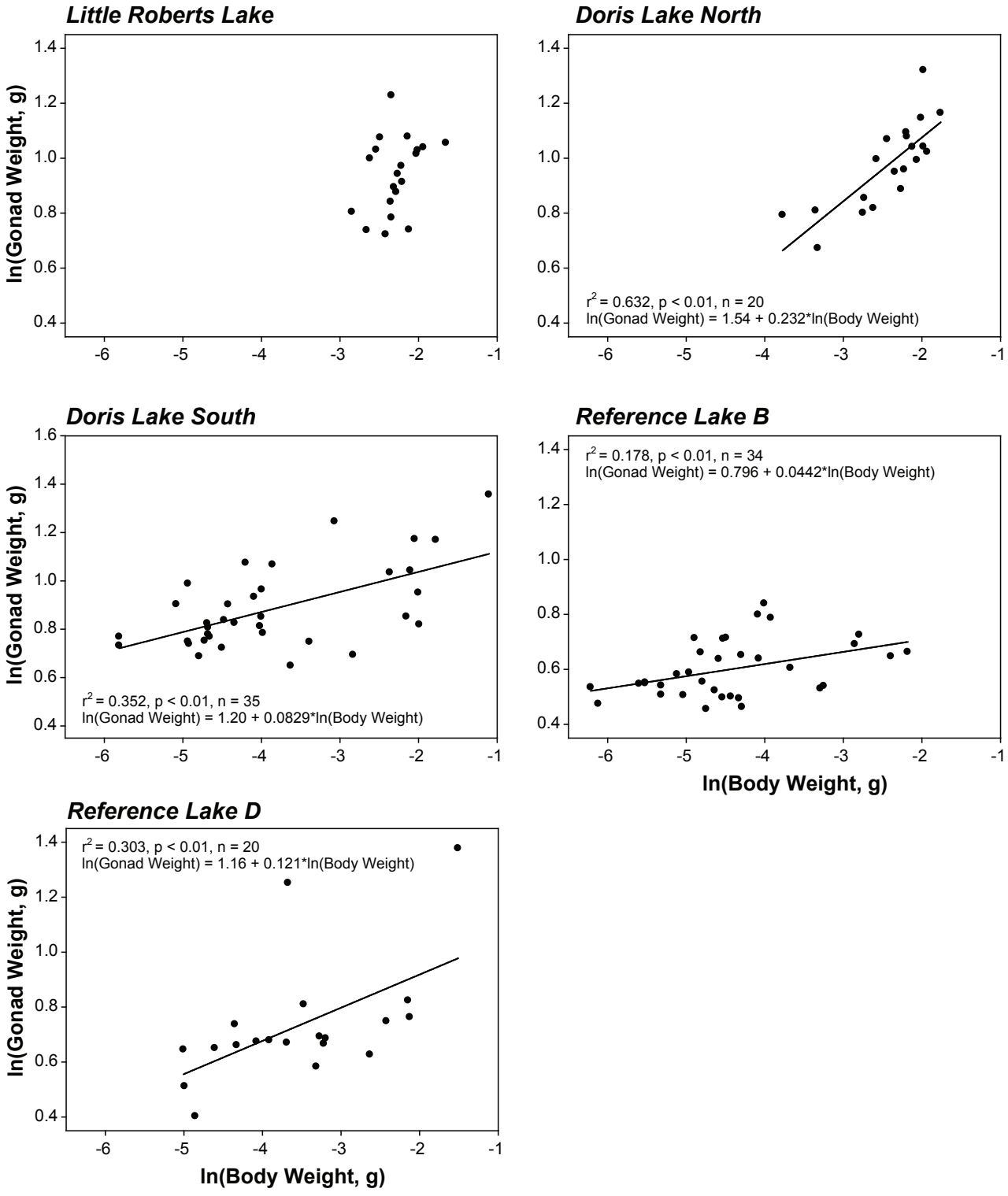

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Body Weight - Gonand Weight Relationships, Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-8

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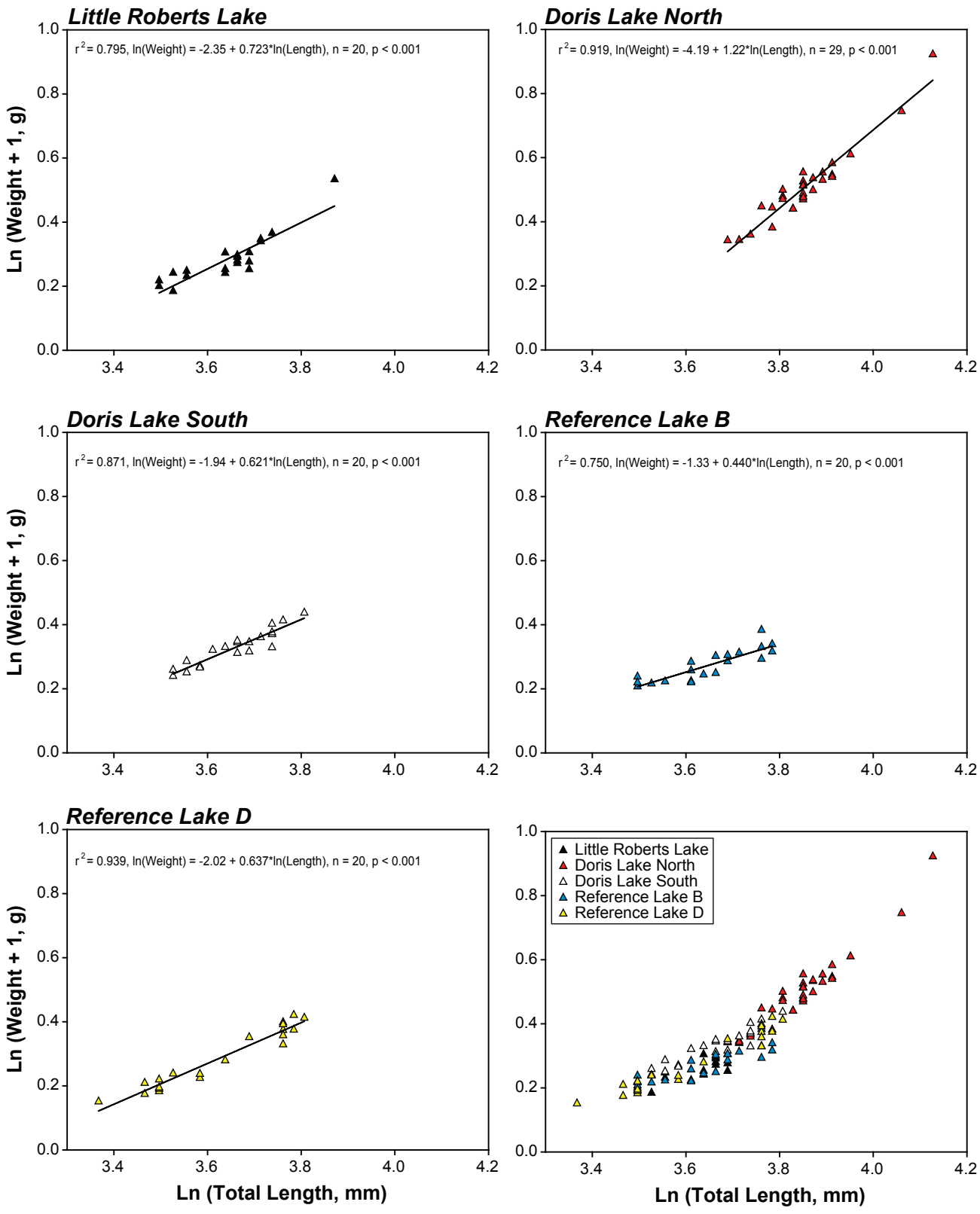

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Weight-Length Relationship of Immature Ninespine Stickleback, 2010

Figure B1.2-9

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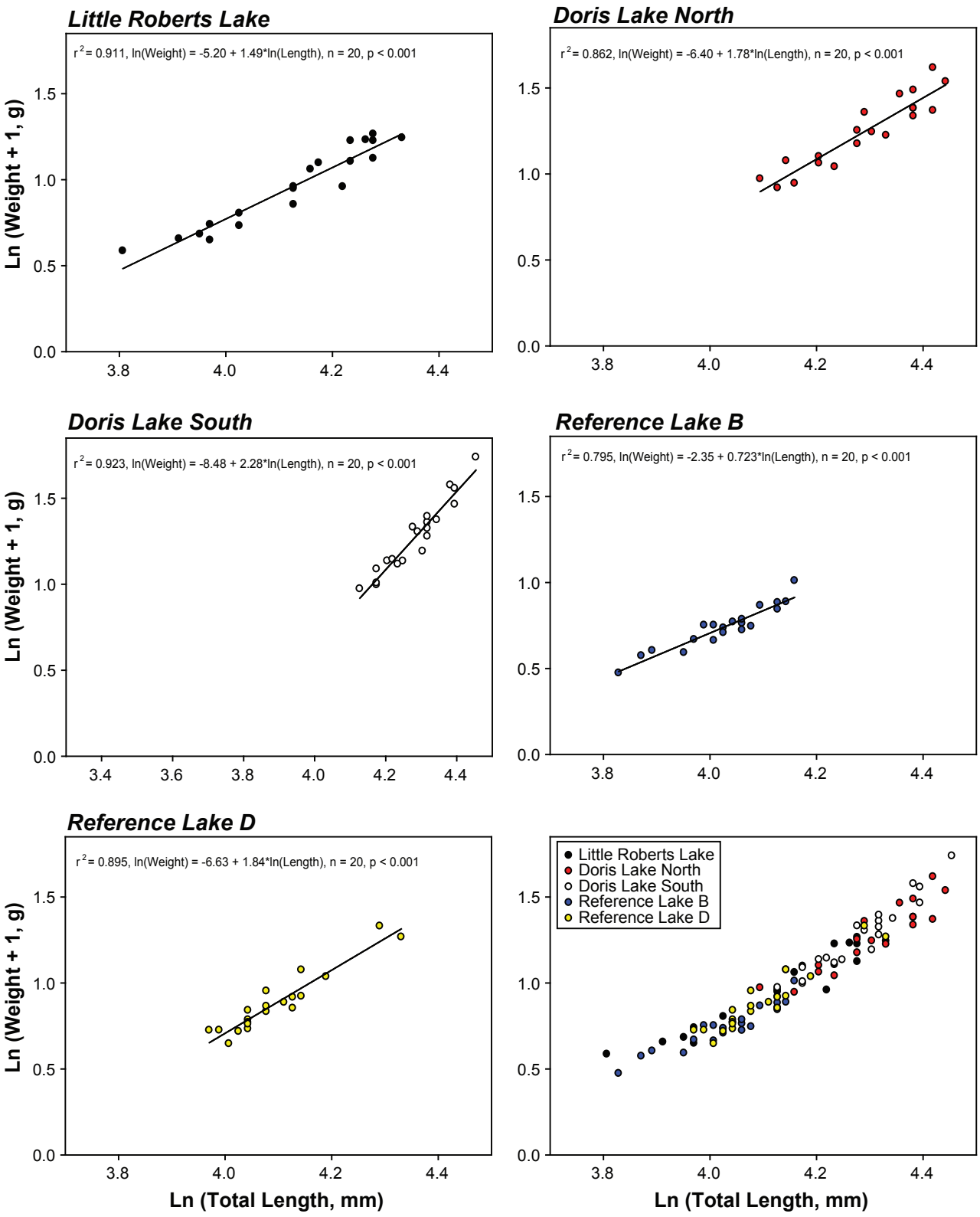

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Weight-Length Relationship of Female Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-10

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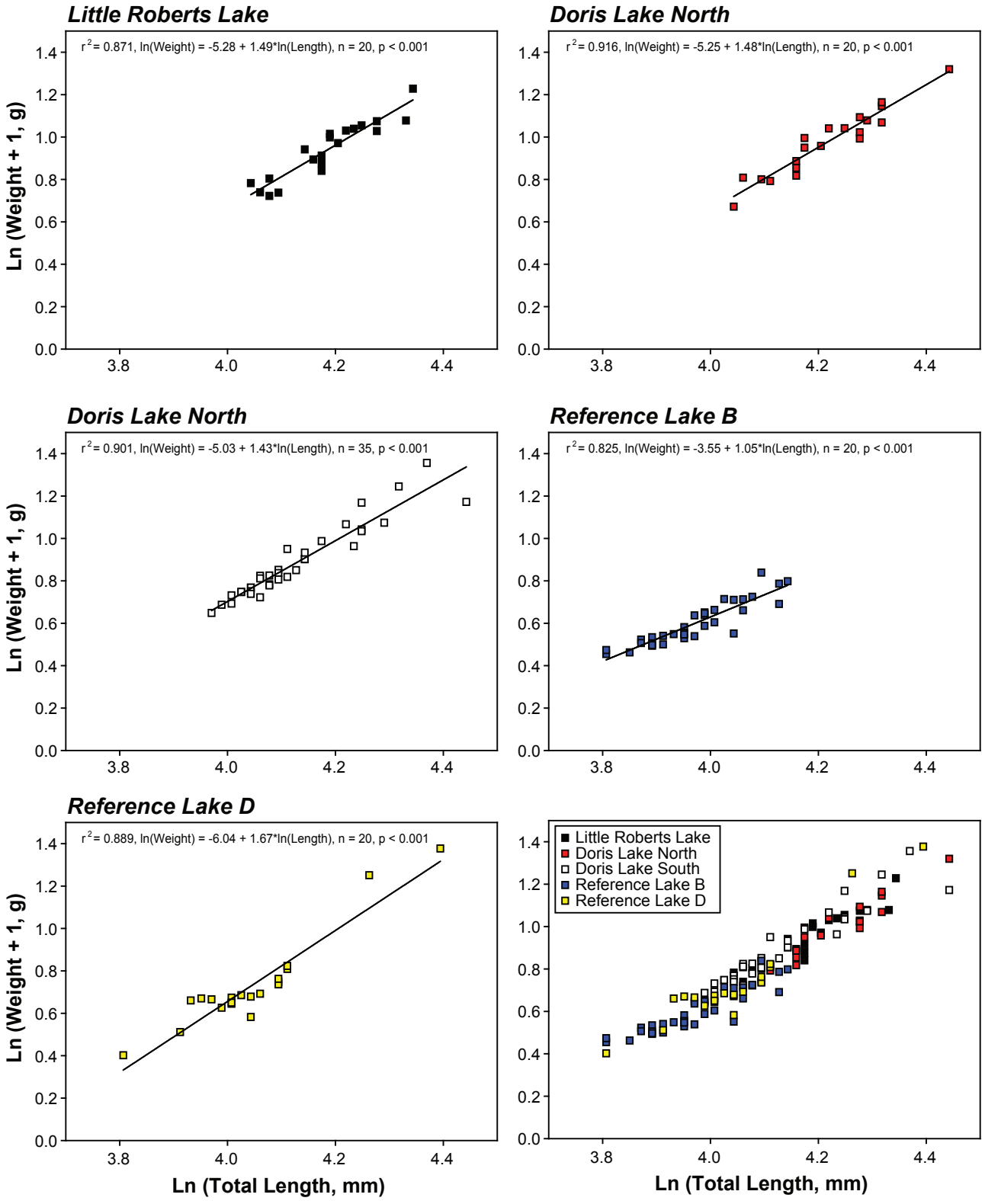

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Weight-Length Relationship of Male Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-11

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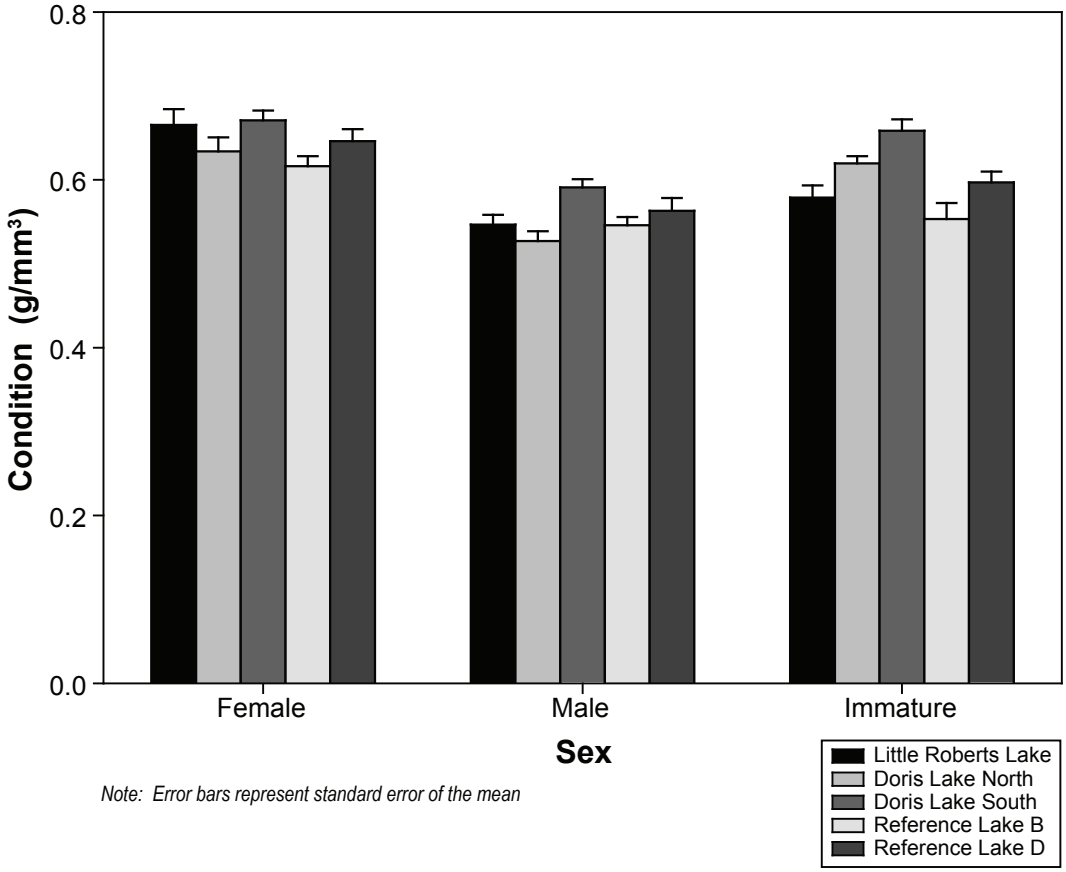

Note: Error bars represent standard error of the mean

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Mean Condition of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-12

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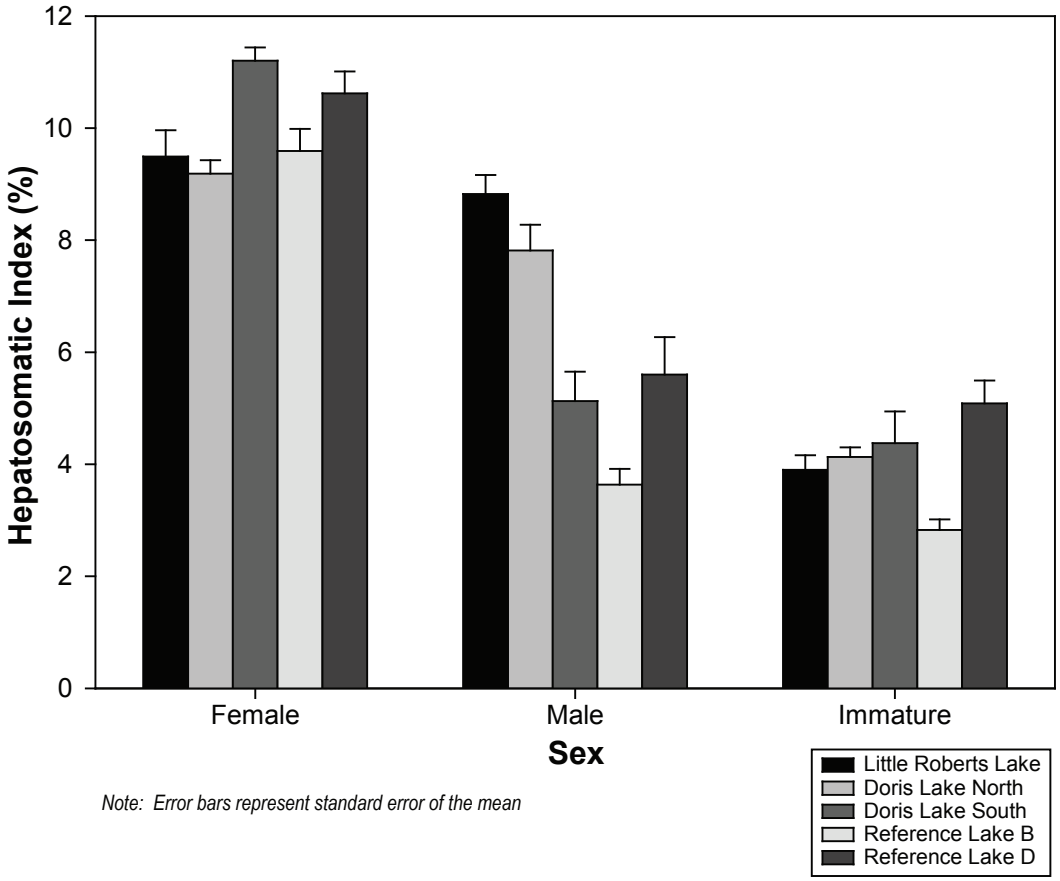

Note: Error bars represent standard error of the mean

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Hepatosomatic Indices of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-13

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The rate at which the livers of immature ninespine stickleback increased in weight with increasing body weight was generally similar among lakes (Figure B1.2-14). However, body weight was entirely reliable as a predictor of liver weight in immature fish, explaining 0% to 65% of the variation in liver weight. In contrast, body weight explained 69% to 89% of the variance in liver weight in mature female ninespine stickleback (Figure B1.2-15) and 31% to 74% of the variance in liver weight in male ninespine stickleback (Figure B1.2-16).

At all sites, ovary weight of female ninespine stickleback increased with body weight (Figure B1.2-17). Body weight explained 46% to 83% of the ovary weight of ninespine stickleback. As body weight increased, so did the ovary weights, and mean ovary weights of female stickleback were similar between sites. Weights of ovaries differed between sites, with ovaries from females collected in Doris Lake (means: North = 0.56 g; South = 0.54 g) being heavier than ovaries collected from females captured in Reference Lake B (mean = 0.21 g).

Survival

Age data for ninespine stickleback are summarized in Table B1.2-2. Age frequencies of ninespine stickleback are shown in Figure B1.2-18. Sampled ninespine stickleback ranged in age from one (all lakes except Reference Lake D) to four years old (all lakes except Little Roberts Lake). The mean age of all individuals was greatest in Little Roberts Lake (3 years old) and lowest in Doris Lake South and Little Roberts Lake (2 years old).

DELTs and Parasites

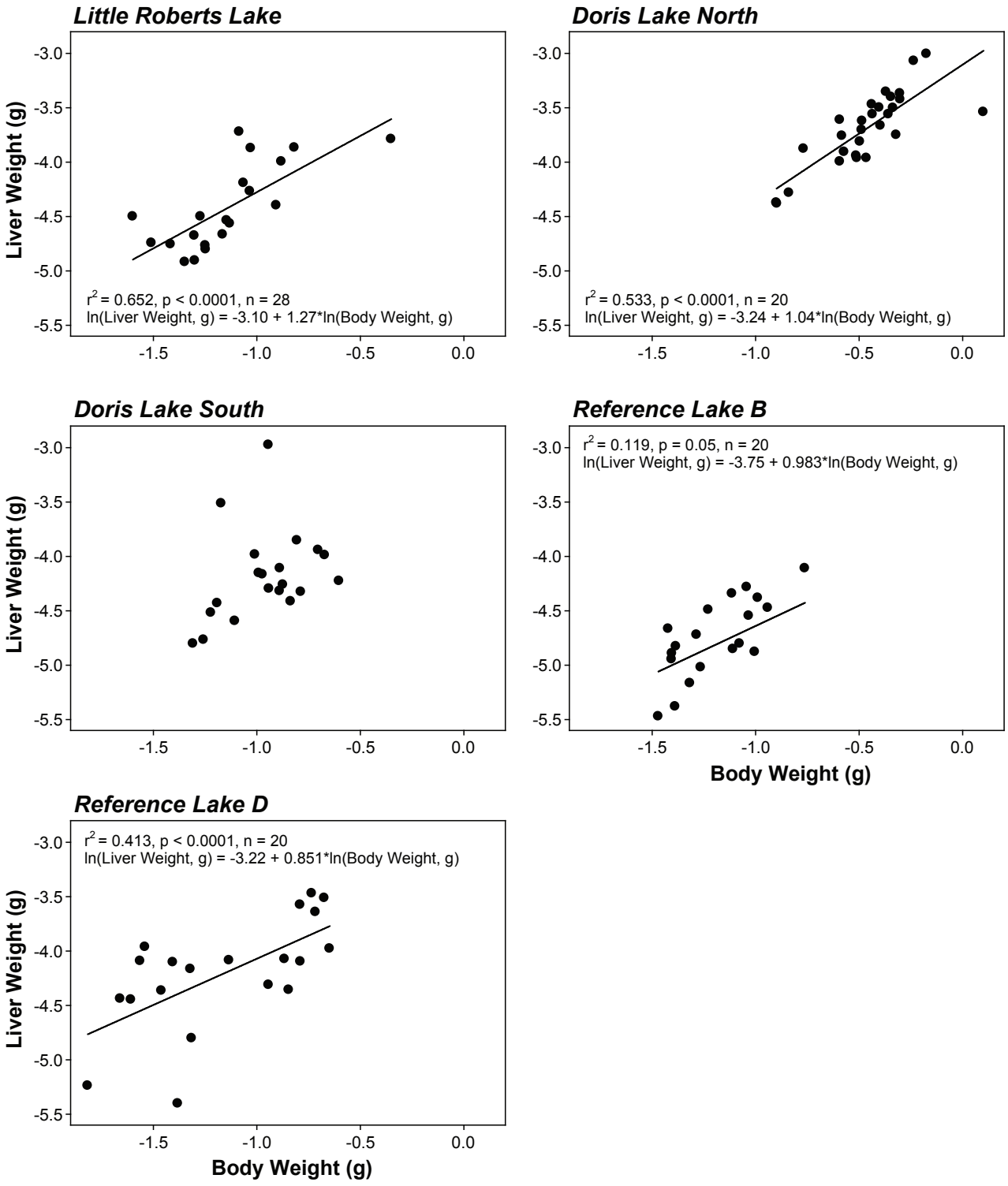
No differences were observed in either the number of immatures or females with parasites or the number of parasites collected from those individuals when those variables were compared between Little Roberts Lake and Reference Lake D. Males from Reference Lake D had higher incidents of parasites and greater numbers of parasites (Figure B1.2-19). No differences were observed in either the number of individuals with parasites or the number of parasites collected from those individuals when those variables were compared between Reference Lake B, Doris Lake North and Doris Lake South (Figure B1.2-19). Overall, the most parasites were found in Reference Lake D (50.7% of individuals), followed by Doris Lake South (27.8%), Reference Lake B (26.6%) and Little Roberts Lake (21.4%). The fewest parasites were found in Doris Lake North (15.9%). Only one individual from any lake (male from Little Roberts Lake) was classified as having a DELT.

B1.2.1.3 Tissue Metals

There were no clear trends in the mean concentration of metals in the tissue of ninespine stickleback between sites (Figure B1.2-20). The concentration of metals from individual samples of ninespine stickleback can be found in Appendix B2-2.

Arsenic

Arsenic is a toxin and tends to accumulate with the age and size of the fish (Eisler 1988a); however, it does not biomagnify as it moves up the food chain because fish and other aquatic organisms are able to excrete it. Most living organisms normally contain measurable concentrations of arsenic, though the amounts measured are typically less than 1 mg/kg wet weight or less than 4 mg/kg dry weight (assuming 80% moisture content). The maximum allowable Health Canada guideline for arsenic in fish tissue is 3.5 mg/kg wet weight, but that guideline is for fish protein concentrate only, not wet whole fish tissue (Health Canada 2001).



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Liver Weight – Body Weight Relationships, Immature Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-14

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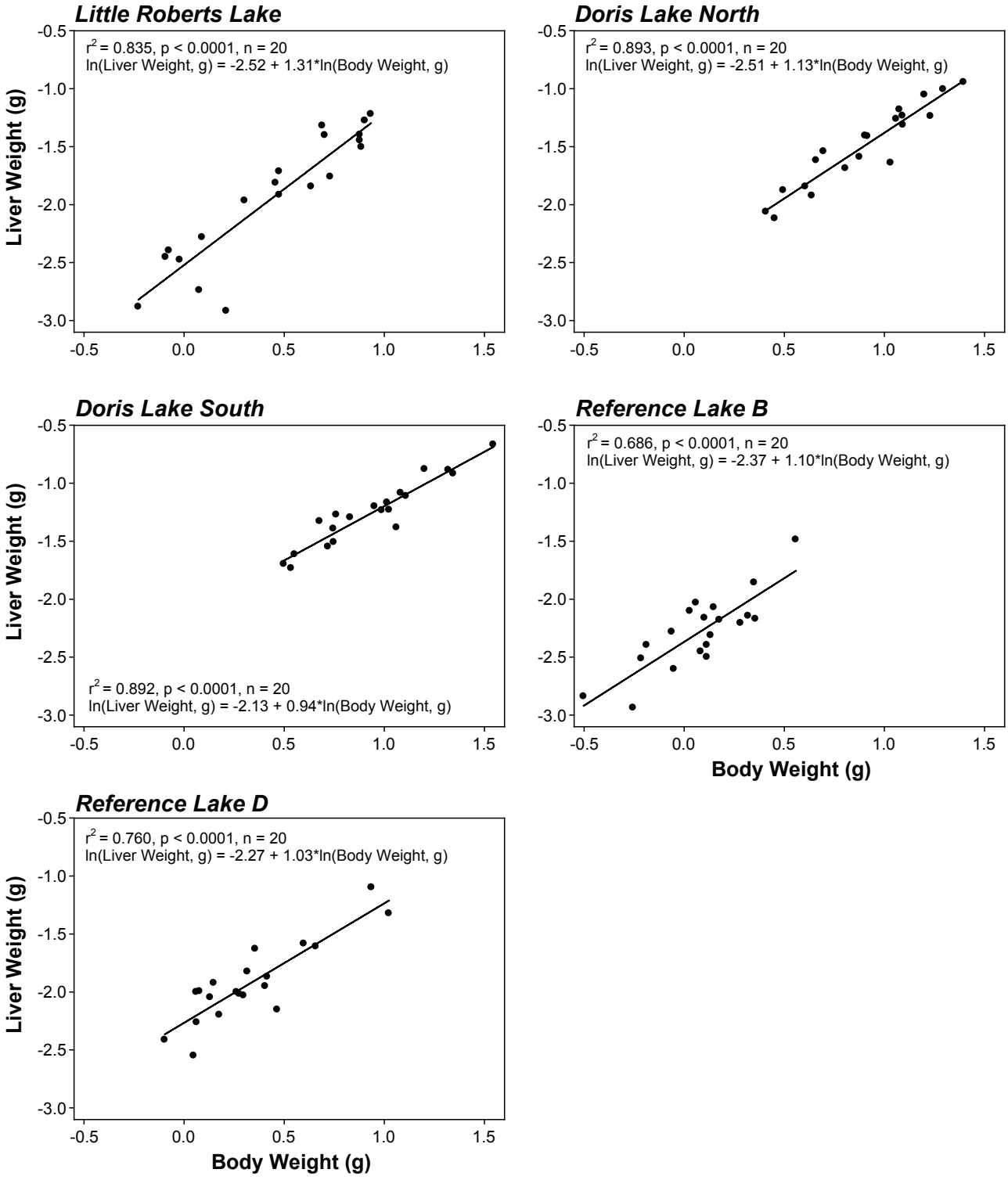

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Liver Weight – Body Weight Relationships, Female Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-15

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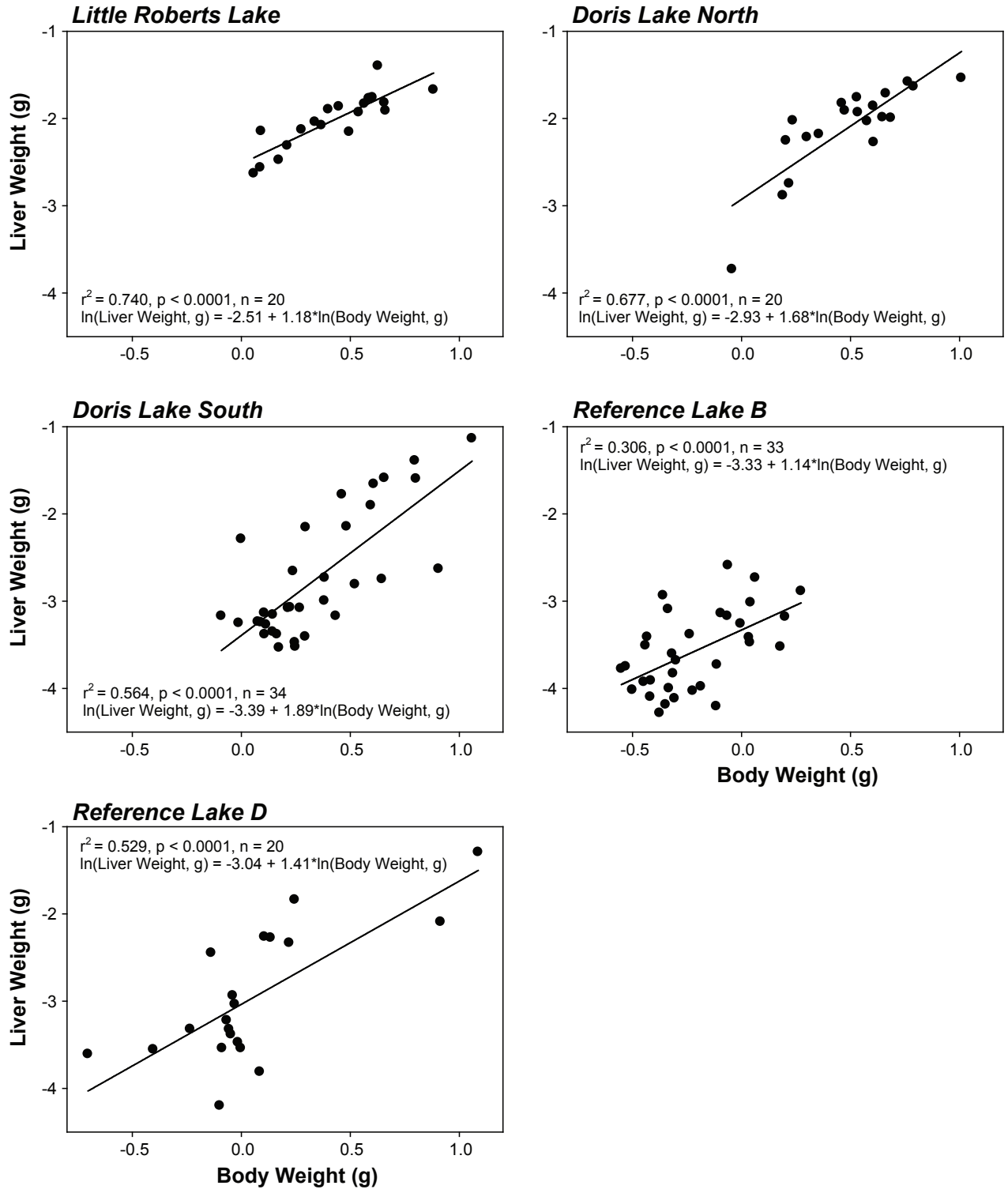

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Liver Weight – Body Weight Relationships, Male Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-16

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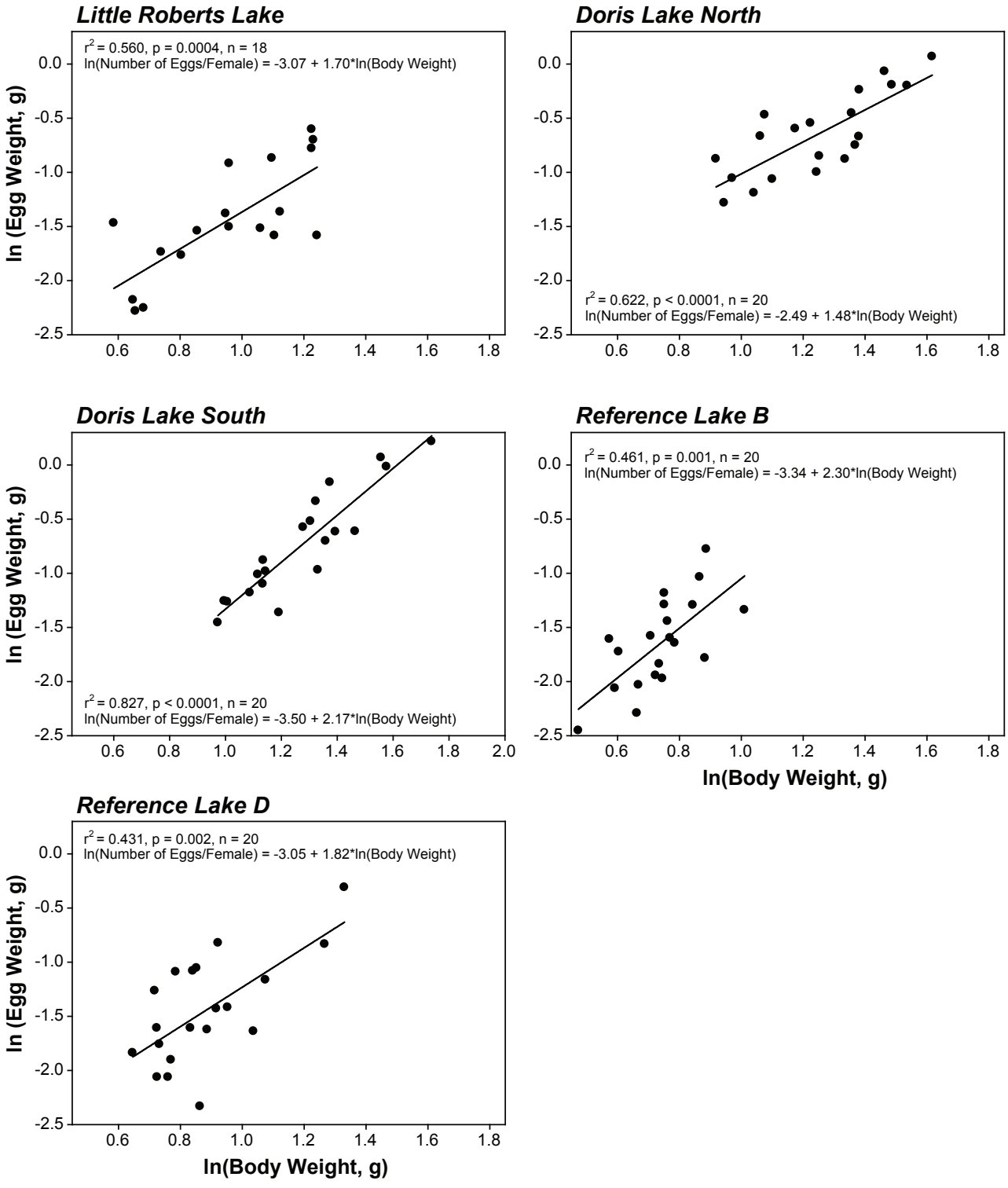

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Ovary Weight – Body Weight Relationships, Doris North Project, 2010

Figure B1.2-17

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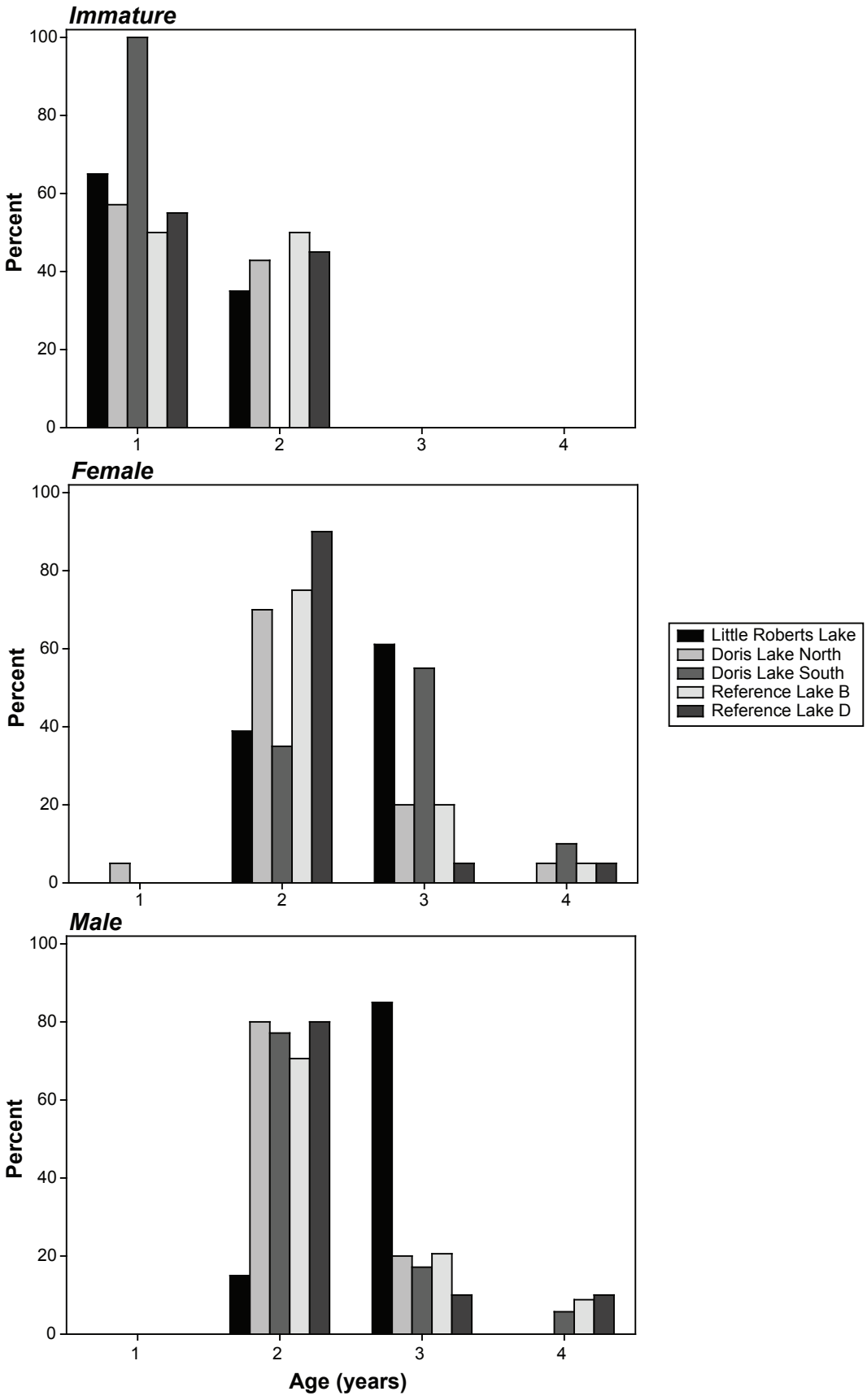

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Age Distributions of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-18

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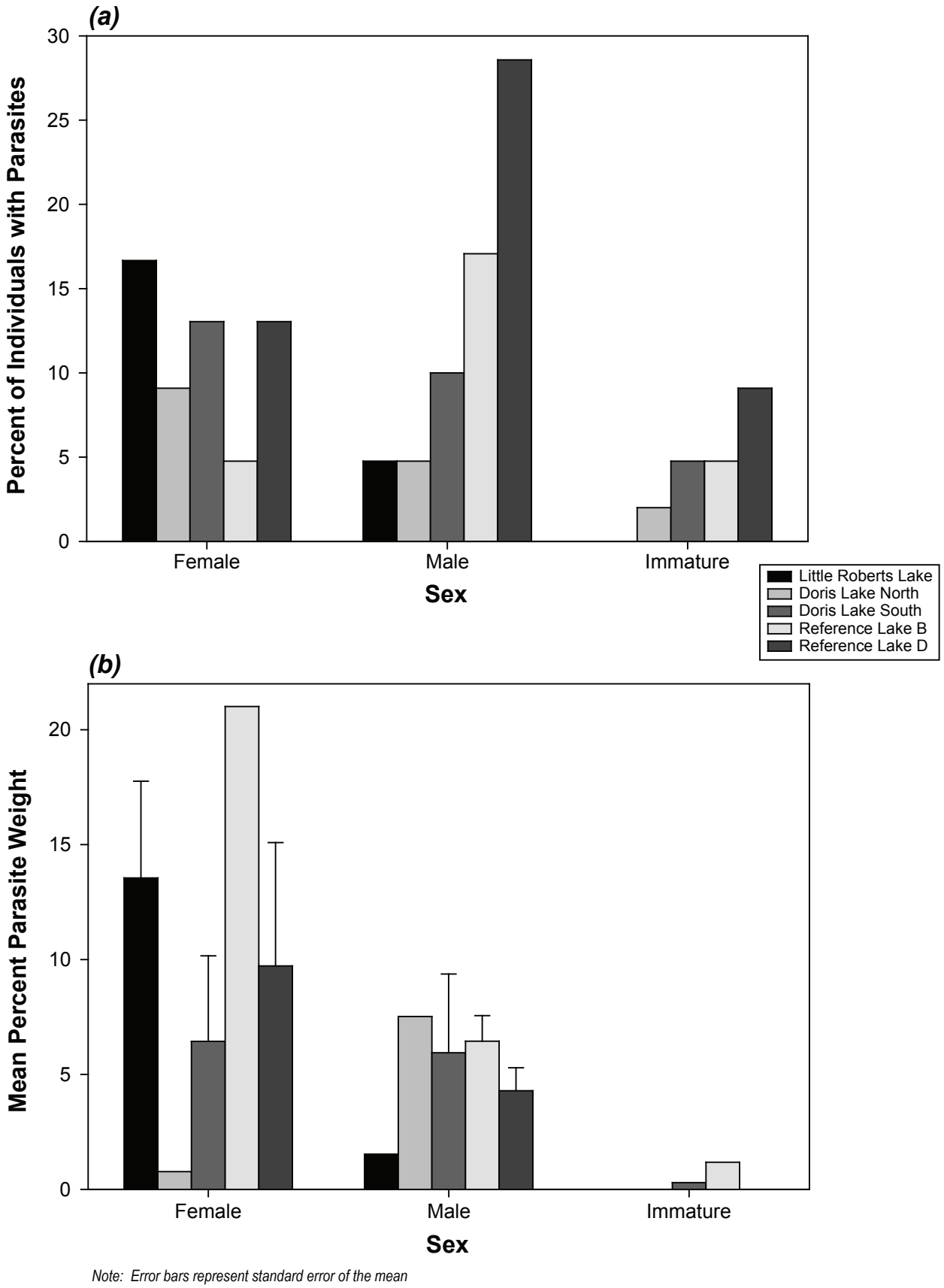

Note: Error bars represent standard error of the mean

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Percentage of Ninespine Stickleback with Parasites (a) and the Mean Percent of Body Weight of Ninespine Stickleback Attributed to Parasites (b), Doris North Project, 2010

Figure B1.2-19

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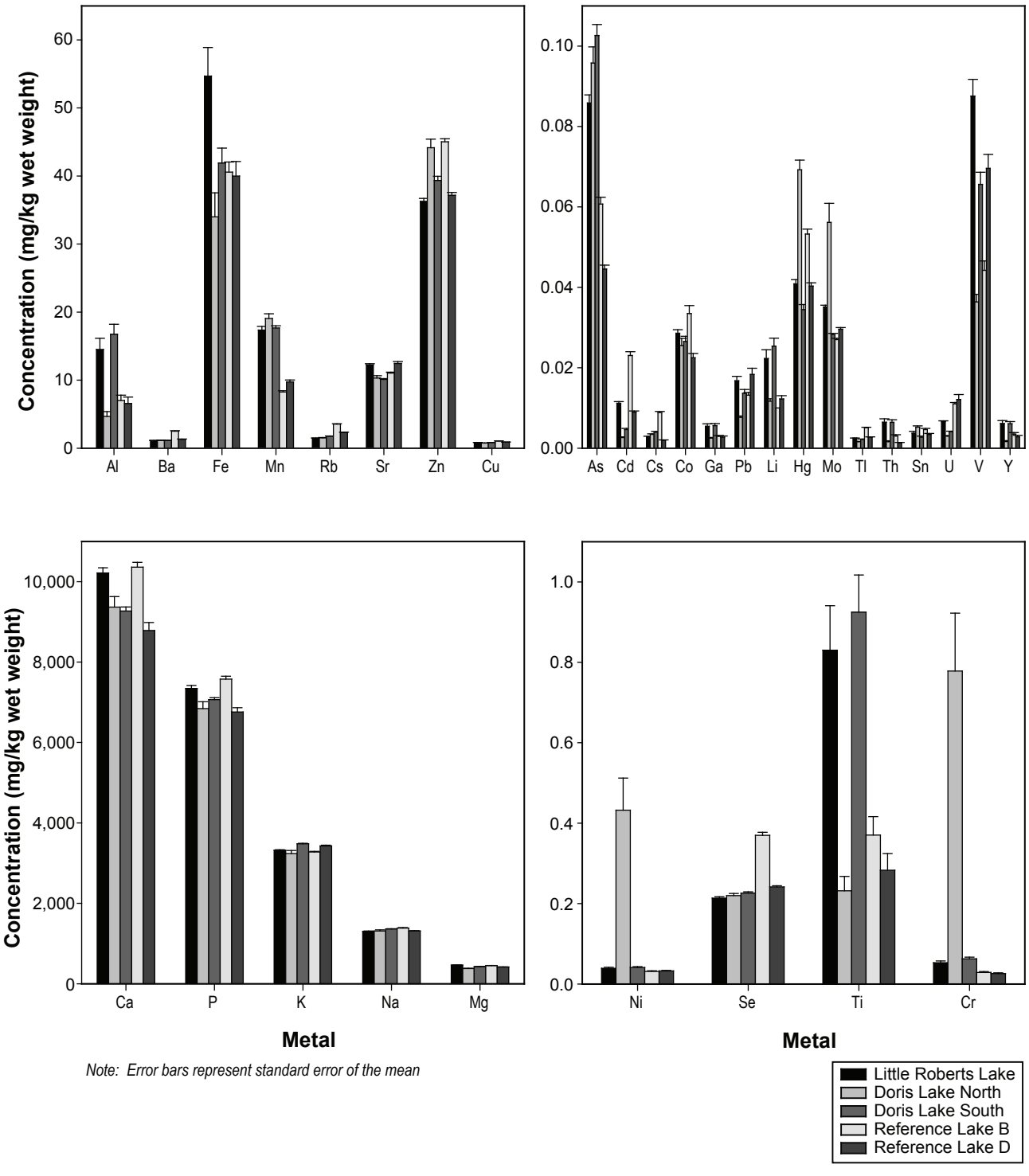

Note: Error bars represent standard error of the mean

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Mean Tissue Metal Concentrations of Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-20

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Tissue metal concentrations of arsenic in ninespine stickleback did not approach the Health Canada guidelines of 3.5 mg/kg wet weight and were lower than typically measured concentrations of arsenic found in living organisms (Figure B1.2-20). Arsenic levels were higher in Little Roberts Lake than in Reference Lake D, and higher in stickleback captured from Doris Lake North and Doris Lake South compared to Reference Lake B.

Mercury

Mercury is a toxic metal with no known biological function (Eisler 1987). In fish, it binds tightly and permanently to proteins because fish lack the metabolic machinery to excrete mercury. Thus, concentrations tend to increase directly with the age and size of fish. For the same reason, mercury is biomagnified as it passes up the food chain. A significant positive relationship between muscle mercury concentration and body weight has been reported for other species of fish in North America and the Northwest Territories and Nunavut (Lockhart et al. 2005). The Health Canada guideline for the maximum allowable concentration of total mercury in fish muscle tissue sold commercially is 0.5 mg/kg wet weight (Health Canada 2001). The mean concentrations of mercury in fish tissue of stickleback captured in Little Roberts Lake and Reference Lake D were similar. The concentrations of mercury in ninespine stickleback from Doris Lake South were lower than in fish from both Doris Lake North and Reference Lake B (Figure B1.2-20). Mercury concentrations in the sampled ninespine stickleback were always below 0.1 mg/kg wet weight, which was far lower than the Health Canada guideline of 0.5 mg/kg.

PCA

A total of 14 metal concentrations were entered into the PCA: aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium and zinc. A scree plot (not shown here) shows that only the first three components were important in interpreting the major trends of the data.

The first, second and third components of the PCA explained 27.5, 24.0 and 18.0% of the variance in the dataset. Principal component one (PC1) was negatively correlated with three metals: chromium, molybdenum and nickel (Table B1.2-3). PC2 was positively correlated with three metals: cadmium, cobalt and copper (Table B1.2-3). PC3 was negatively correlated with mercury only.

Table B1.2-3. Loadings of Metals on Principle Components, Ninespine Stickleback, Doris North Project, 2010

Metal	PC1	PC2	PC3
Variance explained (%)	27.5	24.0	18.0
ln(Chromium)	-0.87		
ln(Molybdenum)	-0.89		
ln(Nickel)	-0.87		
ln(Cadmium)		0.82	
ln(Cobalt)		0.78	
ln(Copper)		0.79	
ln(Mercury)			-0.73

The results of the PCA indicate that metal content of the stickleback in Reference Lake B differed slightly from the other sites with respect to PC1 (Figure B1.2-21). Ninespine stickleback from Reference Lake B and Doris Lake North also differed from individuals from the other lake sites that grouped together on PC2; individuals from Reference Lake B and Doris Lake North also differed from each other with respect to PC2. As well, stickleback from Reference Lake B and Doris Lake North were more similar to each other than to stickleback from the other lake sites with respect to PC3. This might reflect differences in metals present in the ecosystem, as well as differences in the uptake in individuals collected from these waterbodies.

B1.2.2 Marine

B1.2.2.1 Biology

The length, width, and height of mussels (*Mytilus trossulus*) were similar between sites (Figure B1.2-22; Table B1.2-4). The length of mussels sampled ranged from 31 to 86 mm (both mussels were collected from Reference Bay), while the widths of mussels were between 16 mm (Reference Bay) and 30 mm (RBE). The height of individuals ranged from 11 to 25 mm (both mussels were collected from Reference Bay). The mean width and height was slightly higher in RBW (width: 24 mm, height: 18 mm) than in both RBE and Reference Bay (width: 23 mm, height: 17 mm). Whole body and tissue weights of mussels were similar between RBE (mean total weight: 16.2 g, mean tissue weight: 4.9 g) and RBW (Figure B1.2-23; Table B1.2-4). Because mussel samples from Reference Bay were frozen and thawed, tissue and total weight comparisons cannot be made between these mussels and those collected from RBE and RBW. However, given that differences did not exist in any other biological measure (i.e., length, width, or height), it is expected that no differences would occur in weights of these individuals compared to the Roberts Bay mussels.

B1.2.2.2 Tissue Metals and PAHs

Of the 33 metals measured in the tissues of *M. trossulus* (above detection limits), the concentrations of 30 (91%) were highest in the mussels collected from Reference Bay (Figure B1.2-24). There were no trends in the concentrations of metals measured in the tissues of mussels sampled from RBE and RBW. Concentrations of all metals measured in *M. trossulus* tissue can be found in Appendix B2-3.

Arsenic

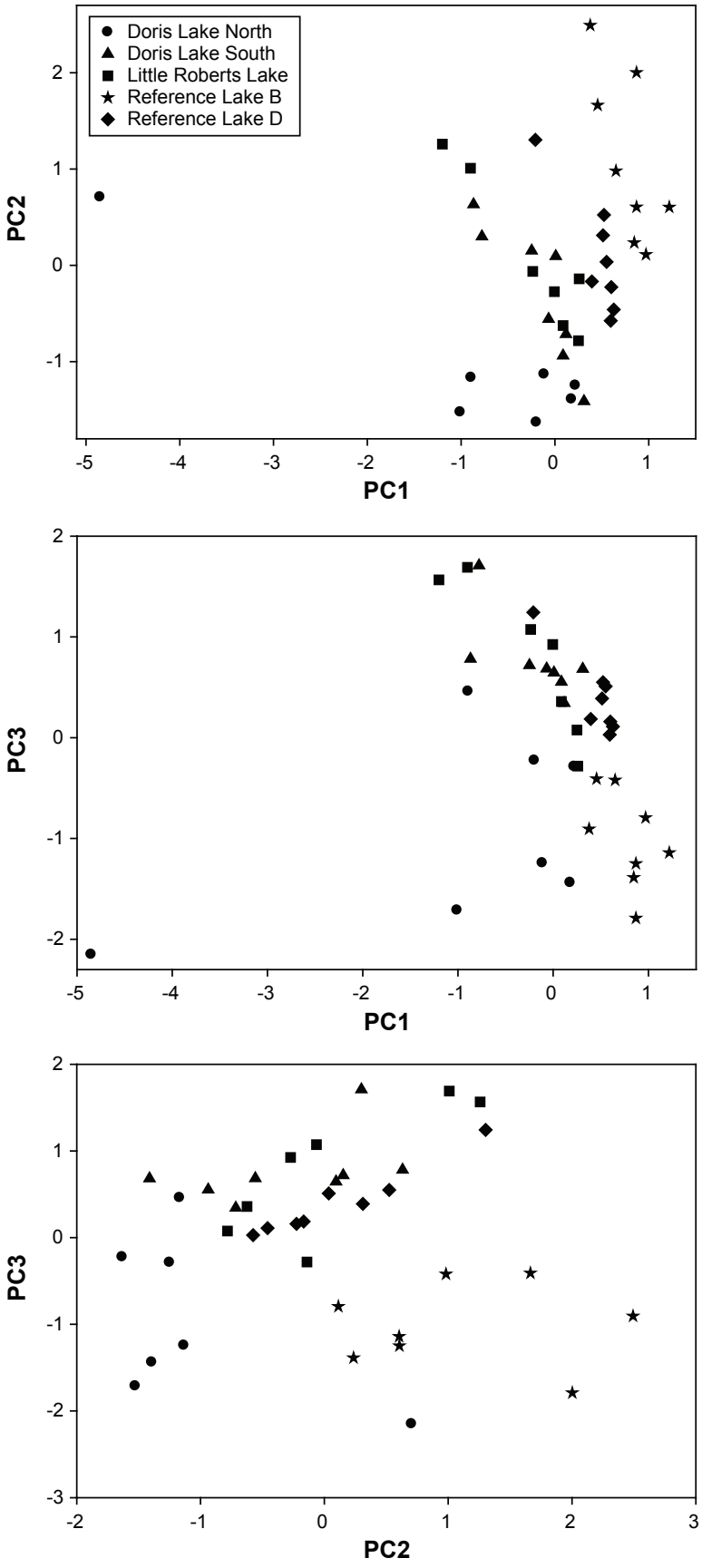
Arsenic was one of three metals measured in the tissues of mussels where the concentration of the metal was lowest in Reference Bay. Mean concentrations of arsenic in the tissues of mussels sampled in RBE were slightly above those measured in mussels in RBW (Figure B1.2-24). The Health Canada guideline for arsenic in fish and shellfish protein concentrate is 3.5 mg/kg.

Mercury

Mercury concentrations measured in mussel tissues were highest in individuals collected from Reference Bay and lowest in individuals collected from RBE (Figure B1.2-24). Mean concentrations were below 0.2 mg/kg dry weight at each marine site. The Health Canada guideline for marine fish and shellfish is 0.5 mg/kg.

PCA

A total of 14 metal concentrations were entered into the PCA: aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium and zinc. A scree plot (not shown here) shows that only the two components were necessary to interpret the major trends of the data.



Results of Principal Components Analysis, Ninespine Stickleback, Doris North Project, 2010

Figure B1.2-21

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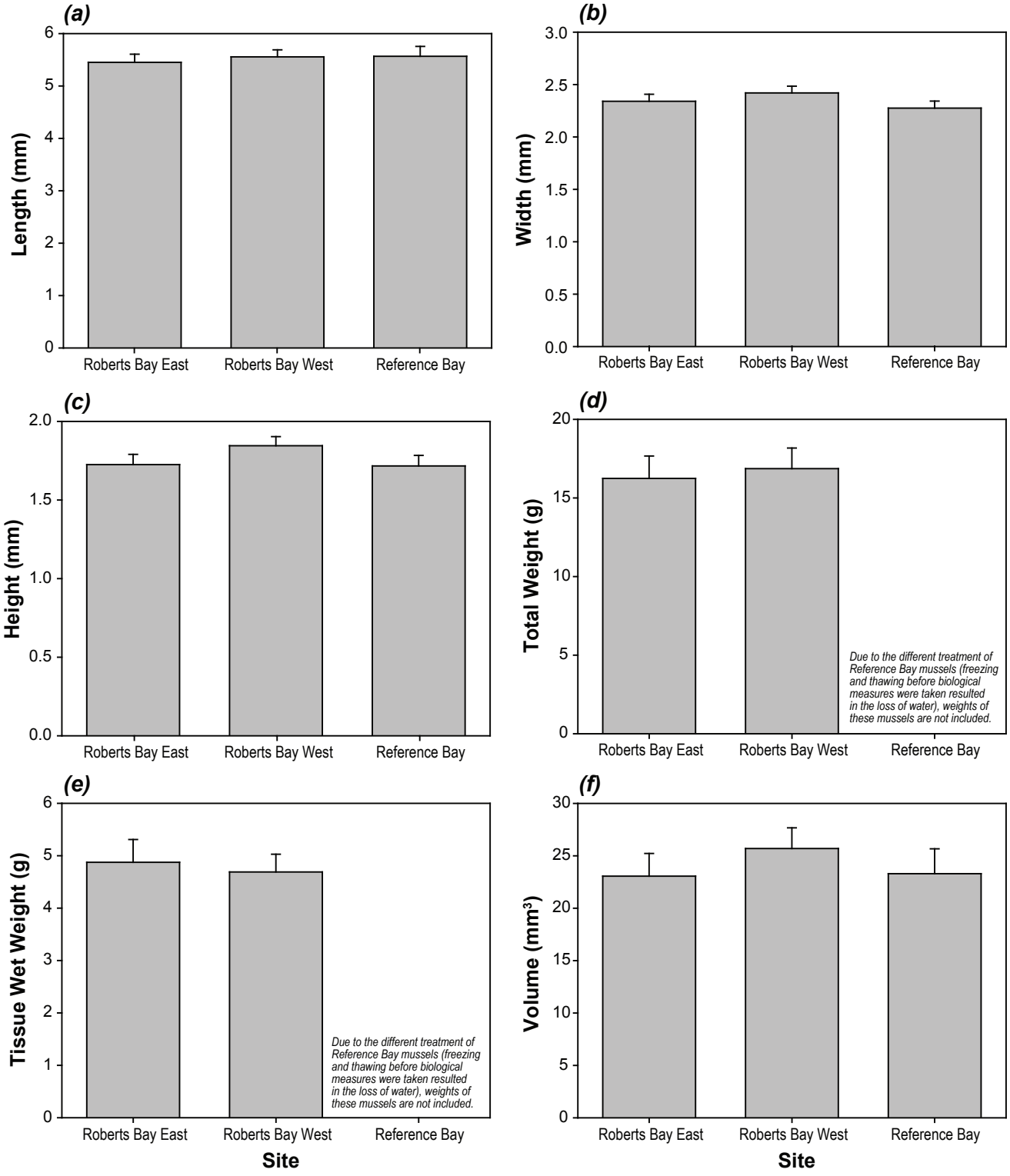

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Mean (a) Length (mm), (b) Width (mm), (c) Height (mm), (d) Total Weight (g), (e) Tissue Wet Weight, and (f) Volume (mm³) of *Mytilus trossulus*, Doris North Project, 2010

Figure B1.2-22

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Table B1.2-4. Biological Attributes of *Mytilus trossulus* , Doris North Project, 2010

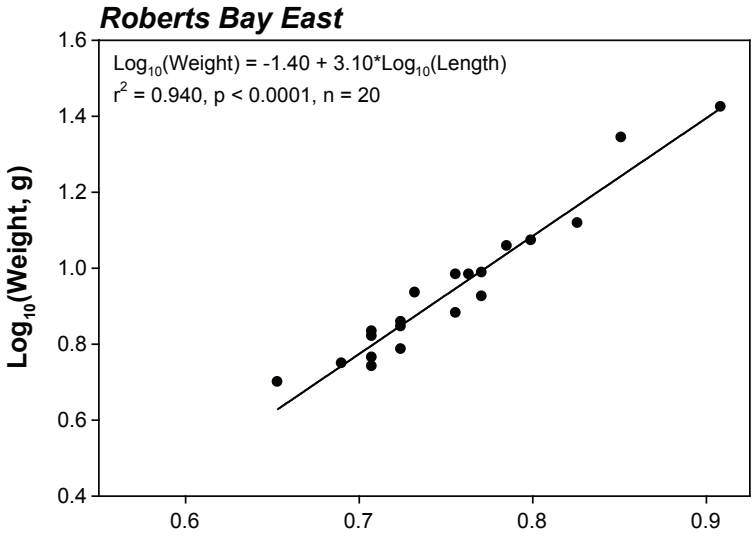
		Length (mm)					Width (mm)					Height (mm)				
Site	n	Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD
Roberts Bay East	20	45 - 72	55	53	1.6	7.0	19 - 30	23	25	0.7	3.0	13 - 23	17	17	0.7	2.9
Roberts Bay West	20	47 - 70	56	55	1.3	6.0	20 - 29	24	23	0.6	2.9	13 - 22	18	19	0.6	2.6
Reference Bay	24	31 - 86	56	55	1.9	9.2	16 - 29	23	23	0.7	3.3	11 - 25	17	17	0.7	3.3

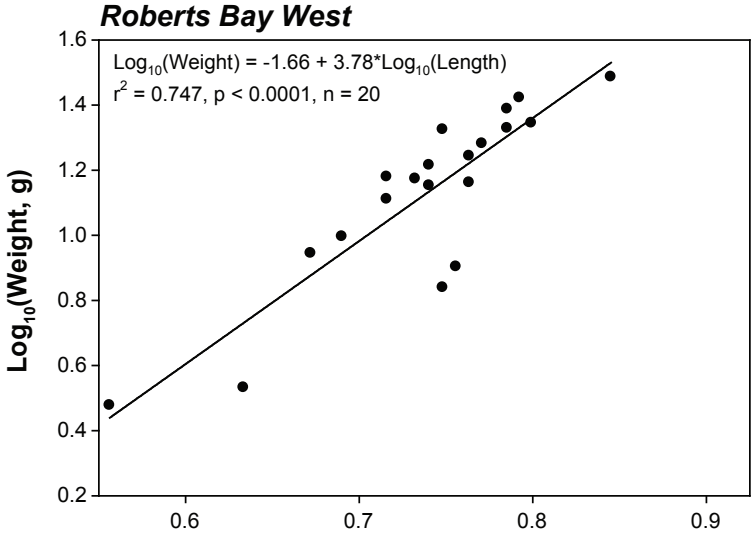
		Volume (mm^3)					Total Weight (g)*					Tissue (Wet Weight, g)*				
Site	n	Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD	Range	Mean	Median	SE	SD
Roberts Bay East	20	11,115 - 47,520	23,053	20,394	2,165	9,683	8.3 - 32.9	16.2	14.5	1.4	6.4	2.7 - 10.5	4.9	4.6	0.4	1.9
Roberts Bay West	20	12,831 - 44,660	25,692	25,153	1,975	8,835	8.8 - 30.6	16.9	15.0	1.3	5.9	2.6 - 8.7	4.7	4.4	0.3	1.5
Reference Bay	24	7,128 - 5,4027	23,295	21,248	2,370	11,609	3.0 - 26.5	9.0	7.4	1.1	5.4	1.4 - 8.6	3.6	3.2	0.3	1.7

SE = standard error of the mean

SD = standard deviation of the mean

** - Reference Bay mussels were frozen and thawed*





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Weight-Length Relationship of *Mytilus trossulus*, Doris North Project, 2010

Figure B1.2-23

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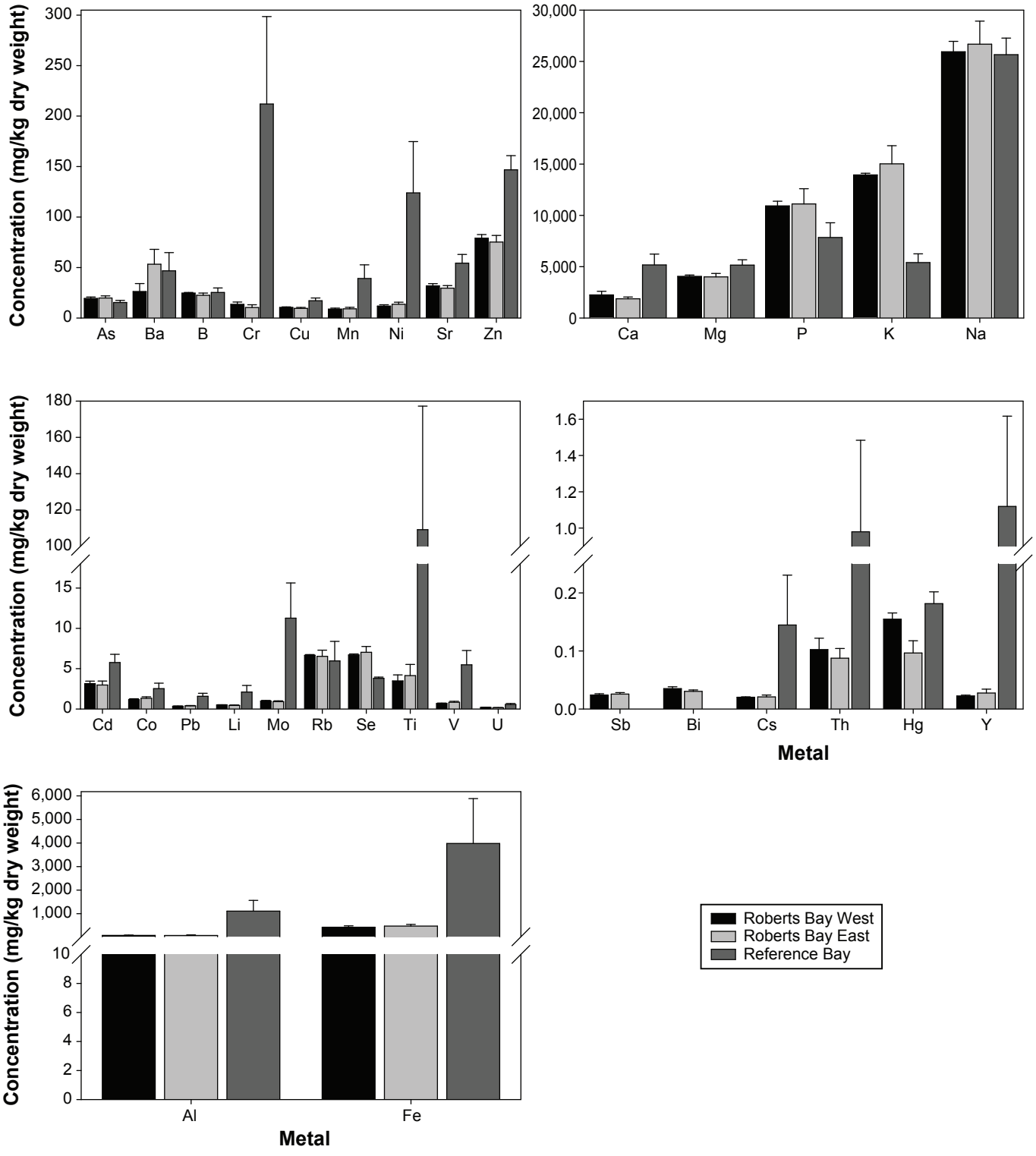

Mean Tissue Metal Concentrations of *Mytilus trossulus*, Doris North Project, 2010

Figure B1.2-24

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The first and second components of the PCA explained 67.2 and 16.5% of the variance in the dataset. The remaining components each explained less than 10% of the variance in the dataset. Principal component one (PC1) was negatively correlated with ten metals (aluminum, copper, iron, lead, molybdenum, nickel, zinc, manganese, cobalt and chromium) (Table B1.2-5). Principal component two (PC2) was positively correlated with two metals: cadmium and mercury (Table B1.2-5).

Table B1.2-5. Loadings of Metals on Principle Components, *Mytilus trossulus*, Doris North Project, 2010

Metal	PC1	PC2
Variance explained (%)	67.2	16.5
Aluminum	-0.98	
Copper	-0.94	
Iron	-0.95	
Lead	-0.82	
Molybdenum	-0.98	
Nickel	-0.97	
Zinc	-0.76	
Manganese	-0.97	
Cobalt	-0.93	
Chromium	-0.98	
Cadmium		0.77
Mercury		0.80

The results of the PCA indicated that metal concentrations in Reference Bay mussels differed slightly from the other sites with respect to PC1 (Figure B1.2-25). The mussels collected from the three waterbodies did not differ with respect to PC2. Taken together, different loadings on PC1 by mussels collected from Reference Bay compared to those collected from RBE and RBW might reflect differences in metals present in the ecosystem, as well as differences in the uptake in individuals in the waterbodies.

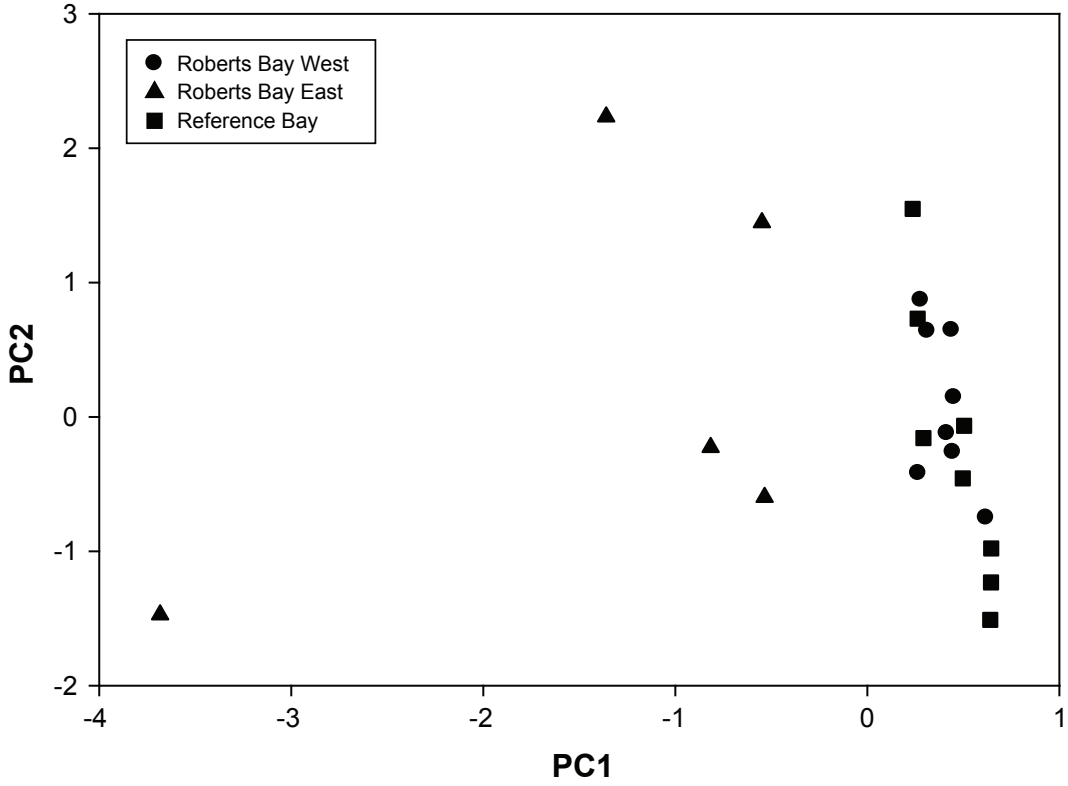
PAHs

Of the 16 polycyclic aromatic hydrocarbons measured in the seven samples (112 measures total), only one was above its detection limit. Anthracene was detectable in one mussel sample taken from Reference Bay; the concentration was measured as 0.056 mg/kg wet weight. No other PAHs were detectable in any samples, which indicated no impact of shipping or jetty-related activities on the PAH concentrations in *M. trossulus* in Roberts Bay.

B1.3 QUALITY CONTROL AND QUALITY ASSURANCE (QA/QC) RESULTS

B1.3.1 Data Collection and Entry

Upon review of field data sheets and electronic versions of data sheets, only one mis-entered value was identified. This value was replaced with the correct value from the field data sheets. Plots of the data did not reveal any outliers, suggesting that no errors existed in the data input.



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Results of Principal Components Analysis for *Mytilus trossulus*, Doris North Project, 2010

Figure B1.2-25

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B1.3.2 Tissue Metals

B1.3.2.1 Ninespine Stickleback

To assess the accuracy of the metal analyses, ALS conducted two measures of quality control: method blanks (MB) and comparison with reference material (CRM). A method blank is a test in which no tissue was added. Three method blanks were run with 39 metals measured for each blank and two method blanks were run with six metals (calcium, magnesium, mercury, phosphorous, potassium and sodium), resulting in a total of 129 comparisons between measurements and targets. Only two of the measurements (1.6%) were above the method detection limit (MDL) and was classified by ALS as "MB-LOR" (Appendix B2-4).

To further assess the accuracy of the metal analyses, samples of a reference material, VA-NRC-TORT2 or lobster hepatopancreas certified by the National Research Council of Canada, were subjected to the same analytical procedures as the ninespine stickleback tissue samples. The measured concentrations of each metal were then compared to the known metal concentrations in the certified material to determine if they fell within the 95% confidence limits expected for each metal. Of the 55 reference material comparisons (RMC) performed, 48 fell within the 95% confidence limits around the target value and seven fell outside the limits (an incidence of 13%; Appendix B2-4). These results were considered to be an acceptable range of analytical accuracy (Amber Springer, ALS Environmental, pers. comm.).

To assess the variability of fish tissue metal analysis, four of the 38 samples (~11% of the total number of samples) were each split into two replicates and the relative percent difference (RPD) between replicate metal concentrations and percent moisture was calculated as:

$$RPD = 100 * ((sample - duplicate) / ((sample + duplicate) / 2)))$$

Thirty-nine metals were measured for each of the four samples and three tissue samples were measured for percent moisture. A total of 159 potential RPD were therefore measured (Appendix B2-5).

However, 19% of those potential RPD were not calculated because one or both of the values were less than the MDL. In general, analytical variability is much higher near the MDL than is considered acceptable. Therefore, those RPD were classified as "RPD-not available" or RPD-NA (Table B1.3-1). Another 38% of those potential RPD were not calculated because both values were between one and five times higher than the MDL. It has been recommended that only RPD calculated from concentrations each of which is greater than five times the MDL should be used for assessing data quality (Clark 2003). Instead of an RPD, the absolute difference between the values was calculated. These results were qualified by ALS as "J" in Appendix B2-5.

Table B1.3-1. Tests of Variability of Tissue Metal Concentrations, Ninespine Stickleback, Doris North Project, 2010

Qualifier	Number of Potential RPD	Percent
RPD-NA	31	19
J	36	23
RPD	92	58
Total	**159**	**100**

RPD = Relative Percent Difference.
RPD-NA = RPD Not Available because one or both values were at or below the MDL.
J = Absolute difference between duplicates. RPD not available because one or both values were less than five times greater than the MDL.

The remaining 92 comparisons were considered to be valid RPD (Table B1.3-1). They ranged from 0.04 to 21% with a mean of 5% and a median of 3%. No RPD exceeded the RPD limits established by ALS (30% for percent moisture and 45% for metals). ALS interpreted these results as showing low variability of analyses (Amber Springer, ALS Environmental, pers. comm.).

B1.3.2.2 Mytilus trossulus

As with the QA/QC protocol for ninespine stickleback tissue metal concentrations, ALS conducted two measures of quality control: method blanks (or MB) and comparison with reference material (or CRM). Two method blanks were run with 25 metals measured for each blank, and two were run with 39 metals resulting in a total of 128 comparisons between measurements and targets. Only one of the measurements (1.0%) was above the method detection limit (or MDL) and was classified by ALS as "MB-LOR" (Appendix B2-6).

With respect to the reference material comparisons, of the 31 reference RMC performed, 28 fell within the 95% confidence limits around the target value and 3 fell outside the limits (an incidence of 10%; Appendix B2-6). These results were considered to be an acceptable range of analytical accuracy (Amber Springer, ALS Environmental, pers. comm.).

Two of the five samples (~40% of the total number of samples) were each split into two replicates and the relative percent difference (RPD) between replicate metal concentrations and percent moisture was calculated as in Section B1.2.2.1.

Twenty-five metals were measured for each of the two samples and both tissue samples were measured for percent moisture. A total of 27 potential RPD were therefore measured (Appendix B2-7).

However, 15% of those potential RPD were not calculated because one or both of the values were less than the MDL. In general, analytical variability is much higher near the MDL than is considered acceptable. Therefore, those RPD were classified as "RPD-not available" or RPD-NA (Table B1.3-2).

Table B1.3-2. Tests of Variability of Tissue Metal Concentrations, *Mytilus trossulus*, Doris North Project, 2010

Qualifier	Number of Potential RPD	Percent
RPD-NA	4	15
RPD	23	85
Total	**27**	**100**

RPD = Relative Percent Difference.
RPD-NA = RPD Not Available because one or both values were at or below the MDL.

The remaining 23 comparisons were considered to be valid RPD (Table B1.3-2). They ranged from 0.1 to 19% with a mean of 4% and a median of 3%. No RPD exceeded the RPD limits established by ALS (30% for percent moisture and 45% for metals). ALS interpreted these results as showing low variability within the analyses (Amber Springer, ALS Environmental, pers. comm.).

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Appendix B2

2010 Fish Raw Data, Doris North Project

Appendix B2-1. CPUE of Ninespine Stickleback, AEMP Lake Sites, Doris North Project, 2010

Appendix B2-2. Analytical Results for Stickleback Metal Concentrations, Doris North Project, 2010

Appendix B2-3. Analytical Results for *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Appendix B2-4. Quality Control Tests of Ninespine Stickleback Metal Concentrations, Doris North Project, 2010

Appendix B2-5. Ninespine Stickleback Tissue Replicate Metal Concentrations, Doris North Project, 2010

Appendix B2-6. Quality Control Tests of *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Appendix B2-7. *Mytilus trossulus* Tissue Replicate Metal Concentrations, Doris North Project, 2010

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Appendix B2-1

CPUE of Ninespine Stickleback, AEMP Lake Sites, Doris North Project, 2010

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Appendix B2-1. CPUE of Ninespine Stickleback, AEMP Lake Sites, Doris North Project, 2010

		Set		Retrieval		UTM (13W)			# Fish per	
Waterbody	Set #	Time	Date	Time	Date	Easting	Northing	Depth	Species	CPUE
Little Roberts	1	900	7-Jul-10	930	08-Jul-10	434697	7562665	0.5	45 NSSB	1.84
	2	900	7-Jul-10	930	08-Jul-10	434697	7562665	0.5	62 NSSB	2.53
	3	900	7-Jul-10	930	08-Jul-10	434697	7562665	0.5	12 NSSB	0.49
	4	900	7-Jul-10	930	08-Jul-10	434750	7532346	0.5	8 NSSB	0.33
	5	900	7-Jul-10	930	08-Jul-10	434750	7532346	0.5	1 NSSB	0.04
Doris North	1	930	6-Jul-10	830	07-Jul-10	434069	7559394	0.5	12 NSSB	0.52
	2	930	6-Jul-10	830	07-Jul-10	434069	7559394	0.5	4 NSSB	0.17
	3	930	6-Jul-10	830	07-Jul-10	434069	7559394	0.5	28 NSSB	1.22
	4	930	6-Jul-10	830	07-Jul-10	434056	7559272	0.5	7 NSSB	0.30
	5	930	6-Jul-10	830	07-Jul-10	434056	7559272	0.5	3 NSSB	0.13
Doris South	1	845	9-Jul-10	930	10-Jul-10	434685	7555693	0.5	21 NSSB	0.87
	2	845	9-Jul-10	930	10-Jul-10	434685	7555693	0.5	47 NSSB	1.94
	3	845	9-Jul-10	930	10-Jul-10	434685	7555693	0.5	13 NSSB	0.54
	4	845	9-Jul-10	930	10-Jul-10	434685	7555693	0.5	9 NSSB	0.37
	5	845	9-Jul-10	930	10-Jul-10	434685	7555693	0.5	5 NSSB	0.21
	6	845	9-Jul-10	930	10-Jul-10	434393	7554002	1.0	69 NSSB	2.85
	7	845	9-Jul-10	930	10-Jul-10	434393	7554002	1.0	25 NSSB	1.03
	8	845	9-Jul-10	930	10-Jul-10	434393	7554002	1.0	18 NSSB	0.74
	9	845	9-Jul-10	930	10-Jul-10	434393	7554002	1.0	35 NSSB	1.44
	10	845	9-Jul-10	930	10-Jul-10	434393	7554002	1.0	67 NSSB	2.76
	11	845	9-Jul-10	930	10-Jul-10	434393	7554002	1.0	54 NSSB	2.23
	12	845	9-Jul-10	930	10-Jul-10	434393	7554002	1.0	117 NSSB	4.82
Reference B	1	1000	8-Jul-10	1000	09-Jul-10	423215	7531947	0.25	85 NSSB	3.54
	2	1000	8-Jul-10	1000	09-Jul-10	423215	7531947	0.25	46 NSSB	1.92
	3	1000	8-Jul-10	1000	09-Jul-10	423825	7530594	0.25	79 NSSB	3.29
	4	1000	8-Jul-10	1000	09-Jul-10	423825	7530594	0.5	121 NSSB	5.04
	5	1000	8-Jul-10	1000	09-Jul-10	422083	7533159	0.5	58 NSSB	2.42
	6	1000	8-Jul-10	1000	09-Jul-10	422083	7533159	0.5	165 NSSB	6.88
	7	1000	8-Jul-10	1000	09-Jul-10	424369	7533259	0.5	26 NSSB	1.08
	8	1000	8-Jul-10	1000	09-Jul-10	422141	7533378	0.5	41 NSSB	1.71
	9	1000	8-Jul-10	1000	09-Jul-10	423216	7531941	0.25	38 NSSB	1.58
	10	1000	8-Jul-10	1000	09-Jul-10	422083	7533159	0.25	134 NSSB'	5.58
	11	1000	8-Jul-10	1000	09-Jul-10	422083	7533159	0.25	25 NSSB	1.04
	12	1000	8-Jul-10	1000	09-Jul-10	422083	7533159	0.25	141 NSSB	5.88
Reference D	1	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	0.5	136 NSSB	5.67
	2	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	0.5	85 NSSB	3.54
	3	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	0.5	76 NSSB	3.17
	4	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	0.5	13 NSSB	0.54
	5	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	1.0	108 NSSB	4.50
	6	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	1.0	67 NSSB	2.79
	7	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	1.0	32 NSSB	1.33
	8	1030	5-Jul-10	1030	06-Jul-10	447923	7562531	1.0	54 NSSB	2.25
Total									**2192 NSSB**	

NOTE: Depths are approximates

NSSB = ninespine stickleback

Appendix B2-2

Analytical Results for Stickleback Metal Concentrations, Doris North Project, 2010

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Appendix B2-2. Analytical Results for Stickleback Metal Concentrations, Doris North Project, 2010

Sample ID	ALS Sample ID	Matrix	% Moisture	Aluminum (Al)-Total	Antimony (Sb)-Total	Arsenic (As)-Total	Barium (Ba)-Total	Beryllium (Be)-Total	Bismuth (Bi)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Calcium (Ca)-Total	Cesium (Cs)-Total	Chromium (Cr)-Total
Doris North #1	L930021-1	Tissue	76.2	16.8	<0.0020	0.0915	1.04	<0.0020	<0.0020	<0.20	0.0037	6840	0.0039	3.23
Doris North #3	L930021-3	Tissue	77.9	5.80	<0.0020	0.0554	0.658	<0.0020	<0.0020	<0.20	<0.0020	6110	0.0020	0.864
Doris North #4	L930021-4	Tissue	78.7	1.02	<0.0020	0.131	1.36	<0.0020	<0.0020	<0.20	<0.0020	11700	0.0041	0.952
Doris North #5	L930021-5	Tissue	74.6	4.00	<0.0020	0.140	1.20	<0.0020	<0.0020	<0.20	0.0030	10400	0.0050	0.042
Doris North #6	L930021-6	Tissue	76.6	1.82	<0.0020	0.0603	0.978	<0.0020	<0.0020	<0.20	0.0039	10300	0.0025	0.308
Doris North #7	L930021-7	Tissue	75.8	0.92	<0.0020	0.101	1.14	<0.0020	<0.0020	<0.20	0.0031	10700	0.0034	0.033
Doris North #8	L930021-8	Tissue	76.8	2.30	<0.0020	0.0913	1.64	<0.0020	<0.0020	<0.20	0.0030	9530	0.0033	0.019
Doris South #1	L930021-9	Tissue	77.1	0.87	<0.0020	0.104	0.810	<0.0020	<0.0020	<0.20	<0.0020	8330	0.0038	0.026
Doris South #2	L930021-10	Tissue	75.2	32.0	0.0057	0.103	1.16	<0.0020	<0.0020	<0.20	0.0054	8220	0.0066	0.120
Doris South #3	L930021-11	Tissue	74.7	34.8	<0.0020	0.135	1.24	<0.0020	<0.0020	<0.20	0.0066	9530	0.0041	0.096
Doris South #4	L930021-12	Tissue	77.4	19.0	<0.0020	0.0910	1.14	<0.0020	<0.0020	<0.20	0.0074	8760	0.0034	0.056
Doris South #5	L930021-13	Tissue	75.7	7.59	<0.0020	0.132	0.971	<0.0020	<0.0020	<0.20	0.0047	9560	0.0042	0.045
Doris South #6	L930021-14	Tissue	77.1	14.6	<0.0020	0.101	1.08	<0.0020	<0.0020	<0.20	0.0028	9440	0.0046	0.079
Doris South #7	L930021-15	Tissue	77.5	8.57	<0.0020	0.0745	1.38	<0.0020	<0.0020	<0.20	0.0029	10600	0.0025	0.035
Doris South #8	L930021-16	Tissue	75.7	16.5	<0.0020	0.0805	1.28	<0.0020	<0.0020	<0.20	0.0063	9720	0.0028	0.044
Little Roberts #1	L930021-17	Tissue	78.4	2.72	<0.0020	0.0696	0.902	<0.0020	<0.0020	<0.20	0.0082	9340	0.0021	0.023
Little Roberts #2	L930021-18	Tissue	75.9	9.17	<0.0020	0.0901	1.10	<0.0020	<0.0020	<0.20	0.0150	10600	0.0023	0.028
Little Roberts #3	L930021-19	Tissue	74.7	35.8	<0.0020	0.107	1.37	<0.0020	<0.0020	<0.20	0.0152	9810	0.0041	0.108
Little Roberts #4	L930021-20	Tissue	75.6	2.63	<0.0020	0.100	1.04	<0.0020	<0.0020	<0.20	0.0090	10100	0.0035	0.023
Little Roberts #5	L930021-21	Tissue	75.9	14.7	<0.0020	0.0768	1.06	<0.0020	<0.0020	<0.20	0.0083	8860	0.0028	0.053
Little Roberts #7	L930021-23	Tissue	74.6	29.0	<0.0020	0.0930	1.09	<0.0020	<0.0020	<0.20	0.0134	10900	0.0035	0.091
Little Roberts #8	L930021-24	Tissue	77.2	7.54	<0.0020	0.0645	1.30	<0.0020	<0.0020	<0.20	0.0092	11900	0.0018	0.045
Reference B #1	L930021-25	Tissue	76.2	1.29	<0.0020	0.0459	1.78	<0.0020	<0.0020	<0.20	0.0172	9650	0.0134	0.021
Reference B #2	L930021-26	Tissue	78.1	1.29	<0.0020	0.0626	2.10	<0.0020	<0.0020	<0.20	0.0211	10900	0.0078	0.013
Reference B #3	L930021-27	Tissue	76.1	2.68	<0.0020	0.0720	2.12	<0.0020	<0.0020	<0.20	0.0179	9230	0.0080	0.016
Reference B #4	L930021-28	Tissue	76.9	7.77	<0.0020	0.0712	2.57	<0.0020	<0.0020	<0.20	0.0346	11700	0.0102	0.031
Reference B #5	L930021-29	Tissue	75.7	15.4	<0.0020	0.0390	2.35	<0.0020	0.0025	<0.20	0.0273	9580	0.0087	0.045
Reference B #6	L930021-30	Tissue	76.4	12.1	<0.0020	0.0514	2.83	<0.0020	0.0027	<0.20	0.0222	10900	0.0094	0.033
Reference B #7	L930021-31	Tissue	77.2	14.3	<0.0020	0.0693	2.94	<0.0020	0.0022	<0.20	0.0317	9630	0.0064	0.061
Reference B #8	L930021-32	Tissue	77.8	1.24	<0.0020	0.0743	3.31	<0.0020	<0.0020	<0.20	0.0123	11300	0.0070	0.011
Reference D #1	L930021-33	Tissue	76.2	5.70	<0.0020	0.0456	1.62	<0.0020	<0.0020	<0.20	0.0078	10700	0.0021	0.040
Reference D #2	L930021-34	Tissue	76.9	1.81	<0.0020	0.0576	1.22	<0.0020	<0.0020	<0.20	0.0096	9350	0.0017	0.017
Reference D #3	L930021-35	Tissue	75.9	5.40	<0.0020	0.0497	1.82	<0.0020	<0.0020	<0.20	0.0075	10200	0.0015	0.023
Reference D #4	L930021-36	Tissue	78.4	23.5	<0.0020	0.0409	1.29	<0.0020	0.0021	<0.20	0.0112	5830	0.0030	0.052
Reference D #5	L930021-37	Tissue	76.0	10.4	<0.0020	0.0486	1.07	<0.0020	<0.0020	<0.20	0.0124	7230	0.0020	0.031
Reference D #6	L930021-38	Tissue	74.5	2.68	<0.0020	0.0369	1.32	<0.0020	<0.0020	<0.20	0.0096	9150	0.0020	0.016
Reference D #7	L930021-39	Tissue	76.6	1.52	<0.0020	0.0328	1.09	<0.0020	<0.0020	<0.20	0.0060	9120	0.0022	0.013
Reference D #8	L930021-40	Tissue	74.1	1.54	<0.0020	0.0443	1.04	<0.0020	0.0020	<0.20	0.0078	8710	0.0015	0.016

Appendix B2-2. Analytical Results for Stickleback Metal Concentrations, Doris North Project, 2010

Sample ID	Cobalt (Co)-Total	Copper (Cu)-Total	Gallium (Ga)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Lithium (Li)-Total	Magnesium (Mg)-Total	Manganese (Mn)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Phosphorus (P)-Total	Potassium (K)-Total	Rhenium (Re)-Total
Doris North #1	0.0568	0.914	0.0055	97.8	0.0114	0.022	339	16.7	0.0663	0.140	1.79	5720	3380	<0.0020
Doris North #3	0.0233	0.566	<0.0040	27.4	0.0052	<0.020	238	9.54	0.0417	0.0536	0.488	4290	1860	<0.0020
Doris North #4	0.0232	0.751	<0.0040	23.6	0.0052	<0.020	412	24.7	0.0636	0.0522	0.515	7970	3350	<0.0020
Doris North #5	0.0235	0.870	<0.0040	23.8	0.0069	<0.020	409	18.2	0.0930	0.0423	0.026	7450	3460	<0.0020
Doris North #6	0.0154	0.660	<0.0040	18.6	0.0085	<0.020	416	26.1	0.0595	0.0395	0.175	7360	3420	<0.0020
Doris North #7	0.0191	0.813	<0.0040	22.6	0.0058	<0.020	431	20.5	0.0968	0.0341	0.017	7930	3640	<0.0020
Doris North #8	0.0175	0.700	<0.0040	24.1	0.0107	<0.020	399	17.7	0.0637	0.0314	0.016	7190	3550	<0.0020
Doris South #1	0.0139	0.678	<0.0040	17.4	0.0047	<0.020	373	13.5	0.0388	0.0234	0.014	6600	3540	<0.0020
Doris South #2	0.0356	0.814	0.0104	61.8	0.0178	0.048	396	19.2	0.0247	0.0312	0.060	6670	3490	<0.0020
Doris South #3	0.0431	0.942	0.0123	68.6	0.0157	0.047	512	20.2	0.0442	0.0294	0.063	7090	3310	<0.0020
Doris South #4	0.0343	0.878	0.0062	49.7	0.0123	0.031	444	16.3	0.0262	0.0308	0.048	6710	3440	<0.0020
Doris South #5	0.0200	0.817	<0.0040	25.3	0.0095	<0.020	418	17.0	0.0250	0.0294	0.028	7330	3510	<0.0020
Doris South #6	0.0189	0.907	0.0046	35.1	0.0107	0.021	411	20.3	0.0266	0.0289	0.038	7190	3640	<0.0020
Doris South #7	0.0192	0.737	<0.0040	34.1	0.0081	<0.020	414	19.6	0.0413	0.0260	0.024	7710	3450	<0.0020
Doris South #8	0.0274	0.832	0.0055	43.2	0.0301	0.026	442	15.2	0.0490	0.0267	0.054	7230	3470	<0.0020
Little Roberts #1	0.0247	0.680	<0.0040	27.5	0.0071	<0.020	427	11.6	0.0515	0.0343	0.022	6890	3470	<0.0020
Little Roberts #2	0.0209	0.719	<0.0040	35.6	0.0238	<0.020	431	13.9	0.0421	0.0394	0.037	7610	3280	<0.0020
Little Roberts #3	0.0399	0.919	0.0131	111	0.0198	0.055	462	22.3	0.0290	0.0390	0.070	7080	3280	<0.0020
Little Roberts #4	0.0265	1.05	<0.0040	29.2	0.0062	<0.020	553	16.1	0.0391	0.0354	0.019	7060	3290	<0.0020
Little Roberts #5	0.0303	0.751	0.0069	55.9	0.0134	0.026	486	15.0	0.0334	0.0312	0.038	6620	3230	<0.0020
Little Roberts #7	0.0356	0.920	0.0102	91.3	0.0307	0.035	462	21.1	0.0405	0.0364	0.057	7940	3480	<0.0020
Little Roberts #8	0.0221	0.794	<0.0040	32.3	0.0163	<0.020	427	21.5	0.0506	0.0302	0.032	8210	3210	<0.0020
Reference B #1	0.0218	0.880	<0.0040	27.9	0.0089	<0.020	471	7.01	0.0575	0.0235	0.019	7120	3100	<0.0020
Reference B #2	0.0197	1.07	<0.0040	20.7	0.0111	<0.020	440	9.23	0.0377	0.0243	0.019	7810	3130	<0.0020
Reference B #3	0.0273	0.936	<0.0040	38.6	0.0075	<0.020	419	7.95	0.0592	0.0277	0.027	6980	3230	<0.0020
Reference B #4	0.0490	1.21	<0.0040	38.0	0.0093	<0.020	485	11.3	0.0560	0.0255	0.036	8240	3270	<0.0020
Reference B #5	0.0438	1.01	0.0054	52.4	0.0178	<0.020	409	6.92	0.0522	0.0303	0.059	7210	3340	<0.0020
Reference B #6	0.0292	0.871	0.0041	49.3	0.0235	<0.020	447	8.18	0.0482	0.0272	0.029	8190	3520	<0.0020
Reference B #7	0.0607	1.37	0.0043	54.1	0.0123	<0.020	488	7.00	0.0452	0.0274	0.042	6900	3300	<0.0020
Reference B #8	0.0163	1.00	<0.0040	43.6	0.0150	<0.020	448	8.46	0.0700	0.0303	0.018	8150	3320	<0.0020
Reference D #1	0.0245	0.872	<0.0040	35.3	0.0076	<0.020	446	13.2	0.0361	0.0306	0.029	7840	3680	<0.0020
Reference D #2	0.0179	0.814	<0.0040	29.3	0.0406	<0.020	437	9.85	0.0443	0.0350	0.030	7200	3350	<0.0020
Reference D #3	0.0227	0.992	<0.0040	40.8	0.0269	<0.020	451	11.2	0.0337	0.0271	0.033	7370	3230	<0.0020
Reference D #4	0.0425	0.884	0.0081	79.8	0.0207	0.028	350	6.17	0.0347	0.0296	0.052	5220	3290	<0.0020
Reference D #5	0.0197	1.07	<0.0040	45.3	0.0141	<0.020	408	7.77	0.0331	0.0261	0.037	5840	3370	<0.0020
Reference D #6	0.0174	0.768	<0.0040	30.5	0.0064	<0.020	418	11.4	0.0458	0.0280	0.026	7070	3570	<0.0020
Reference D #7	0.0176	0.918	<0.0040	31.0	0.0062	<0.020	442	9.21	0.0452	0.0268	0.021	6800	3420	<0.0020
Reference D #8	0.0176	0.843	<0.0040	27.9	0.0243	<0.020	375	9.10	0.0496	0.0336	0.033	6730	3510	<0.0020

Appendix B2-2. Analytical Results for Stickleback Metal Concentrations, Doris North Project, 2010

Sample ID	Rubidium (Rb)-Total	Selenium (Se)-Total	Sodium (Na)-Total	Strontium (Sr)-Total	Tellurium (Te)-Total	Thallium (Tl)-Total	Thorium (Th)-Total	Tin (Sn)-Total	Titanium (Ti)-Total	Uranium (U)-Total	Vanadium (V)-Total	Yttrium (Y)-Total	Zinc (Zn)-Total	Zirconium (Zr)-Total
Doris North #1	1.68	0.236	1290	7.40	<0.0040	0.00183	0.0054	0.0085	0.829	0.00339	0.0637	0.0055	36.7	<0.040
Doris North #3	0.80	0.144	840	6.41	<0.0040	0.00121	<0.0020	<0.0040	0.259	0.00229	0.0272	<0.0020	27.9	<0.040
Doris North #4	1.43	0.240	1450	13.6	<0.0040	0.00173	<0.0020	0.0047	0.032	0.00239	0.0315	<0.0020	59.6	<0.040
Doris North #5	1.66	0.259	1550	11.6	<0.0040	0.00131	<0.0020	0.0062	0.318	0.00244	0.0322	<0.0020	45.4	<0.040
Doris North #6	1.43	0.183	1370	12.4	<0.0040	0.00200	<0.0020	0.0082	0.066	0.00465	0.0500	<0.0020	44.3	<0.040
Doris North #7	1.88	0.244	1330	11.2	<0.0040	0.00155	<0.0020	<0.0040	0.027	0.00348	0.0199	<0.0020	51.3	<0.040
Doris North #8	1.78	0.234	1350	9.64	<0.0040	0.00178	<0.0020	0.0050	0.091	0.00246	0.0301	<0.0020	43.9	<0.040
Doris South #1	1.77	0.207	1400	9.22	<0.0040	0.00219	<0.0020	0.0080	0.023	0.00310	0.0369	<0.0020	30.0	<0.040
Doris South #2	2.09	0.197	1330	10.0	<0.0040	0.00316	0.0125	<0.0040	1.91	0.00463	0.0999	0.0117	34.6	<0.040
Doris South #3	1.97	0.243	1250	10.5	<0.0040	0.00218	0.0148	<0.0040	2.08	0.00543	0.0963	0.0127	43.4	<0.040
Doris South #4	1.62	0.210	1390	9.82	<0.0040	0.00228	0.0070	<0.0040	1.07	0.00495	0.0633	0.0075	43.8	<0.040
Doris South #5	1.73	0.269	1320	10.6	<0.0040	0.00202	<0.0020	<0.0040	0.345	0.00357	0.0403	0.0029	41.2	<0.040
Doris South #6	1.91	0.222	1320	9.92	<0.0040	0.00207	0.0054	<0.0040	0.721	0.00348	0.0554	0.0047	41.6	<0.040
Doris South #7	1.59	0.215	1440	11.7	<0.0040	0.00175	0.0030	<0.0040	0.381	0.00380	0.0525	0.0027	38.6	<0.040
Doris South #8	1.46	0.246	1440	9.14	<0.0040	0.00209	0.0066	<0.0040	0.868	0.00417	0.0803	0.0054	41.6	<0.040
Little Roberts #1	1.37	0.205	1380	11.0	<0.0040	0.00193	<0.0020	<0.0040	0.112	0.00511	0.0648	<0.0020	37.8	<0.040
Little Roberts #2	1.35	0.194	1420	13.2	<0.0040	0.00256	0.0036	0.0117	0.406	0.00625	0.0550	0.0036	31.9	<0.040
Little Roberts #3	1.52	0.213	1240	12.8	<0.0040	0.00308	0.0191	0.0044	2.43	0.00840	0.137	0.0163	38.8	0.041
Little Roberts #4	1.68	0.276	1250	11.8	<0.0040	0.00230	<0.0020	<0.0040	0.078	0.00740	0.0724	<0.0020	38.9	<0.040
Little Roberts #5	1.47	0.199	1200	10.2	<0.0040	0.00235	0.0063	<0.0040	0.706	0.00487	0.0727	0.0074	34.4	<0.040
Little Roberts #7	1.56	0.206	1370	12.4	<0.0040	0.00276	0.0119	<0.0040	1.66	0.00930	0.133	0.0109	31.8	<0.040
Little Roberts #8	1.44	0.201	1250	14.3	<0.0040	0.00242	0.0024	<0.0040	0.419	0.00469	0.0781	0.0028	40.3	<0.040
Reference B #1	3.84	0.314	1240	9.97	<0.0040	0.00433	<0.0020	<0.0040	0.067	0.00786	0.0319	<0.0020	42.0	<0.040
Reference B #2	3.45	0.395	1240	12.0	<0.0040	0.00426	<0.0020	0.0045	0.072	0.0117	0.0284	<0.0020	48.0	<0.040
Reference B #3	4.11	0.445	1370	9.72	<0.0040	0.00462	<0.0020	0.0049	0.090	0.00988	0.0222	<0.0020	40.4	<0.040
Reference B #4	3.13	0.459	1470	12.0	<0.0040	0.00693	0.0024	<0.0040	0.316	0.0162	0.0447	0.0034	46.6	<0.040
Reference B #5	3.29	0.322	1430	10.8	<0.0040	0.00498	0.0064	0.0077	0.810	0.0121	0.0720	0.0077	40.6	<0.040
Reference B #6	3.30	0.335	1440	12.5	<0.0040	0.00567	0.0055	0.0077	0.622	0.0108	0.0615	0.0059	48.7	<0.040
Reference B #7	3.10	0.299	1380	10.0	<0.0040	0.00452	0.0059	0.0043	0.936	0.0122	0.0613	0.0070	45.4	<0.040
Reference B #8	4.09	0.389	1500	11.3	<0.0040	0.00542	<0.0020	0.0041	0.049	0.00744	0.0319	<0.0020	48.5	<0.040
Reference D #1	2.39	0.261	1350	15.1	<0.0040	0.00358	0.0025	<0.0040	0.253	0.0113	0.119	0.0029	37.4	<0.040
Reference D #2	2.66	0.267	1220	13.2	<0.0040	0.00281	<0.0020	0.0069	0.070	0.0348	0.0898	<0.0020	38.4	<0.040
Reference D #3	2.20	0.255	1170	15.1	<0.0040	0.00235	0.0023	0.0049	0.249	0.0134	0.0568	0.0027	42.1	<0.040
Reference D #4	2.26	0.237	1300	9.01	<0.0040	0.00300	<0.0020	<0.0040	1.04	0.0119	0.0936	0.0090	31.7	<0.040
Reference D #5	2.37	0.237	1310	9.62	<0.0040	0.00244	<0.0020	<0.0040	0.423	0.00938	0.0560	0.0042	33.4	<0.040
Reference D #6	2.03	0.226	1470	12.0	<0.0040	0.00268	<0.0020	<0.0040	0.129	0.00560	0.0466	<0.0020	39.4	<0.040
Reference D #7	2.54	0.196	1360	13.0	<0.0040	0.00235	<0.0020	0.0055	0.049	0.00513	0.0527	<0.0020	37.4	<0.040
Reference D #8	2.06	0.252	1310	12.6	<0.0040	0.00291	<0.0020	<0.0040	0.050	0.00544	0.0423	<0.0020	37.6	<0.040

Appendix B2-3

Analytical Results for *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

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Appendix B2-3. Analytical Results for *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Sample ID	ALS Sample ID	Matrix	Aluminum (Al)-Total	Antimony (Sb)-Total	Arsenic (As)-Total	Barium (Ba)-Total	Beryllium (Be)-Total	Bismuth (Bi)-Total	Boron (B)-Total	Cadmium (Cd)-Total	Calcium (Ca)-Total	Cesium (Cs)-Total	Chromium (Cr)-Total	Cobalt (Co)-Total
RBW#2	L930021-41	Tissue	40.0	0.028	23.2	18.2	<0.020	0.036	24.70	4.21	2380	0.02	9.86	1.23
RBW#4	L930021-42	Tissue	35.3	0.031	18.6	23.2	<0.020	0.043	25.50	3.47	2200	0.02	6.72	1.21
RBW#5	L930021-43	Tissue	96.1	0.028	16.6	13.1	<0.020	0.032	26.50	2.34	1600	0.02	12.50	1.08
RBW#6	L930021-44	Tissue	80.1	0.021	20.4	29.0	<0.020	0.026	22.20	2.22	4600	0.02	15.70	0.96
RBW#7	L930021-45	Tissue	49.4	0.023	22.7	77.0	<0.020	0.035	26.50	3.98	2140	0.02	15.70	1.43
RBW#8	L930021-46	Tissue	48.1	<0.020	14.1	14.6	<0.020	0.023	23.80	2.24	1760	0.02	6.76	0.74
RBW#11	L930021-47	Tissue	132.0	0.026	15.7	31.1	<0.020	0.035	22.50	2.68	1500	0.02	27.00	1.57
RBW#12	L930021-48	Tissue	147.0	0.025	24.1	3.9	<0.020	0.051	25.80	4.02	1800	0.02	14.00	1.24
RBE#1	L930021-49	Tissue	102.0	0.033	19.6	8.3	<0.020	0.031	21.70	2.58	2390	0.02	20.60	1.78
RBE#2	L930021-50	Tissue	36.0	0.029	19.4	53.0	<0.020	0.033	22.40	5.80	1790	0.02	3.35	1.85
RBE#4	L930021-51	Tissue	19.3	0.018	13.6	9.6	<0.010	0.017	15.40	1.80	1400	0.01	8.46	0.74
RBE#5	L930021-52	Tissue	29.3	0.022	17.3	7.6	<0.020	0.026	19.70	1.91	1580	0.02	4.52	0.92
RBE#6	L930021-53	Tissue	34.2	0.021	18.8	76.2	<0.020	0.028	23.00	1.67	1620	0.02	3.01	1.24
RBE#9	L930021-54	Tissue	41.4	0.024	17.2	113.0	<0.020	0.036	23.70	3.87	1920	0.02	5.38	1.02
RBE#13	L930021-55	Tissue	215.0	0.038	33.8	60.0	<0.030	0.040	36.40	3.41	2820	0.04	19.10	2.14
RBE#14	L930021-56	Tissue	130.0	0.021	18.7	98.4	<0.020	0.032	17.90	2.77	1460	0.02	18.60	0.95
REF3	L965618-3	Tissue	542.7	< DL	12.0	13.9	< DL	< DL	17.50	4.03	3468	0.06	141.94	1.65
REF4	L965618-4	Tissue	700.0	< DL	12.1	16.1	< DL	< DL	19.08	4.83	2883	0.03	140.83	1.96
REF5	L965618-5	Tissue	2870.7	< DL	12.7	40.2	< DL	< DL	20.60	3.69	5672	0.06	551.72	5.16
REF1	L965618-1	Tissue	1053.0	< DL	22.4	113.0	< DL	< DL	27.42	8.98	4939	0.09	162.12	2.44
REF2	L965618-2	Tissue	381.4	< DL	17.8	50.7	< DL	< DL	41.86	7.28	8895	0.49	63.26	1.41
REF COMP1	L965618-46	Tissue	698.4	0.0200	12.1	51.4	0.0256	0.068	17.36	3.50	3032	0.06	5.34	0.91
REF COMP2	L965618-47	Tissue	1000.0	0.0208	13.1	37.4	0.0368	0.090	19.15	4.58	2972	0.09	14.72	1.37
REF COMP3	L965618-48	Tissue	1106.8	0.0204	13.0	40.0	0.0398	0.081	20.39	4.06	2961	0.09	6.71	1.31

Note: < DL = less than detection limits; units = mg/kg dry weight

Appendix B2-3. Analytical Results for *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Sample ID	Copper (Cu)-Total	Gallium (Ga)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Lithium (Li)-Total	Magnesium (Mg)-Total	Manganese (Mn)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Phosphorus (P)-Total	Potassium (K)-Total	Rhenium (Re)-Total	Rubidium (Rb)-Total
RBW#2	9.58	<0.040	374	0.468	0.48	4020	6.53	0.17	0.8	10.4	11000	13600	<0.020	6.38
RBW#4	9.68	<0.040	328	0.264	0.49	4180	6.63	0.17	0.9	9.0	9680	13600	<0.020	6.25
RBW#5	10.90	<0.040	365	0.241	0.54	4110	7.80	0.15	1.0	10.7	9940	13800	<0.020	6.63
RBW#6	10.90	<0.040	362	0.255	0.44	3610	11.20	0.13	0.9	11.5	11400	13900	<0.020	6.73
RBW#7	12.40	<0.040	431	0.430	0.51	4360	7.99	0.17	1.1	13.9	11800	14800	<0.020	6.99
RBW#8	7.39	<0.040	254	0.239	0.44	3780	6.190	0.11	0.7	7.0	13400	14400	<0.020	6.66
RBW#11	11.20	0.04	501	0.331	0.51	3750	11.80	0.13	1.4	19.4	9580	13400	<0.020	6.96
RBW#12	11.90	0.05	799	0.496	0.62	4680	12.70	0.20	1.0	12.7	10600	14000	<0.020	6.67
RBE#1	11.00	<0.040	619	0.487	0.56	4490	11.90	0.13	1.3	21.4	10500	15200	<0.020	6.63
RBE#2	9.83	<0.040	373	0.528	0.40	4020	7.06	0.14	0.9	13.2	10100	14700	<0.020	6.31
RBE#4	7.45	<0.020	236	0.267	0.24	2540	4.99	0.02	0.6	8.6	7720	10700	<0.010	4.79
RBE#5	8.37	<0.040	295	0.244	0.35	3440	6.63	0.03	0.7	9.2	8830	13000	<0.020	5.66
RBE#6	7.99	<0.040	336	0.305	0.38	4080	6.940	0.03	0.7	9.9	12000	14800	<0.020	6.56
RBE#9	8.73	<0.040	415	0.342	0.49	4470	7.24	0.14	0.9	9.0	8620	13600	<0.020	5.74
RBE#13	15.30	0.07	801	0.493	0.72	5710	17.80	0.16	1.4	23.3	21000	26700	<0.030	11.60
RBE#14	7.96	0.05	701	0.458	0.43	3290	10.60	0.11	1.0	14.3	10100	11500	<0.020	4.98
REF3	13.55	0.27	1935	0.677	1.05	3944	27.34	0.14	5.4	79.8	4194	3460	< DL	2.98
REF4	14.58	0.13	1250	0.983	1.42	4233	31.08	0.17	9.4	90.0	4517	3700	< DL	2.32
REF5	27.41	0.29	2224	2.009	5.17	5267	91.38	0.15	28.4	323.3	10862	5233	< DL	3.78
REF1	17.88	0.37	2970	2.773	2.27	6803	32.88	0.25	8.4	90.9	9894	7015	< DL	5.27
REF2	12.21	2.22	11523	1.419	< DL	5547	13.26	0.20	4.7	35.7	9756	7628	< DL	15.47
REF COMP1	12.64	0.26	1544	0.952	1.28	3880	14.32	0.13	1.4	4.8	8560	3656	< DL	3.22
REF COMP2	14.15	0.37	2123	1.377	1.78	4415	19.62	0.16	2.4	11.1	8849	4519	< DL	4.22
REF COMP3	13.01	0.41	2184	1.495	1.96	4291	21.26	0.17	1.2	6.0	7971	4175	< DL	4.35

Note: < DL = less than detection limits; units = mg/kg dry weight

Appendix B2-3. Analytical Results for *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Sample ID	Selenium (Se)-Total	Sodium (Na)-Total	Strontium (Sr)-Total	Tellurium (Te)-Total	Thallium (Tl)-Total	Thorium (Th)-Total	Tin (Sn)-Total	Titanium (Ti)-Total	Uranium (U)-Total	Vanadium (V)-Total	Yttrium (Y)-Total	Zinc (Zn)-Total	Zirconium (Zr)-Total
RBW#2	7.08	26500	36	<0.040	<0.0040	0.108	<0.040	1.6	0.20	0.58	0.204	73.0	<0.40
RBW#4	6.53	27800	32	<0.040	<0.0040	0.083	<0.040	1.4	0.18	0.58	0.189	70.7	<0.40
RBW#5	6.76	27100	27	<0.040	<0.0040	0.062	<0.040	4.0	0.16	0.59	0.172	73.6	<0.40
RBW#6	6.54	22000	42	<0.040	<0.0040	0.061	<0.040	3.8	0.15	0.56	0.169	99.7	<0.40
RBW#7	6.99	28600	38	<0.040	<0.0040	0.104	<0.040	1.9	0.29	0.72	0.191	81.5	<0.40
RBW#8	6.54	23800	25	<0.040	<0.0040	0.073	0.05	2.2	0.15	0.55	0.152	68.1	<0.40
RBW#11	6.12	22300	26	<0.040	<0.0040	0.231	0.06	6.3	0.16	0.94	0.188	86.2	<0.40
RBW#12	7.10	29400	30	<0.040	<0.0040	0.097	<0.040	6.7	0.25	0.94	0.272	79.7	<0.40
RBE#1	6.64	30300	29	<0.040	0.0067	0.094	0.04	5.4	0.16	1.16	0.148	76.2	<0.40
RBE#2	7.55	26400	29	<0.040	0.0058	0.084	<0.040	1.7	0.16	1.06	0.232	103.0	<0.40
RBE#4	4.85	16400	21	<0.020	0.0043	0.043	<0.020	1.1	0.08	0.37	0.072	66.3	<0.20
RBE#5	5.58	23300	24	<0.040	0.0046	0.049	<0.040	1.6	0.09	0.51	0.131	61.4	<0.40
RBE#6	7.15	27300	29	<0.040	0.0061	0.080	<0.040	1.9	0.15	0.66	0.175	72.4	<0.40
RBE#9	6.74	32200	36	<0.040	0.0042	0.049	<0.040	1.8	0.20	0.55	0.304	61.9	<0.40
RBE#13	11.60	36300	43	<0.060	0.0093	0.187	<0.060	11.6	0.22	1.36	0.207	104.0	<0.60
RBE#14	6.13	21200	25	<0.040	0.0045	0.114	<0.040	8.2	0.23	1.00	0.452	56.8	<0.40
REF3	3.71	22097	36	< DL	< DL	0.364	4.06	43.5	0.33	3.23	0.708	121.0	0.363
REF4	4.08	24000	39	< DL	< DL	0.256	4.63	18.8	0.32	4.17	0.413	117.5	< DL
REF5	3.28	23190	49	< DL	< DL	0.459	3.30	45.1	0.51	12.33	0.603	162.1	0.603
REF1	4.09	28636	68	< DL	< DL	0.868	3.95	58.2	0.93	5.15	0.782	140.3	0.788
REF2	3.84	30349	80	< DL	< DL	2.953	3.92	380.2	0.71	2.56	3.093	193.0	2.198
REF COMP1	3.65	17840	41	< DL	0.0139	0.310	0.94	34.0	0.39	3.10	0.470	161.6	< DL
REF COMP2	4.08	20094	42	< DL	0.0209	0.535	1.80	55.5	0.42	3.94	0.629	132.1	< DL
REF COMP3	4.16	18544	42	< DL	0.0225	0.749	1.35	67.4	0.46	4.38	0.741	131.1	0.563

Note: < DL = less than detection limits; units = mg/kg dry weight

Appendix B2-4

Quality Control Tests of Ninespine Stickleback Metal Concentrations, Doris North Project, 2010

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Appendix B2-4. Quality Control Tests of Ninespine Stickleback Metal Concentrations, Doris North Project, 2010

Matrix	QC Type	Analyte	QC Spl. No.	Reference	Result	Target	Units	%	Limits	Qualifier
Tissue	CRM	Arsenic (As)-Total	WG1179058-5	VA-NRC-TORT2	22.1	21.6	mg/kg wwt	102	70-130	
Tissue	CRM	Cadmium (Cd)-Total	WG1179058-5	VA-NRC-TORT2	28.6	26.7	mg/kg wwt	107	70-130	
Tissue	CRM	Cobalt (Co)-Total	WG1179058-5	VA-NRC-TORT2	0.539	0.510	mg/kg wwt	106	70-130	
Tissue	CRM	Copper (Cu)-Total	WG1179058-5	VA-NRC-TORT2	105	106	mg/kg wwt	99	70-130	
Tissue	CRM	Iron (Fe)-Total	WG1179058-5	VA-NRC-TORT2	105	105	mg/kg wwt	100	70-130	
Tissue	CRM	Lead (Pb)-Total	WG1179058-5	VA-NRC-TORT2	0.334	0.350	mg/kg wwt	96	70-130	
Tissue	CRM	Manganese (Mn)-Total	WG1179058-5	VA-NRC-TORT2	13.6	13.6	mg/kg wwt	100	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1179058-5	VA-NRC-TORT2	0.219	0.270	mg/kg wwt	81	70-130	
Tissue	CRM	Molybdenum (Mo)-Total	WG1179058-5	VA-NRC-TORT2	0.950	0.950	mg/kg wwt	100	70-130	
Tissue	CRM	Nickel (Ni)-Total	WG1179058-5	VA-NRC-TORT2	2.41	2.50	mg/kg wwt	96	70-130	
Tissue	CRM	Selenium (Se)-Total	WG1179058-5	VA-NRC-TORT2	5.30	5.63	mg/kg wwt	94	70-130	
Tissue	CRM	Strontium (Sr)-Total	WG1179058-5	VA-NRC-TORT2	44.0	45.2	mg/kg wwt	97	70-130	
Tissue	CRM	Vanadium (V)-Total	WG1179058-5	VA-NRC-TORT2	1.79	1.64	mg/kg wwt	109	70-130	
Tissue	CRM	Zinc (Zn)-Total	WG1179058-5	VA-NRC-TORT2	182	180	mg/kg wwt	101	70-130	
Tissue	CRM	Arsenic (As)-Total	WG1179058-6	VA-NRC-DOLT4	9.73	9.66	mg/kg wwt	101	70-130	
Tissue	CRM	Cadmium (Cd)-Total	WG1179058-6	VA-NRC-DOLT4	25.3	24.3	mg/kg wwt	104	70-130	
Tissue	CRM	Copper (Cu)-Total	WG1179058-6	VA-NRC-DOLT4	33.6	31.2	mg/kg wwt	108	70-130	
Tissue	CRM	Iron (Fe)-Total	WG1179058-6	VA-NRC-DOLT4	1910	1830	mg/kg wwt	104	70-130	
Tissue	CRM	Lead (Pb)-Total	WG1179058-6	VA-NRC-DOLT4	0.161	0.160	mg/kg wwt	101	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1179058-6	VA-NRC-DOLT4	2.25	2.58	mg/kg wwt	87	70-130	
Tissue	CRM	Nickel (Ni)-Total	WG1179058-6	VA-NRC-DOLT4	0.972	0.970	mg/kg wwt	100	70-130	
Tissue	CRM	Selenium (Se)-Total	WG1179058-6	VA-NRC-DOLT4	8.55	8.30	mg/kg wwt	103	70-130	
Tissue	CRM	Zinc (Zn)-Total	WG1179058-6	VA-NRC-DOLT4	120	116	mg/kg wwt	103	70-130	
Tissue	CRM	Arsenic (As)-Total	WG1179058-8	VA-NRC-DOLT4	9.43	9.66	mg/kg wwt	98	70-130	
Tissue	CRM	Cadmium (Cd)-Total	WG1179058-8	VA-NRC-DOLT4	25.8	24.3	mg/kg wwt	106	70-130	
Tissue	CRM	Copper (Cu)-Total	WG1179058-8	VA-NRC-DOLT4	34.4	31.2	mg/kg wwt	110	70-130	
Tissue	CRM	Iron (Fe)-Total	WG1179058-8	VA-NRC-DOLT4	1930	1830	mg/kg wwt	105	70-130	
Tissue	CRM	Lead (Pb)-Total	WG1179058-8	VA-NRC-DOLT4	0.149	0.160	mg/kg wwt	93	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1179058-8	VA-NRC-DOLT4	2.17	2.58	mg/kg wwt	84	70-130	
Tissue	CRM	Nickel (Ni)-Total	WG1179058-8	VA-NRC-DOLT4	0.919	0.970	mg/kg wwt	95	70-130	
Tissue	CRM	Selenium (Se)-Total	WG1179058-8	VA-NRC-DOLT4	8.24	8.30	mg/kg wwt	99	70-130	
Tissue	CRM	Zinc (Zn)-Total	WG1179058-8	VA-NRC-DOLT4	121	116	mg/kg wwt	104	70-130	
Tissue	CRM	Arsenic (As)-Total	WG1184449-3	VA-NRC-DOLT4	9.27	9.66	mg/kg wwt	96	70-130	
Tissue	CRM	Cadmium (Cd)-Total	WG1184449-3	VA-NRC-DOLT4	25.3	24.3	mg/kg wwt	104	70-130	
Tissue	CRM	Copper (Cu)-Total	WG1184449-3	VA-NRC-DOLT4	32.8	31.2	mg/kg wwt	105	70-130	
Tissue	CRM	Iron (Fe)-Total	WG1184449-3	VA-NRC-DOLT4	1820	1830	mg/kg wwt	99	70-130	
Tissue	CRM	Lead (Pb)-Total	WG1184449-3	VA-NRC-DOLT4	0.141	0.160	mg/kg wwt	88	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1184449-3	VA-NRC-DOLT4	2.65	2.58	mg/kg wwt	103	70-130	
Tissue	CRM	Nickel (Ni)-Total	WG1184449-3	VA-NRC-DOLT4	0.943	0.970	mg/kg wwt	97	70-130	
Tissue	CRM	Selenium (Se)-Total	WG1184449-3	VA-NRC-DOLT4	8.96	8.30	mg/kg wwt	108	70-130	
Tissue	CRM	Zinc (Zn)-Total	WG1184449-3	VA-NRC-DOLT4	125	116	mg/kg wwt	107	70-130	
Tissue	CRM	Arsenic (As)-Total	WG1184449-4	VA-NRC-TORT2	23.9	21.6	mg/kg wwt	111	70-130	
Tissue	CRM	Cadmium (Cd)-Total	WG1184449-4	VA-NRC-TORT2	29.8	26.7	mg/kg wwt	112	70-130	
Tissue	CRM	Cobalt (Co)-Total	WG1184449-4	VA-NRC-TORT2	0.561	0.510	mg/kg wwt	110	70-130	
Tissue	CRM	Copper (Cu)-Total	WG1184449-4	VA-NRC-TORT2	106	106	mg/kg wwt	100	70-130	
Tissue	CRM	Iron (Fe)-Total	WG1184449-4	VA-NRC-TORT2	107	105	mg/kg wwt	102	70-130	
Tissue	CRM	Lead (Pb)-Total	WG1184449-4	VA-NRC-TORT2	0.362	0.350	mg/kg wwt	103	70-130	
Tissue	CRM	Manganese (Mn)-Total	WG1184449-4	VA-NRC-TORT2	13.6	13.6	mg/kg wwt	100	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1184449-4	VA-NRC-TORT2	0.249	0.270	mg/kg wwt	92	70-130	
Tissue	CRM	Molybdenum (Mo)-Total	WG1184449-4	VA-NRC-TORT2	0.980	0.950	mg/kg wwt	103	70-130	
Tissue	CRM	Nickel (Ni)-Total	WG1184449-4	VA-NRC-TORT2	2.34	2.50	mg/kg wwt	94	70-130	
Tissue	CRM	Selenium (Se)-Total	WG1184449-4	VA-NRC-TORT2	5.79	5.63	mg/kg wwt	103	70-130	
Tissue	CRM	Strontium (Sr)-Total	WG1184449-4	VA-NRC-TORT2	46.3	45.2	mg/kg wwt	102	70-130	
Tissue	CRM	Vanadium (V)-Total	WG1184449-4	VA-NRC-TORT2	1.77	1.64	mg/kg wwt	108	70-130	
Tissue	CRM	Zinc (Zn)-Total	WG1184449-4	VA-NRC-TORT2	190	180	mg/kg wwt	106	70-130	
Tissue	MB	Aluminum (Al)-Total	WG1179058-1		<0.40	<0.4	mg/kg wwt	-	0.4	
Tissue	MB	Antimony (Sb)-Total	WG1179058-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Arsenic (As)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Barium (Ba)-Total	WG1179058-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Beryllium (Be)-Total	WG1179058-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Bismuth (Bi)-Total	WG1179058-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Boron (B)-Total	WG1179058-1		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Cadmium (Cd)-Total	WG1179058-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Calcium (Ca)-Total	WG1179058-1		<0.50	<0.5	mg/kg wwt	-	0.5	

Appendix B2-4. Quality Control Tests of Ninespine Stickleback Metal Concentrations, Doris North Project, 2010

Matrix	QC Type	Analyte	QC Spl. No.	Reference	Result	Target	Units	%	Limits	Qualifier
Tissue	MB	Cesium (Cs)-Total	WG1179058-1		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Chromium (Cr)-Total	WG1179058-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Cobalt (Co)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Copper (Cu)-Total	WG1179058-1		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Gallium (Ga)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Iron (Fe)-Total	WG1179058-1		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Lead (Pb)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Lithium (Li)-Total	WG1179058-1		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Magnesium (Mg)-Total	WG1179058-1		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Manganese (Mn)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Mercury (Hg)-Total	WG1179058-1		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Molybdenum (Mo)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Nickel (Ni)-Total	WG1179058-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Phosphorus (P)-Total	WG1179058-1		<5.0	<5	mg/kg wwt	-	5	
Tissue	MB	Potassium (K)-Total	WG1179058-1		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Rhenium (Re)-Total	WG1179058-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Rubidium (Rb)-Total	WG1179058-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Selenium (Se)-Total	WG1179058-1		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Sodium (Na)-Total	WG1179058-1		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Strontium (Sr)-Total	WG1179058-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Tellurium (Te)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Thallium (Tl)-Total	WG1179058-1		<0.00040	<0.0004	mg/kg wwt	-	0.0004	
Tissue	MB	Thorium (Th)-Total	WG1179058-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Tin (Sn)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Titanium (Ti)-Total	WG1179058-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Uranium (U)-Total	WG1179058-1		<0.00040	<0.0004	mg/kg wwt	-	0.0004	
Tissue	MB	Vanadium (V)-Total	WG1179058-1		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Yttrium (Y)-Total	WG1179058-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Zinc (Zn)-Total	WG1179058-1		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Zirconium (Zr)-Total	WG1179058-1		<0.040	<0.04	mg/kg wwt	-	0.04	
Tissue	MB	Aluminum (Al)-Total	WG1179058-2		<0.40	<0.4	mg/kg wwt	-	0.4	
Tissue	MB	Antimony (Sb)-Total	WG1179058-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Arsenic (As)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Barium (Ba)-Total	WG1179058-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Beryllium (Be)-Total	WG1179058-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Bismuth (Bi)-Total	WG1179058-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Boron (B)-Total	WG1179058-2		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Cadmium (Cd)-Total	WG1179058-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Calcium (Ca)-Total	WG1179058-2		<0.50	<0.5	mg/kg wwt	-	0.5	
Tissue	MB	Cesium (Cs)-Total	WG1179058-2		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Chromium (Cr)-Total	WG1179058-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Cobalt (Co)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Copper (Cu)-Total	WG1179058-2		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Gallium (Ga)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Iron (Fe)-Total	WG1179058-2		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Lead (Pb)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Lithium (Li)-Total	WG1179058-2		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Magnesium (Mg)-Total	WG1179058-2		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Manganese (Mn)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Mercury (Hg)-Total	WG1179058-2		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Molybdenum (Mo)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Nickel (Ni)-Total	WG1179058-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Phosphorus (P)-Total	WG1179058-2		<5.0	<5	mg/kg wwt	-	5	
Tissue	MB	Potassium (K)-Total	WG1179058-2		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Rhenium (Re)-Total	WG1179058-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Rubidium (Rb)-Total	WG1179058-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Selenium (Se)-Total	WG1179058-2		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Sodium (Na)-Total	WG1179058-2		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Strontium (Sr)-Total	WG1179058-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Tellurium (Te)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Thallium (Tl)-Total	WG1179058-2		<0.00040	<0.0004	mg/kg wwt	-	0.0004	
Tissue	MB	Thorium (Th)-Total	WG1179058-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Tin (Sn)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Titanium (Ti)-Total	WG1179058-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Uranium (U)-Total	WG1179058-2		<0.00040	<0.0004	mg/kg wwt	-	0.0004	
Tissue	MB	Vanadium (V)-Total	WG1179058-2		<0.0040	<0.004	mg/kg wwt	-	0.004	

Appendix B2-4. Quality Control Tests of Ninespine Stickleback Metal Concentrations, Doris North Project, 2010

Matrix	QC Type	Analyte	QC Spl. No.	Reference	Result	Target	Units	%	Limits	Qualifier
Tissue	MB	Yttrium (Y)-Total	WG1179058-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Zinc (Zn)-Total	WG1179058-2		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Zirconium (Zr)-Total	WG1179058-2		<0.040	<0.04	mg/kg wwt	-	0.04	
Tissue	MB	Aluminum (Al)-Total	WG1179058-7		<0.40	<0.4	mg/kg wwt	-	0.4	
Tissue	MB	Antimony (Sb)-Total	WG1179058-7		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Arsenic (As)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Barium (Ba)-Total	WG1179058-7		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Beryllium (Be)-Total	WG1179058-7		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Bismuth (Bi)-Total	WG1179058-7		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Boron (B)-Total	WG1179058-7		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Cadmium (Cd)-Total	WG1179058-7		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Calcium (Ca)-Total	WG1179058-7		<0.50	<0.5	mg/kg wwt	-	0.5	
Tissue	MB	Cesium (Cs)-Total	WG1179058-7		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Chromium (Cr)-Total	WG1179058-7		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Cobalt (Co)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Copper (Cu)-Total	WG1179058-7		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Gallium (Ga)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Iron (Fe)-Total	WG1179058-7		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Lead (Pb)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Lithium (Li)-Total	WG1179058-7		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Magnesium (Mg)-Total	WG1179058-7		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Manganese (Mn)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Mercury (Hg)-Total	WG1179058-7		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Molybdenum (Mo)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Nickel (Ni)-Total	WG1179058-7		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Phosphorus (P)-Total	WG1179058-7		<5.0	<5	mg/kg wwt	-	5	
Tissue	MB	Potassium (K)-Total	WG1179058-7		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Rhenium (Re)-Total	WG1179058-7		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Rubidium (Rb)-Total	WG1179058-7		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Selenium (Se)-Total	WG1179058-7		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Sodium (Na)-Total	WG1179058-7		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Strontium (Sr)-Total	WG1179058-7		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Tellurium (Te)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Thallium (Tl)-Total	WG1179058-7		<0.00040	<0.0004	mg/kg wwt	-	0.0004	
Tissue	MB	Thorium (Th)-Total	WG1179058-7		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Tin (Sn)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Titanium (Ti)-Total	WG1179058-7		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Uranium (U)-Total	WG1179058-7		<0.00040	<0.0004	mg/kg wwt	-	0.0004	
Tissue	MB	Vanadium (V)-Total	WG1179058-7		<0.0040	<0.004	mg/kg wwt	-	0.004	
Tissue	MB	Yttrium (Y)-Total	WG1179058-7		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Zinc (Zn)-Total	WG1179058-7		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Zirconium (Zr)-Total	WG1179058-7		<0.040	<0.04	mg/kg wwt	-	0.04	
Tissue	MB	Calcium (Ca)-Total	WG1184449-1		0.56	<0.5	mg/kg wwt	-	0.5	MB-LOR
Tissue	MB	Magnesium (Mg)-Total	WG1184449-1		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Mercury (Hg)-Total	WG1184449-1		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Phosphorus (P)-Total	WG1184449-1		<5.0	<5	mg/kg wwt	-	5	
Tissue	MB	Potassium (K)-Total	WG1184449-1		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Sodium (Na)-Total	WG1184449-1		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Calcium (Ca)-Total	WG1184449-2		1.04	<0.5	mg/kg wwt	-	0.5	MB-LOR
Tissue	MB	Magnesium (Mg)-Total	WG1184449-2		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Mercury (Hg)-Total	WG1184449-2		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Phosphorus (P)-Total	WG1184449-2		<5.0	<5	mg/kg wwt	-	5	
Tissue	MB	Potassium (K)-Total	WG1184449-2		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Sodium (Na)-Total	WG1184449-2		<20	<20	mg/kg wwt	-	20	

MB = Method Blank

CRM = Comparison with Reference Material

MB-LOR = Method Blank exceeds data quality objectives. LORs adjusted for samples with positive hits below 5 times blank level

QC = Quality control

Appendix B2-5

Ninespine Stickleback Tissue Replicate Metal Concentrations, Doris North Project, 2010

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Appendix B2-5. Ninespine Stickleback Tissue Replicate Metal Concentrations, Doris North Project, 2010

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD	RPD Limit	Difference	DifferenceLimit	Qualifier
Physical Tests											
L930021-1	Tissue	WG1179234-2	% Moisture	76.2	76.9	%	0.89	20	-	-	-
L930021-3	Tissue	WG1179234-3	% Moisture	77.9	78.7	%	1.0	20	-	-	-
L930021-54	Tissue	WG1179234-1	% Moisture	88.2	88.8	%	0.69	20	-	-	-
Metals											
L930021-1	Tissue	WG1179058-9	Aluminum (Al)-Total	16.8	15.3	mg/kg wwt	9.6	39	-	-	-
L930021-21	Tissue	WG1179058-4	Aluminum (Al)-Total	14.7	14.7	mg/kg wwt	0.098	39	-	-	-
L930021-42	Tissue	WG1184449-5	Aluminum (Al)-Total	4.06	3.97	mg/kg wwt	-	-	0.08	1.6	J
L930021-51	Tissue	WG1179058-3	Aluminum (Al)-Total	3.25	2.77	mg/kg wwt	-	-	0.48	1.6	J
L930021-1	Tissue	WG1179058-9	Antimony (Sb)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Antimony (Sb)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Antimony (Sb)-Total	0.0036	0.0031	mg/kg wwt	-	-	0.0004	0.008	J
L930021-51	Tissue	WG1179058-3	Antimony (Sb)-Total	0.0031	0.0030	mg/kg wwt	-	-	0.0001	0.008	J
L930021-1	Tissue	WG1179058-9	Arsenic (As)-Total	0.0915	0.0999	mg/kg wwt	8.8	39	-	-	-
L930021-21	Tissue	WG1179058-4	Arsenic (As)-Total	0.0768	0.0815	mg/kg wwt	5.9	39	-	-	-
L930021-42	Tissue	WG1184449-5	Arsenic (As)-Total	2.14	2.26	mg/kg wwt	5.4	39	-	-	-
L930021-51	Tissue	WG1179058-3	Arsenic (As)-Total	2.28	2.23	mg/kg wwt	2.1	39	-	-	-
L930021-1	Tissue	WG1179058-9	Barium (Ba)-Total	1.04	1.10	mg/kg wwt	6.5	39	-	-	-
L930021-21	Tissue	WG1179058-4	Barium (Ba)-Total	1.06	0.929	mg/kg wwt	14	39	-	-	-
L930021-42	Tissue	WG1184449-5	Barium (Ba)-Total	2.67	2.85	mg/kg wwt	6.6	39	-	-	-
L930021-51	Tissue	WG1179058-3	Barium (Ba)-Total	1.61	1.31	mg/kg wwt	21	39	-	-	-
L930021-1	Tissue	WG1179058-9	Beryllium (Be)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Beryllium (Be)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Beryllium (Be)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-51	Tissue	WG1179058-3	Beryllium (Be)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-1	Tissue	WG1179058-9	Bismuth (Bi)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Bismuth (Bi)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Bismuth (Bi)-Total	0.0049	0.0049	mg/kg wwt	-	-	0.0000	0.008	J
L930021-51	Tissue	WG1179058-3	Bismuth (Bi)-Total	0.0029	0.0029	mg/kg wwt	-	-	0.0001	0.008	J
L930021-1	Tissue	WG1179058-9	Boron (B)-Total	<0.20	<0.20	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Boron (B)-Total	<0.20	<0.20	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Boron (B)-Total	2.94	2.93	mg/kg wwt	0.31	39	-	-	-
L930021-51	Tissue	WG1179058-3	Boron (B)-Total	2.59	2.60	mg/kg wwt	0.73	39	-	-	-
L930021-1	Tissue	WG1179058-9	Cadmium (Cd)-Total	0.0037	0.0034	mg/kg wwt	-	-	0.0003	0.008	J
L930021-21	Tissue	WG1179058-4	Cadmium (Cd)-Total	0.0083	0.0085	mg/kg wwt	-	-	0.0002	0.008	J
L930021-42	Tissue	WG1184449-5	Cadmium (Cd)-Total	0.399	0.373	mg/kg wwt	6.8	39	-	-	-
L930021-51	Tissue	WG1179058-3	Cadmium (Cd)-Total	0.304	0.321	mg/kg wwt	5.6	39	-	-	-
L930021-1	Tissue	WG1179058-9	Calcium (Ca)-Total	6840	7030	mg/kg wwt	2.7	50	-	-	-
L930021-21	Tissue	WG1179058-4	Calcium (Ca)-Total	8860	8080	mg/kg wwt	9.2	50	-	-	-
L930021-42	Tissue	WG1184449-5	Calcium (Ca)-Total	253	258	mg/kg wwt	1.8	50	-	-	-
L930021-51	Tissue	WG1179058-3	Calcium (Ca)-Total	236	243	mg/kg wwt	2.9	50	-	-	-
L930021-1	Tissue	WG1179058-9	Cesium (Cs)-Total	0.0039	0.0038	mg/kg wwt	-	-	0.0001	0.004	J
L930021-21	Tissue	WG1179058-4	Cesium (Cs)-Total	0.0028	0.0022	mg/kg wwt	-	-	0.0006	0.004	J
L930021-42	Tissue	WG1184449-5	Cesium (Cs)-Total	0.0019	0.0018	mg/kg wwt	-	-	0.0001	0.004	J
L930021-51	Tissue	WG1179058-3	Cesium (Cs)-Total	0.0024	0.0023	mg/kg wwt	-	-	0.0000	0.004	J
L930021-1	Tissue	WG1179058-9	Chromium (Cr)-Total	3.23	3.07	mg/kg wwt	5.1	39	-	-	-
L930021-21	Tissue	WG1179058-4	Chromium (Cr)-Total	0.053	0.033	mg/kg wwt	-	-	0.020	0.04	J
L930021-42	Tissue	WG1184449-5	Chromium (Cr)-Total	0.773	0.719	mg/kg wwt	7.3	39	-	-	-
L930021-51	Tissue	WG1179058-3	Chromium (Cr)-Total	1.42	1.16	mg/kg wwt	20	39	-	-	-
L930021-1	Tissue	WG1179058-9	Cobalt (Co)-Total	0.0568	0.0549	mg/kg wwt	3.4	39	-	-	-
L930021-21	Tissue	WG1179058-4	Cobalt (Co)-Total	0.0303	0.0261	mg/kg wwt	-	-	0.0042	0.016	J
L930021-42	Tissue	WG1184449-5	Cobalt (Co)-Total	0.139	0.136	mg/kg wwt	2.3	39	-	-	-
L930021-51	Tissue	WG1179058-3	Cobalt (Co)-Total	0.124	0.116	mg/kg wwt	6.6	39	-	-	-
L930021-1	Tissue	WG1179058-9	Copper (Cu)-Total	0.914	0.908	mg/kg wwt	0.68	39	-	-	-
L930021-21	Tissue	WG1179058-4	Copper (Cu)-Total	0.751	0.797	mg/kg wwt	5.9	39	-	-	-
L930021-42	Tissue	WG1184449-5	Copper (Cu)-Total	1.11	1.08	mg/kg wwt	3.4	39	-	-	-
L930021-51	Tissue	WG1179058-3	Copper (Cu)-Total	1.25	1.41	mg/kg wwt	11	39	-	-	-
L930021-1	Tissue	WG1179058-9	Gallium (Ga)-Total	0.0055	0.0049	mg/kg wwt	-	-	0.0006	0.016	J
L930021-21	Tissue	WG1179058-4	Gallium (Ga)-Total	0.0069	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Gallium (Ga)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-51	Tissue	WG1179058-3	Gallium (Ga)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-1	Tissue	WG1179058-9	Iron (Fe)-Total	97.8	90.9	mg/kg wwt	7.4	39	-	-	-
L930021-21	Tissue	WG1179058-4	Iron (Fe)-Total	55.9	55.1	mg/kg wwt	1.4	39	-	-	-
L930021-42	Tissue	WG1184449-5	Iron (Fe)-Total	37.7	37.3	mg/kg wwt	0.99	39	-	-	-
L930021-51	Tissue	WG1179058-3	Iron (Fe)-Total	39.7	38.6	mg/kg wwt	2.8	39	-	-	-
L930021-1	Tissue	WG1179058-9	Lead (Pb)-Total	0.0114	0.0102	mg/kg wwt	-	-	0.0012	0.016	J
L930021-21	Tissue	WG1179058-4	Lead (Pb)-Total	0.0134	0.0129	mg/kg wwt	-	-	0.0005	0.016	J
L930021-42	Tissue	WG1184449-5	Lead (Pb)-Total	0.0304	0.0289	mg/kg wwt	-	-	0.0014	0.016	J
L930021-51	Tissue	WG1179058-3	Lead (Pb)-Total	0.0449	0.0438	mg/kg wwt	2.6	39	-	-	-

Appendix B2-5. Ninespine Stickleback Tissue Replicate Metal Concentrations, Doris North Project, 2010

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD	RPD Limit	Difference	DifferenceLimit	Qualifier
L930021-1	Tissue	WG1179058-9	Lithium (Li)-Total	0.022	<0.020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Lithium (Li)-Total	0.026	<0.020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Lithium (Li)-Total	0.056	0.054	mg/kg wwt	-	-	0.002	0.08	J
L930021-51	Tissue	WG1179058-3	Lithium (Li)-Total	0.041	0.041	mg/kg wwt	-	-	0.000	0.08	J
L930021-1	Tissue	WG1179058-9	Magnesium (Mg)-Total	339	338	mg/kg wwt	0.44	30	-	-	-
L930021-21	Tissue	WG1179058-4	Magnesium (Mg)-Total	486	459	mg/kg wwt	5.7	30	-	-	-
L930021-42	Tissue	WG1184449-5	Magnesium (Mg)-Total	481	476	mg/kg wwt	1.2	30	-	-	-
L930021-51	Tissue	WG1179058-3	Magnesium (Mg)-Total	428	440	mg/kg wwt	2.7	30	-	-	-
L930021-1	Tissue	WG1179058-9	Manganese (Mn)-Total	16.7	17.4	mg/kg wwt	3.9	39	-	-	-
L930021-21	Tissue	WG1179058-4	Manganese (Mn)-Total	15.0	14.5	mg/kg wwt	3.2	39	-	-	-
L930021-42	Tissue	WG1184449-5	Manganese (Mn)-Total	0.763	0.748	mg/kg wwt	2.0	39	-	-	-
L930021-51	Tissue	WG1179058-3	Manganese (Mn)-Total	0.840	0.827	mg/kg wwt	1.6	39	-	-	-
L930021-1	Tissue	WG1179058-9	Mercury (Hg)-Total	0.0663	0.0670	mg/kg wwt	0.98	30	-	-	-
L930021-21	Tissue	WG1179058-4	Mercury (Hg)-Total	0.0334	0.0339	mg/kg wwt	1.3	30	-	-	-
L930021-42	Tissue	WG1184449-5	Mercury (Hg)-Total	0.0197	0.0197	mg/kg wwt	0.33	30	-	-	-
L930021-51	Tissue	WG1179058-3	Mercury (Hg)-Total	0.0041	0.0032	mg/kg wwt	-	-	0.0008	0.004	J
L930021-1	Tissue	WG1179058-9	Molybdenum (Mo)-Total	0.140	0.141	mg/kg wwt	1.3	39	-	-	-
L930021-21	Tissue	WG1179058-4	Molybdenum (Mo)-Total	0.0312	0.0297	mg/kg wwt	-	-	0.0015	0.016	J
L930021-42	Tissue	WG1184449-5	Molybdenum (Mo)-Total	0.101	0.0965	mg/kg wwt	4.4	39	-	-	-
L930021-51	Tissue	WG1179058-3	Molybdenum (Mo)-Total	0.101	0.0995	mg/kg wwt	1.2	39	-	-	-
L930021-1	Tissue	WG1179058-9	Nickel (Ni)-Total	1.79	1.62	mg/kg wwt	10	39	-	-	-
L930021-21	Tissue	WG1179058-4	Nickel (Ni)-Total	0.038	0.030	mg/kg wwt	-	-	0.008	0.04	J
L930021-42	Tissue	WG1184449-5	Nickel (Ni)-Total	1.03	0.960	mg/kg wwt	7.4	39	-	-	-
L930021-51	Tissue	WG1179058-3	Nickel (Ni)-Total	1.45	1.28	mg/kg wwt	13	39	-	-	-
L930021-1	Tissue	WG1179058-9	Phosphorus (P)-Total	5720	5870	mg/kg wwt	2.7	30	-	-	-
L930021-21	Tissue	WG1179058-4	Phosphorus (P)-Total	6620	6230	mg/kg wwt	6.1	30	-	-	-
L930021-42	Tissue	WG1184449-5	Phosphorus (P)-Total	1110	1120	mg/kg wwt	0.14	30	-	-	-
L930021-51	Tissue	WG1179058-3	Phosphorus (P)-Total	1300	1320	mg/kg wwt	1.4	30	-	-	-
L930021-1	Tissue	WG1179058-9	Potassium (K)-Total	3380	3370	mg/kg wwt	0.21	30	-	-	-
L930021-21	Tissue	WG1179058-4	Potassium (K)-Total	3230	3210	mg/kg wwt	0.75	30	-	-	-
L930021-42	Tissue	WG1184449-5	Potassium (K)-Total	1570	1580	mg/kg wwt	0.42	30	-	-	-
L930021-51	Tissue	WG1179058-3	Potassium (K)-Total	1800	1820	mg/kg wwt	1.2	30	-	-	-
L930021-1	Tissue	WG1179058-9	Rhenium (Re)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Rhenium (Re)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Rhenium (Re)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-51	Tissue	WG1179058-3	Rhenium (Re)-Total	<0.0020	<0.0020	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-1	Tissue	WG1179058-9	Rubidium (Rb)-Total	1.68	1.69	mg/kg wwt	0.73	39	-	-	-
L930021-21	Tissue	WG1179058-4	Rubidium (Rb)-Total	1.47	1.46	mg/kg wwt	0.96	39	-	-	-
L930021-42	Tissue	WG1184449-5	Rubidium (Rb)-Total	0.719	0.708	mg/kg wwt	1.5	39	-	-	-
L930021-51	Tissue	WG1179058-3	Rubidium (Rb)-Total	0.807	0.811	mg/kg wwt	0.51	39	-	-	-
L930021-1	Tissue	WG1179058-9	Selenium (Se)-Total	0.236	0.228	mg/kg wwt	3.1	39	-	-	-
L930021-21	Tissue	WG1179058-4	Selenium (Se)-Total	0.199	0.233	mg/kg wwt	-	-	0.035	0.08	J
L930021-42	Tissue	WG1184449-5	Selenium (Se)-Total	0.752	0.710	mg/kg wwt	5.7	39	-	-	-
L930021-51	Tissue	WG1179058-3	Selenium (Se)-Total	0.817	0.800	mg/kg wwt	2.2	39	-	-	-
L930021-1	Tissue	WG1179058-9	Sodium (Na)-Total	1290	1300	mg/kg wwt	0.60	30	-	-	-
L930021-21	Tissue	WG1179058-4	Sodium (Na)-Total	1200	1190	mg/kg wwt	0.23	30	-	-	-
L930021-42	Tissue	WG1184449-5	Sodium (Na)-Total	3200	3200	mg/kg wwt	0.039	30	-	-	-
L930021-51	Tissue	WG1179058-3	Sodium (Na)-Total	2770	2800	mg/kg wwt	1.1	30	-	-	-
L930021-1	Tissue	WG1179058-9	Strontium (Sr)-Total	7.40	7.90	mg/kg wwt	6.5	39	-	-	-
L930021-21	Tissue	WG1179058-4	Strontium (Sr)-Total	10.2	9.12	mg/kg wwt	11	39	-	-	-
L930021-42	Tissue	WG1184449-5	Strontium (Sr)-Total	3.66	3.48	mg/kg wwt	4.9	39	-	-	-
L930021-51	Tissue	WG1179058-3	Strontium (Sr)-Total	3.56	3.76	mg/kg wwt	5.5	39	-	-	-
L930021-1	Tissue	WG1179058-9	Tellurium (Te)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Tellurium (Te)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Tellurium (Te)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-51	Tissue	WG1179058-3	Tellurium (Te)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-1	Tissue	WG1179058-9	Thallium (Tl)-Total	0.00183	0.00180	mg/kg wwt	-	-	0.00003	0.0016	J
L930021-21	Tissue	WG1179058-4	Thallium (Tl)-Total	0.00235	0.00209	mg/kg wwt	-	-	0.00026	0.0016	J
L930021-42	Tissue	WG1184449-5	Thallium (Tl)-Total	<0.00040	<0.00040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-51	Tissue	WG1179058-3	Thallium (Tl)-Total	0.00072	0.00079	mg/kg wwt	-	-	0.00007	0.0016	J
L930021-1	Tissue	WG1179058-9	Thorium (Th)-Total	0.0054	0.0029	mg/kg wwt	-	-	0.0025	0.008	J
L930021-21	Tissue	WG1179058-4	Thorium (Th)-Total	0.0063	0.0081	mg/kg wwt	-	-	0.0019	0.008	J
L930021-42	Tissue	WG1184449-5	Thorium (Th)-Total	0.0095	0.0098	mg/kg wwt	-	-	0.0003	0.008	J
L930021-51	Tissue	WG1179058-3	Thorium (Th)-Total	0.0073	0.0064	mg/kg wwt	-	-	0.0009	0.008	J
L930021-1	Tissue	WG1179058-9	Tin (Sn)-Total	0.0085	0.0072	mg/kg wwt	-	-	0.0013	0.016	J
L930021-21	Tissue	WG1179058-4	Tin (Sn)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Tin (Sn)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-51	Tissue	WG1179058-3	Tin (Sn)-Total	<0.0040	<0.0040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-1	Tissue	WG1179058-9	Titanium (Ti)-Total	0.829	0.744	mg/kg wwt	11	39	-	-	-
L930021-21	Tissue	WG1179058-4	Titanium (Ti)-Total	0.706	0.735	mg/kg wwt	4.1	39	-	-	-
L930021-42	Tissue	WG1184449-5	Titanium (Ti)-Total	0.159	0.166	mg/kg wwt	4.3	39	-	-	-
L930021-51	Tissue	WG1179058-3	Titanium (Ti)-Total	0.177	0.146	mg/kg wwt	19	39	-	-	-

Appendix B2-5. Ninespine Stickleback Tissue Replicate Metal Concentrations, Doris North Project, 2010

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD	RPD Limit	Difference	DifferenceLimit	Qualifier
L930021-1	Tissue	WG1179058-9	Uranium (U)-Total	0.00339	0.00337	mg/kg wwt	-	-	0.00002	0.0016	J
L930021-21	Tissue	WG1179058-4	Uranium (U)-Total	0.00487	0.00436	mg/kg wwt	11	39	-	-	-
L930021-42	Tissue	WG1184449-5	Uranium (U)-Total	0.0204	0.0205	mg/kg wwt	0.28	39	-	-	-
L930021-51	Tissue	WG1179058-3	Uranium (U)-Total	0.0131	0.0129	mg/kg wwt	2.1	39	-	-	-
L930021-1	Tissue	WG1179058-9	Vanadium (V)-Total	0.0637	0.0622	mg/kg wwt	2.3	39	-	-	-
L930021-21	Tissue	WG1179058-4	Vanadium (V)-Total	0.0727	0.0554	mg/kg wwt	27	39	-	-	-
L930021-42	Tissue	WG1184449-5	Vanadium (V)-Total	0.0670	0.0662	mg/kg wwt	1.2	39	-	-	-
L930021-51	Tissue	WG1179058-3	Vanadium (V)-Total	0.0614	0.0728	mg/kg wwt	17	39	-	-	-
L930021-1	Tissue	WG1179058-9	Yttrium (Y)-Total	0.0055	0.0051	mg/kg wwt	-	-	0.0004	0.008	J
L930021-21	Tissue	WG1179058-4	Yttrium (Y)-Total	0.0074	0.0045	mg/kg wwt	-	-	0.0029	0.008	J
L930021-42	Tissue	WG1184449-5	Yttrium (Y)-Total	0.0218	0.0216	mg/kg wwt	0.72	39	-	-	-
L930021-51	Tissue	WG1179058-3	Yttrium (Y)-Total	0.0121	0.0115	mg/kg wwt	-	-	0.0006	0.008	J
L930021-1	Tissue	WG1179058-9	Zinc (Zn)-Total	36.7	36.2	mg/kg wwt	1.3	39	-	-	-
L930021-21	Tissue	WG1179058-4	Zinc (Zn)-Total	34.4	32.2	mg/kg wwt	6.7	39	-	-	-
L930021-42	Tissue	WG1184449-5	Zinc (Zn)-Total	8.13	8.07	mg/kg wwt	0.73	39	-	-	-
L930021-51	Tissue	WG1179058-3	Zinc (Zn)-Total	11.2	11.5	mg/kg wwt	2.7	39	-	-	-
L930021-1	Tissue	WG1179058-9	Zirconium (Zr)-Total	<0.040	<0.040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-21	Tissue	WG1179058-4	Zirconium (Zr)-Total	<0.040	<0.040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-42	Tissue	WG1184449-5	Zirconium (Zr)-Total	<0.040	<0.040	mg/kg wwt	N/A	39	-	-	RPD-NA
L930021-51	Tissue	WG1179058-3	Zirconium (Zr)-Total	<0.040	<0.040	mg/kg wwt	N/A	39	-	-	RPD-NA

RPD = Relative Percent Difference

RPD-NA = RPD Not Available because one or both values were at or below the MDL

J = Absolute difference between duplicates. RPD not available because one or both values were less than five times greater than the MDL

Appendix B2-6

Quality Control Tests of *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

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Appendix B2-6. Quality Control Tests of *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Matrix	QC Type	Analyte	QC Spl. No.	Reference	Result	Target	Units	%	Limits	Qualifier
Tissue	CRM	Selenium (Se)-Total	WG1226571-5	VA-NRC-DOLT4	9.81	8.30	mg/kg wwt	118.19	70-130	
Tissue	CRM	Zinc (Zn)-Total	WG1226571-5	VA-NRC-DOLT4	129	116	mg/kg wwt	111.21	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1234254-4	VA-NRC-TORT2	0.266	0.270	mg/kg wwt	98.52	70-130	
Tissue	CRM	Arsenic (As)-Total	WG1234254-5	VA-NRC-DOLT4	9.58	9.66	mg/kg wwt	99.17	70-130	
Tissue	CRM	Cadmium (Cd)-Total	WG1234254-5	VA-NRC-DOLT4	27.4	24.3	mg/kg wwt	112.76	70-130	
Tissue	CRM	Copper (Cu)-Total	WG1234254-5	VA-NRC-DOLT4	35.3	31.2	mg/kg wwt	113.14	70-130	
Tissue	CRM	Iron (Fe)-Total	WG1234254-5	VA-NRC-DOLT4	1900	1830	mg/kg wwt	103.83	70-130	
Tissue	CRM	Lead (Pb)-Total	WG1234254-5	VA-NRC-DOLT4	0.151	0.160	mg/kg wwt	94.38	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1234254-5	VA-NRC-DOLT4	1.85	2.58	mg/kg wwt	71.71	70-130	
Tissue	CRM	Nickel (Ni)-Total	WG1234254-5	VA-NRC-DOLT4	0.948	0.970	mg/kg wwt	97.73	70-130	
Tissue	CRM	Selenium (Se)-Total	WG1234254-5	VA-NRC-DOLT4	9.73	8.30	mg/kg wwt	117.23	70-130	
Tissue	CRM	Zinc (Zn)-Total	WG1234254-5	VA-NRC-DOLT4	141	116	mg/kg wwt	121.55	70-130	
Tissue	CRM	Arsenic (As)-Total	WG1234254-7	VA-NIST-1547	0.0700	0.0600	mg/kg wwt	116.67	.04-.08	
Tissue	CRM	Barium (Ba)-Total	WG1234254-7	VA-NIST-1547	133	124	mg/kg wwt	107.26	70-130	
Tissue	CRM	Boron (B)-Total	WG1234254-7	VA-NIST-1547	32.4	29.0	mg/kg wwt	111.72	70-130	
Tissue	CRM	Cadmium (Cd)-Total	WG1234254-7	VA-NIST-1547	0.0285	0.0260	mg/kg wwt	109.62	.016-.036	
Tissue	CRM	Calcium (Ca)-Total	WG1234254-7	VA-NIST-1547	14800	15600	mg/kg wwt	94.87	70-130	
Tissue	CRM	Cobalt (Co)-Total	WG1234254-7	VA-NIST-1547	0.0639	0.0700	mg/kg wwt	91.29	.05-.09	
Tissue	CRM	Copper (Cu)-Total	WG1234254-7	VA-NIST-1547	3.98	3.70	mg/kg wwt	107.57	70-130	
Tissue	CRM	Iron (Fe)-Total	WG1234254-7	VA-NIST-1547	214	218	mg/kg wwt	98.17	70-130	
Tissue	CRM	Lead (Pb)-Total	WG1234254-7	VA-NIST-1547	0.901	0.870	mg/kg wwt	103.56	70-130	
Tissue	CRM	Magnesium (Mg)-Total	WG1234254-7	VA-NIST-1547	4180	4320	mg/kg wwt	96.76	70-130	
Tissue	CRM	Manganese (Mn)-Total	WG1234254-7	VA-NIST-1547	102	98.0	mg/kg wwt	104.08	70-130	
Tissue	CRM	Mercury (Hg)-Total	WG1234254-7	VA-NIST-1547	0.0371	0.0310	mg/kg wwt	119.68	70-130	
Tissue	CRM	Phosphorus (P)-Total	WG1234254-7	VA-NIST-1547	1320	1370	mg/kg wwt	96.35	70-130	
Tissue	CRM	Potassium (K)-Total	WG1234254-7	VA-NIST-1547	24500	24300	mg/kg wwt	100.82	70-130	
Tissue	CRM	Rubidium (Rb)-Total	WG1234254-7	VA-NIST-1547	20.9	19.7	mg/kg wwt	106.09	70-130	
Tissue	CRM	Selenium (Se)-Total	WG1234254-7	VA-NIST-1547	0.124	0.120	mg/kg wwt	103.33	.02-.22	
Tissue	CRM	Strontium (Sr)-Total	WG1234254-7	VA-NIST-1547	58.9	53.0	mg/kg wwt	111.13	70-130	
Tissue	CRM	Thorium (Th)-Total	WG1234254-7	VA-NIST-1547	0.0461	0.0500	mg/kg wwt	92.20	.04-.06	
Tissue	CRM	Zinc (Zn)-Total	WG1234254-7	VA-NIST-1547	21.1	17.9	mg/kg wwt	117.88	70-130	
Tissue	MB	Aluminum (Al)-Total	WG1226571-1		<2.0	<2	mg/kg wwt	-	2	
Tissue	MB	Antimony (Sb)-Total	WG1226571-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Arsenic (As)-Total	WG1226571-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Barium (Ba)-Total	WG1226571-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Beryllium (Be)-Total	WG1226571-1		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Bismuth (Bi)-Total	WG1226571-1		<0.030	<0.03	mg/kg wwt	-	0.03	
Tissue	MB	Cadmium (Cd)-Total	WG1226571-1		<0.0050	<0.005	mg/kg wwt	-	0.005	
Tissue	MB	Calcium (Ca)-Total	WG1226571-1		<2.0	<2	mg/kg wwt	-	2	
Tissue	MB	Chromium (Cr)-Total	WG1226571-1		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Cobalt (Co)-Total	WG1226571-1		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Copper (Cu)-Total	WG1226571-1		0.032	<0.01	mg/kg wwt	-	0.01	MB-LOR
Tissue	MB	Lead (Pb)-Total	WG1226571-1		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Lithium (Li)-Total	WG1226571-1		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Magnesium (Mg)-Total	WG1226571-1		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Manganese (Mn)-Total	WG1226571-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Mercury (Hg)-Total	WG1226571-1		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Molybdenum (Mo)-Total	WG1226571-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Nickel (Ni)-Total	WG1226571-1		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Selenium (Se)-Total	WG1226571-1		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Strontium (Sr)-Total	WG1226571-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Thallium (Tl)-Total	WG1226571-1		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Tin (Sn)-Total	WG1226571-1		<0.050	<0.05	mg/kg wwt	-	0.05	
Tissue	MB	Uranium (U)-Total	WG1226571-1		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Vanadium (V)-Total	WG1226571-1		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Zinc (Zn)-Total	WG1226571-1		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Aluminum (Al)-Total	WG1226571-2		<2.0	<2	mg/kg wwt	-	2	
Tissue	MB	Antimony (Sb)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Arsenic (As)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Barium (Ba)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Beryllium (Be)-Total	WG1226571-2		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Bismuth (Bi)-Total	WG1226571-2		<0.030	<0.03	mg/kg wwt	-	0.03	
Tissue	MB	Cadmium (Cd)-Total	WG1226571-2		<0.0050	<0.005	mg/kg wwt	-	0.005	

Appendix B2-6. Quality Control Tests of *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Matrix	QC Type	Analyte	QC Spl. No.	Reference	Result	Target	Units	%	Limits	Qualifier
Tissue	MB	Calcium (Ca)-Total	WG1226571-2		<2.0	<2	mg/kg wwt	-	2	
Tissue	MB	Chromium (Cr)-Total	WG1226571-2		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Cobalt (Co)-Total	WG1226571-2		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Copper (Cu)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Lead (Pb)-Total	WG1226571-2		<0.020	<0.02	mg/kg wwt	-	0.02	
Tissue	MB	Lithium (Li)-Total	WG1226571-2		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Magnesium (Mg)-Total	WG1226571-2		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Manganese (Mn)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Mercury (Hg)-Total	WG1226571-2		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Molybdenum (Mo)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Nickel (Ni)-Total	WG1226571-2		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Selenium (Se)-Total	WG1226571-2		<0.20	<0.2	mg/kg wwt	-	0.2	
Tissue	MB	Strontium (Sr)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Thallium (Tl)-Total	WG1226571-2		<0.010	<0.01	mg/kg wwt	-	0.01	
Tissue	MB	Tin (Sn)-Total	WG1226571-2		<0.050	<0.05	mg/kg wwt	-	0.05	
Tissue	MB	Uranium (U)-Total	WG1226571-2		<0.0020	<0.002	mg/kg wwt	-	0.002	
Tissue	MB	Vanadium (V)-Total	WG1226571-2		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Zinc (Zn)-Total	WG1226571-2		<0.10	<0.1	mg/kg wwt	-	0.1	
Tissue	MB	Aluminum (Al)-Total	WG1234254-1		<0.40	<0.4	mg/kg wwt	-	2	
Tissue	MB	Antimony (Sb)-Total	WG1234254-1		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Arsenic (As)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Barium (Ba)-Total	WG1234254-1		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Beryllium (Be)-Total	WG1234254-1		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Bismuth (Bi)-Total	WG1234254-1		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Boron (B)-Total	WG1234254-1		<0.20	<0.2	mg/kg wwt	-	1	
Tissue	MB	Cadmium (Cd)-Total	WG1234254-1		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Calcium (Ca)-Total	WG1234254-1		<0.50	<0.5	mg/kg wwt	-	0.5	
Tissue	MB	Cesium (Cs)-Total	WG1234254-1		<0.0010	<0.001	mg/kg wwt	-	0.005	
Tissue	MB	Chromium (Cr)-Total	WG1234254-1		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Cobalt (Co)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Copper (Cu)-Total	WG1234254-1		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Gallium (Ga)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Iron (Fe)-Total	WG1234254-1		<0.20	<0.2	mg/kg wwt	-	1	
Tissue	MB	Lithium (Li)-Total	WG1234254-1		<0.020	<0.02	mg/kg wwt	-	0.1	
Tissue	MB	Magnesium (Mg)-Total	WG1234254-1		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Manganese (Mn)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Mercury (Hg)-Total	WG1234254-1		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Molybdenum (Mo)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Nickel (Ni)-Total	WG1234254-1		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Phosphorus (P)-Total	WG1234254-1		<5.0	<5	mg/kg wwt	-	5	
Tissue	MB	Potassium (K)-Total	WG1234254-1		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Rhenium (Re)-Total	WG1234254-1		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Rubidium (Rb)-Total	WG1234254-1		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Selenium (Se)-Total	WG1234254-1		<0.020	<0.02	mg/kg wwt	-	0.1	
Tissue	MB	Sodium (Na)-Total	WG1234254-1		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Strontium (Sr)-Total	WG1234254-1		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Tellurium (Te)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Thallium (Tl)-Total	WG1234254-1		<0.00040	<0.0004	mg/kg wwt	-	0.002	
Tissue	MB	Thorium (Th)-Total	WG1234254-1		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Tin (Sn)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Titanium (Ti)-Total	WG1234254-1		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Uranium (U)-Total	WG1234254-1		<0.00040	<0.0004	mg/kg wwt	-	0.002	
Tissue	MB	Vanadium (V)-Total	WG1234254-1		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Yttrium (Y)-Total	WG1234254-1		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Zinc (Zn)-Total	WG1234254-1		<0.10	<0.1	mg/kg wwt	-	0.5	
Tissue	MB	Zirconium (Zr)-Total	WG1234254-1		<0.040	<0.04	mg/kg wwt	-	0.2	
Tissue	MB	Aluminum (Al)-Total	WG1234254-2		<0.40	<0.4	mg/kg wwt	-	2	
Tissue	MB	Antimony (Sb)-Total	WG1234254-2		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Arsenic (As)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Barium (Ba)-Total	WG1234254-2		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Beryllium (Be)-Total	WG1234254-2		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Bismuth (Bi)-Total	WG1234254-2		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Boron (B)-Total	WG1234254-2		<0.20	<0.2	mg/kg wwt	-	1	
Tissue	MB	Cadmium (Cd)-Total	WG1234254-2		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Calcium (Ca)-Total	WG1234254-2		<0.50	<0.5	mg/kg wwt	-	0.5	
Tissue	MB	Cesium (Cs)-Total	WG1234254-2		<0.0010	<0.001	mg/kg wwt	-	0.005	

Appendix B2-6. Quality Control Tests of *Mytilus trossulus* Metal Concentrations, Doris North Project, 2010

Matrix	QC Type	Analyte	QC Spl. No.	Reference	Result	Target	Units	%	Limits	Qualifier
Tissue	MB	Chromium (Cr)-Total	WG1234254-2		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Cobalt (Co)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Copper (Cu)-Total	WG1234254-2		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Gallium (Ga)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Iron (Fe)-Total	WG1234254-2		<0.20	<0.2	mg/kg wwt	-	1	
Tissue	MB	Lead (Pb)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Lithium (Li)-Total	WG1234254-2		<0.020	<0.02	mg/kg wwt	-	0.1	
Tissue	MB	Magnesium (Mg)-Total	WG1234254-2		<1.0	<1	mg/kg wwt	-	1	
Tissue	MB	Manganese (Mn)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Mercury (Hg)-Total	WG1234254-2		<0.0010	<0.001	mg/kg wwt	-	0.001	
Tissue	MB	Molybdenum (Mo)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Nickel (Ni)-Total	WG1234254-2		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Phosphorus (P)-Total	WG1234254-2		<5.0	<5	mg/kg wwt	-	5	
Tissue	MB	Potassium (K)-Total	WG1234254-2		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Rhenium (Re)-Total	WG1234254-2		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Rubidium (Rb)-Total	WG1234254-2		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Selenium (Se)-Total	WG1234254-2		<0.020	<0.02	mg/kg wwt	-	0.1	
Tissue	MB	Sodium (Na)-Total	WG1234254-2		<20	<20	mg/kg wwt	-	20	
Tissue	MB	Strontium (Sr)-Total	WG1234254-2		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Tellurium (Te)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Thallium (Tl)-Total	WG1234254-2		<0.00040	<0.0004	mg/kg wwt	-	0.002	
Tissue	MB	Thorium (Th)-Total	WG1234254-2		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Tin (Sn)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Titanium (Ti)-Total	WG1234254-2		<0.010	<0.01	mg/kg wwt	-	0.05	
Tissue	MB	Uranium (U)-Total	WG1234254-2		<0.00040	<0.0004	mg/kg wwt	-	0.002	
Tissue	MB	Vanadium (V)-Total	WG1234254-2		<0.0040	<0.004	mg/kg wwt	-	0.02	
Tissue	MB	Yttrium (Y)-Total	WG1234254-2		<0.0020	<0.002	mg/kg wwt	-	0.01	
Tissue	MB	Zinc (Zn)-Total	WG1234254-2		<0.10	<0.1	mg/kg wwt	-	0.5	
Tissue	MB	Zirconium (Zr)-Total	WG1234254-2		<0.040	<0.04	mg/kg wwt	-	0.2	

MB = Method Blank

CRM = Comparison with Reference Material

MB-LOR = Method Blank exceeds data quality objectives. LORs adjusted for samples with positive hits below 5 times blank level

QC = Quality control

Appendix B2-7

Mytilus trossulus Tissue Replicate Metal Concentrations, Doris North Project, 2010

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Appendix B2-7. *Mytilus trossulus* Tissue Replicate Metal Concentrations, Doris North Project, 2010

Sample ID	Matrix	ALS ID	Analyte	Replicate 1	Replicate 2	Units	RPD	RPD Limit	Difference	Difference Limit	Qualifier
Physical Tests											
L965618-3	Tissue	WG1226608-1	% Moisture	87.6	87.5	%	0.10	20	-	-	-
Metals											
L965618-3	Tissue	WG1226571-3	Aluminum (Al)-Total	67.3	67.9	mg/kg wwt	0.78	30	-	-	-
L965618-3	Tissue	WG1226571-3	Antimony (Sb)-Total	<0.010	<0.010	mg/kg wwt	N/A	30	-	-	RPD-NA
L965618-3	Tissue	WG1226571-3	Arsenic (As)-Total	1.49	1.54	mg/kg wwt	3.1	30	-	-	-
L965618-3	Tissue	WG1226571-3	Barium (Ba)-Total	1.72	1.75	mg/kg wwt	1.2	30	-	-	-
L965618-3	Tissue	WG1226571-3	Beryllium (Be)-Total	<0.10	<0.10	mg/kg wwt	N/A	30	-	-	RPD-NA
L965618-3	Tissue	WG1226571-3	Bismuth (Bi)-Total	<0.030	<0.030	mg/kg wwt	N/A	30	-	-	RPD-NA
L965618-3	Tissue	WG1226571-3	Cadmium (Cd)-Total	0.500	0.520	mg/kg wwt	3.9	30	-	-	-
L965618-3	Tissue	WG1226571-3	Calcium (Ca)-Total	430	423	mg/kg wwt	1.8	50	-	-	-
L965618-3	Tissue	WG1226571-3	Chromium (Cr)-Total	17.6	17.2	mg/kg wwt	1.9	30	-	-	-
L965618-3	Tissue	WG1226571-3	Cobalt (Co)-Total	0.204	0.206	mg/kg wwt	1.1	30	-	-	-
L965618-3	Tissue	WG1226571-3	Copper (Cu)-Total	1.68	1.38	mg/kg wwt	19	30	-	-	-
L965618-3	Tissue	WG1226571-3	Lead (Pb)-Total	0.084	0.087	mg/kg wwt	3.9	30	-	-	-
L965618-3	Tissue	WG1226571-3	Lithium (Li)-Total	0.13	0.13	mg/kg wwt	1.4	30	-	-	-
L965618-3	Tissue	WG1226571-3	Magnesium (Mg)-Total	489	514	mg/kg wwt	5.1	30	-	-	-
L965618-3	Tissue	WG1226571-3	Manganese (Mn)-Total	3.39	3.40	mg/kg wwt	0.30	30	-	-	-
L965618-3	Tissue	WG1226571-3	Mercury (Hg)-Total	0.0168	0.0166	mg/kg wwt	1.4	30	-	-	-
L965618-3	Tissue	WG1226571-3	Molybdenum (Mo)-Total	0.666	0.626	mg/kg wwt	6.2	30	-	-	-
L965618-3	Tissue	WG1226571-3	Nickel (Ni)-Total	9.89	10.0	mg/kg wwt	1.2	30	-	-	-
L965618-3	Tissue	WG1226571-3	Selenium (Se)-Total	0.46	0.49	mg/kg wwt	6.0	30	-	-	-
L965618-3	Tissue	WG1226571-3	Strontium (Sr)-Total	4.42	4.56	mg/kg wwt	3.2	50	-	-	-
L965618-3	Tissue	WG1226571-3	Thallium (Tl)-Total	<0.010	<0.010	mg/kg wwt	N/A	30	-	-	RPD-NA
L965618-3	Tissue	WG1226571-3	Tin (Sn)-Total	0.504	0.562	mg/kg wwt	11	30	-	-	-
L965618-3	Tissue	WG1226571-3	Uranium (U)-Total	0.0409	0.0428	mg/kg wwt	4.6	30	-	-	-
L965618-3	Tissue	WG1226571-3	Vanadium (V)-Total	0.40	0.39	mg/kg wwt	2.7	30	-	-	-
L965618-3	Tissue	WG1226571-3	Zinc (Zn)-Total	15.0	15.6	mg/kg wwt	3.7	30	-	-	-
Physical Tests											
L965618-56	Tissue	WG1229981-1	% Moisture	84.7	85.0	%	0.29	20	-	-	-

RPD = Relative Percent Difference

RPD-NA = RPD Not Available because one or both values were at or below the MDL

J = Absolute difference between duplicates. RPD not available because one or both values were less than five times greater than the MDL

Appendix C

2010 Evaluation of Effects Supporting Information

Appendix C1. 2010 Historical Data Selection Rationale for Evaluation of Effects, Doris North Project

Appendix C2. 2010 Statistical Methodology and Results for Evaluation of Effects, Doris North Project

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Appendix C1

2010 Historical Data Selection Rationale for Evaluation of Effects, Doris North Project

Appendix C1-1. Historical Data Selection Rationale for Water Quality, Doris North Project, 2010

Appendix C1-2. Historical Data Selection Rationale for Sediment Quality, Doris North Project, 2010

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Appendix C1-1

Historical Data Selection Rationale for Water Quality, Doris North Project, 2010

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Appendix C1-1. Historical Data Selection Rationale for Water Quality, Doris North Project, 2010

Sampling Sites	Years Sampled	Months Sampled	Data Included from Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Streams					
Doris OF	1996	June, August	All	None	
	1997	June July, August	All	None	
	2000	June, September	All	None	
	2003	July, August, September	All	None	
	2004	June, July, August, September	All	None	
	2005	June, July, August, September	All	None	
	2006	June, July, August, September	All	None	
	2007	June, July, August, September	All	None	
	2008	June, July, August, September	All	None	
	2009	June, August, September	All	None	
	2010	June, July, August, September	All	None	
Roberts OF	2004	June, July, August, September	All	None	
	2005	June, July, August, September	All	None	
	2006	June, July, August, September	All	None	
	2007	June, July, August, September	All	None	
	2008	June, July, August, September	All	None	
	2010	June, August, September	All	None	
Little Roberts OF	1996	June, August	None	All	• 1996-1997 sampling site was further downstream than 2003-2010 sampling site.
	1997	June, July, August	None	All	• 1996-1997 sampling site was further downstream than 2003-2010 sampling site.
	2003	July, August, September	All	None	
	2004	June, July, August, September	All	None	
	2005	June, July, August, September	All	None	
	2006	June, July, August, September	All	None	
	2007	June, July, August, September	All	None	
	2008	June, July, August, September	All	None	
	2009	June, August, September	All	None	
	2010	June, July, August, September	All	None	
Reference B OF	2009	June, August, September	All	None	
	2010	June, July, August, September	All	None	
Reference D OF	2010	June, July, August, September	All	None	

Appendix C1-1. Historical Data Selection Rationale for Water Quality, Doris North Project, 2010

Sampling Sites	Years Sampled	Months Sampled	Data Included from Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Lakes					
Doris South	1995	May, June, July, August	Included August samples collected from boat at site SW4	Excluded under-ice samples collected in May and June, and shoreline grabs from July and August	• May and June sampling location was near the centre of the lake and not near the 2010 Doris South site. • Shoreline grabs from July and August are from a shallow near-shore site that is not comparable to the 2010 Doris South site.
	1996	April, August	None	All	• Sampling location was near the centre of the lake and not near the 2010 Doris South site.
	1997	April, July, August	None	All	• Sampling location was near the centre of the lake and not near the 2010 Doris South site.
	1998	April	None	All	• Sampling location was near the centre of the lake and not near the 2010 Doris South site.
	2000	July, August	None	All	• Sampling location was near the centre of the lake and not near the 2010 Doris South site.
	2009	April, August	All	None	
	2010	April, July, August, September	All	None	
Doris North	1995	May, June, July, August	Included May and June under-ice samples and August samples collected from boat a site SW3	Excluded shoreline grabs from July and August	• Shoreline grabs from July and August are from a shallow near-shore site that is not comparable to the 2010 Doris North site.
	2003	July, August, September	All	None	
	2004	June, July, August, September	All	None	
	2005	July, August, September	All	None	
	2006	May, July, August, September	All	None	
	2007	May, July, August, September	All	None	
	2008	May, July, August, September	All	None	
	2009	April, August	All	None	
	2010	April, July, August, September	All	None	
Little Roberts	1995	May, June, July, August	Included May and June under-ice samples	Excluded shoreline grabs from July and August	• Shoreline grabs from July and August are from a near-shore site that is not comparable to the 2010 Little Roberts Lake site.
	1996	August	All	None	
	1997	July	All	None	
	2003	July, August, September	All	None	
	2004	July, August, September	All	None	
	2005	July, August, September	All	None	
	2006	May, July, August, September	All	None	
	2007	May, July, August, September	All	None	
	2008	May, July, August, September	All	None	
	2009	April, August	All	None	
	2010	April, July, August, September	All	None	

Appendix C1-1. Historical Data Selection Rationale for Water Quality, Doris North Project, 2010

Sampling Sites	Years Sampled	Months Sampled	Data Included from Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Lakes					
Reference B	2009	April, August	All	None	
	2010	April, July, August, September	All	None	
Reference D	2010	April, July, August, September	All	None	
Marine Sites					
RBW	1996	August	None	All	• 1996-1998 sampling sites were >1 km away from 2010 RBW site.
	1997	August	None	All	• 1996-1998 sampling sites were >1 km away from 2010 RBW site.
	1998	July	None	All	• 1996-1998 sampling sites were >1 km away from 2010 RBW site.
	2009	April, August	Included surface samples from sites WT1 and ST2	Exluded samples from sites: WT2, WT4, WT6, ST1, ST2, ST3, ST4, ST5, ST5, and deep sample from site ST2	• Excluded sites that were >1 km away from 2010 RBW site, and excluded deep samples because only surface samples were collected in 2010.
	2010	April, July, August, September	All	None	
RBE	2004	July, August, September	All	None	
	2005	July, August, September	All	None	
	2006	May, July, August, September	All	None	
	2007	May, July, August, September	All	None	
	2008	July, August, September	All	None	
	2009	April, August	All	None	
	2010	April, July, August, September	All	None	
REF-Marine	2009	April, August	Included surface samples from site RP3	Excluded samples from sites: REF-W and REF-4, and deep samples from site RP3	• Excluded sites that were >1 km away from 2010 REF-Marine site, and excluded deep samples because only surface samples were collected in 2010.
	2010	April, July, August, September	Included samples from site REF-Marine	Excluded samples from site REF-4	• Excluded sites that were >1 km away from 2010 REF-Marine site.

Appendix C1-2

Historical Data Selection Rationale for Sediment Quality, Doris North Project, 2010

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Appendix C1-2. Historical Data Selection Rationale for Sediment Quality, Doris North Project, 2010

Sampling sites	Years Sampled	Month Sampled	Data Included from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Streams				
Doris OF	2009	August	Yes	
Roberts OF	-	-	-	• No historical data collected
Little Roberts OF	2009	August	Yes	
Reference B OF	2009	August	Yes	
Reference D OF	-	-	-	• No historical data collected
Lakes				
Doris South	1996	August	No	• deep site sampled in central Doris Lake; 1 replicate
(shallow)	1997	July	No	• deep site sampled in central Doris Lake; 1 replicate
	2002	August	No	• deep site sampled
	2009	August	No	• located near stream inflow; particle size dominated by sand (low metals)
Doris North	2002	August	No	• shallow site
(deep)	2009	August	Yes	
Little Roberts	1996	August	No	• 1 replicate
(shallow)	1997	July	No	• 1 replicate
	2009	August	Yes	
Reference B (deep)	2009	August	No	• shallow depth on opposite side of lake
Reference D (shallow)	-	-	-	• No historical data collected
Marine Sites				
RBW	1997	August	No	• deep site (10 m); >1 km from 2010 RBW
(shallow)	2002	August	Yes	• opposite side of jetty but within 1 km of 2010 RBW
	2009	August	No	• sites >1 km away from 2010 RBW site
RBE (shallow)	1997	August	No	• deep site (10 m); multiple depth samples (0-1 cm and 1-3 cm)
REF-Marine (shallow)	2009	August	Yes	

Appendix C2

2010 Statistical Methodology and Results for Evaluation of Effects, Doris North Project

Appendix C2-1. Statistical Methodology and Results for Water Quality Evaluation of Effects, Doris North Project, 2010

Appendix C2-2. Statistical Methodology and Results for Sediment Quality Evaluation of Effects, Doris North Project, 2010

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Appendix C2-1

Statistical Methodology and Results for Water Quality Evaluation of Effects, Doris North Project, 2010

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APPENDIX C2-1
STATISTICAL METHODOLOGY AND RESULTS FOR WATER QUALITY EVALUATION OF EFFECTS, DORIS NORTH PROJECT, 2010

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1. Analysis Methods

1.1 ASSUMPTIONS

There are several assumptions made for the analyses in this section. The key assumption is that the samples taken are a random sample of the body's water quality for that monitoring period (e.g., for that month in that year when measured) and of the sampling location. There is no way to assess this assumption other than by a careful consideration of the landscape and sampling protocol.

Another necessary assumption is that missing data (e.g., a stream was not measured in a month in a particular year) is missing completely at random (MCAR) so that there is no information about the water quality from the "missingness". This assumption could be violated if, for example, samples were not taken because it was known that water quality was compromised on the selected sampling date. There is no way to assess this assumption except by carefully considering why data was not collected on a particular date. If, for example, data were not collected because the sampling vial broke in transit, this is likely a case of MCAR.

It is further assumed that the water columns of all sampled waterbodies are completely mixed so that depth effects can be ignored. This assumption was verified by examining the raw sample means at various depths, and fitting statistical models to examine the effects of depth, and few depth effects were seen.

1.2 REPLICATE SAMPLES

Replicate samples collected within the same day and at the same depth are treated as pseudo-replicates (Hurlbert, 1984) and values are averaged before further analyses. This will be an approximate analysis (compared to actually modelling replicated values as nested within a particular day), but given the high variability seen for most of the readings, the reported results should be insensitive to this averaging.

1.3 DEALING WITH CENSORING (VALUES BELOW DETECTION LIMITS)

The proportion of data with readings below the detection limit varies by waterbody and by chemical parameter. The analyses below follow the advice of McBride (2005, Section 11.4.3).

- When the dataset has a small number of below detection values, we replace these values by the detection limit or by ½ of the detection limit and conducted the analyses under both substitutions and note if the results differ materially in either case. In this report, only the results from substituting ½ of detection limit for censored values are presented as analyses using the detection limit as the substituted value did not differ in any great way.
- When the dataset has mostly values below the detection limit (e.g., more than about 70% below detection limit), there is very little that can be done as there is essentially no information (other than the values are below the detection limit). The analyses will be performed as above, but interpreting the results should be done carefully. Helsel (2005) has other suggestions for analysis (e.g., comparing the proportions below the detection limits) but these tests will require much larger sample sizes than available here.
- When there are intermediate amount of censoring, a more complex analysis can be conducted that fully integrates the information from the censored values with the known values. This is most easily done using Bayesian methods using MCMC methods as likelihood methods would require integration of the likelihood for each censored value over and above dealing with the

other random effects in the model. There is currently, no readily available software available for the latter. Fortunately, most chemical parameters fall into one of the two previous categories.

It should be noted that for data collected in the late 1990's, the detection limits were considerably larger than the detection limits available for more modern sampling (often 5x or 6x larger). Consequently, there is little to be gained from using this very early data and it will often be removed prior to analysis and treated as outliers as noted in the sections below.

1.4 TRANSFORMATIONS

For all water quality parameters, the values were fairly homogeneous and no obvious transformation was suggested, i.e., metals analyzed on the ppm scale and pH measured on the log-scale.

1.5 DEALING WITH SPARSE DATA IN SOME CLASSIFICATIONS SUCH AS SEASON

In models with season effects, samples were not always collected during all seasons of all years or periods. In these cases, interaction effects involving season cannot be fit but additive models can still be fit.

1.6 OUTLINE OF ANALYSIS PLAN

There are several classes of statistical tests that can be done to assess evidence of change in the mean of the biological variable over time and to assess if changes in the means may reflect an impact of the Project.

1.6.1 Before vs. After Analysis for Each Body

The first analysis conducted compares the mean readings before and after Project initiation, i.e. the mean for 2010 (after initiation of construction) is compared to the mean of years prior to 2010 (before initiation of construction). Each body of water is treated independently and each chemical parameter is treated separately.

The final statistical model (in standard shorthand notation) is:

$$WQ = Period\ Season\ Period*Season\ \ Year(Period)\text{-}R$$

where *WQ* is the (mean) reading for a date within a year; *Period* is the effect of before vs. after Project initiation; *Season* is the effect of early or late in the year; *Period*Season* represent the interaction between Project and season effects (i.e., is the effect of the period consistent in both seasons); and *Year(Period)* is a random year effect. This separates the variation in water quality into components representing variation within a season in a year and year-to-year variation. If the data are too sparse (e.g. not all seasons measured in all periods), then the *Period*Season* interaction effect cannot be estimated and is dropped.

This model is preferable to simply treating all measurement within a period (e.g., over several years pre-construction) as having the same mean and assuming that they are completely independent of each other. This model also "averages" the water quality values over the several years of data collected pre-construction in way that weights each year equally rather then weighting by the sample size (which would be the case if a simple mean of measurements overall years pre-construction were done). For example, suppose that the water quality measured in year 1 was 22 ppm, while the two readings measured in year 2 were 25 and 27 ppm. The simple mean (22+25+27)/3=24.7 ppm would be more heavily weighted toward the mean in the second year. In order to give each year's data equal weight, the reading over both years is computed as an average of averages:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2}=24.0\,ppm$$

This can be extended to multiple years in a similar fashion.

This model is fit using a mixed-model ANOVA using Proc Mixed in SAS 9.2. In order to reduce the number of "false positives" because a large number of statistical tests are done, a reduced significance level (e.g. 0.01) should be used when reviewing the results. Estimates of the differences in means between the two periods are not presented in this report because of the very small number of statistically significant differences found, but are available if needed.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, e.g., the water quality readings in 2010 could be worse than expected because of long term climate change that is unrelated to the Project. Consequently, if a statistically significant effect is detected, it will require further investigation.

1.6.2 BACI Analysis

The standard method to assess an environmental impact is through a Before-After-Control-Impact (BACI) analysis (Smith, 2002). The analysis of these designs looks for non-parallelism in response over time between the Project and reference streams. A BACI analysis was performed for each Project waterbody versus the corresponding reference waterbody.

The formal statistical model (in standard shorthand notation) is:

*WQ = Period Season Period*Season Class Period*Class Year(Period)-R*

where *WQ* is the mean water quality reading on a date; *Period* is the effect of period (before or after construction); *Season* is the effect of season (early or late); *Period*Season* is the interaction between the period and season effects (i.e., is the change in the mean over the two periods the same for both seasons); *Class* is the effect of water body classification (Project or reference); *Period*Class* is the BACI effect of interest (i.e., is the effect of *Period* the same (parallel) for both classes of water body); and *Year(Period)* is the random year effect for multiple years within each period. If there were multiple reference bodies, a term *Body(Class)-R* will also be added to the model and so the change in the mean for the Project stream is compared to the average change in the mean for the reference bodies.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (After-Before) over the two classes of water bodies (Project or reference).

In some cases, not all bodies are measured in every year. This information does provide information about the year-to-year variation when compared with other years.

The BACI estimate is computed as the "difference in the differences", i.e.:

$$BACI=\left(\mu_{PA}-\mu_{PB}\right)-\left(\mu_{RA}-\mu_{RB}\right)$$

where $\mu_{PB}$is the mean water quality reading in the *Project* class *after* Project construction with a similar definition for the other population means. The BACI contrast is estimated by replacing the

population means above by the model-based estimates. Estimated differences close to 0 would indicate no evidence of non-parallelism.

Note that the hypothesis that the BACI contrast has the value of zero is identical to the hypothesis that the Period*Class interaction is zero with identical p-values. Consequently, only the results for the BACI contrast are reported in the tables.

This model was fit using a mixed-model ANOVA using Proc Mixed in SAS 9.2.

Note that as in any BACI analysis without replicated sites in the two classes, the results are specific to those sites used and cannot be extrapolated to other sites. The results may be specific to these particular sites for some site-specific factor such as geomorphology.

1.6.3 Multivariate Approaches

All of the approaches above analyze each chemical parameter independently of each other. However, the chemical constituents do not occur independently of each other, and presumably higher power would result if a multivariate approach were used. However, because of the censoring and missing data, no simple multivariate approach is possible and such an analysis would likely require the use of a full Bayesian MCMC approach. This has not been attempted in this report.

2. Results

2.1 STREAM DATA

A summary of the amount of censoring (below detection limit) for the stream data is found in Table Stream-1. High levels of censoring in all streams were found for the Cd, Hg, Nitrate, and Ra parameters and the results of the analyses for these parameters will be non-informative and should be discarded.

Table Stream-1. Summary of the Proportion Censored (before Outliers Removed) in Each Stream for Each Chemical Parameter

	Stream				
Parameter	Doris OF Prop Censored	Little Roberts OF Prop Censored	Ref. B OF Prop Censored	Ref. D OF Prop Censored	Roberts OF Prop Censored
Al	0.00	0.00	0.00	0.00	0.00
Alk	0.00	0.00	0.00	0.00	0.00
Ammonia	0.32	0.31	0.64	0.50	0.24
As	0.05	0.03	0.00	0.00	0.00
CN	0.75	0.52	0.00	0.13	0.62
Cd	0.79	0.69	1.00	1.00	0.69
Cu	0.00	0.00	0.00	0.00	0.00
Fe	0.00	0.00	0.00	0.00	0.00
Hardness	0.00	0.00	0.00	0.00	0.00
Hg	0.86	0.89	1.00	1.00	0.76
Mo	0.05	0.00	0.86	0.00	0.00
Ni	0.05	0.00	0.14	0.13	0.00
Nitrate	0.86	0.95	0.50	0.75	0.83
Pb	0.19	0.21	1.00	0.25	0.07
Ra	0.82	0.88	0.88	0.75	0.93
TSS	0.14	0.08	0.93	0.88	0.07
Zn	0.29	0.33	1.00	1.00	0.21
pH	0.00	0.00	0.00	0.00	0.00

High level of censoring for TSS, Ammonia, Mo, Pb, and Zn was found in one or all of the reference streams but a lower proportion of censored values were found in Project streams. In these cases, the results will require further investigation to ensure that the censoring is not causing an artifact in the results.

Preliminary plots of the data showed some outliers, primarily from readings in the late 1990's where the detection limit was much higher than in recent times (Table Stream-2). These were discarded as such a large detection limit compared to more recent data provides little information on the actual value. Some other outliers that were not related to high detection limits were also discarded.

Table Stream-2. Summary of Potential Outliers from the Stream Data (Censored Values Were Replaced by Half of the Detection Limit)

Stream	Parameter	Year	Date	Rep	Reading	Censored*
Doris OF	Ammonia	1997	July 19. 1997	1	1.359800	0
Doris OF	Ammonia	1997	July 19. 1997	2	1.402400	0
Doris OF	Ammonia	1997	August 20, 1997	1	1.353300	0
Doris OF	As	1996	August 22, 1996	1	0.003000	0
Doris OF	Cd	1996	August 22, 1996	1	0.000025	1
Doris OF	Cd	1997	June 19, 1997	1	0.000100	1
Doris OF	Cd	1997	July 19, 1997	1	0.000100	1
Doris OF	Cd	1997	July 19, 1997	2	0.000100	1
Doris OF	Cd	1997	August 20, 1997	1	0.000100	1
Doris OF	Cd	2000	June 20, 2000	1	0.000025	1
Doris OF	Cd	2000	June 20, 2000	2	0.000025	1
Doris OF	Cd	2000	September 14, 2000	1	0.000025	1
Doris OF	Cd	2000	September 14, 2000	2	0.000025	1
Doris OF	Cd	2004	June 24, 2004	1	0.000025	1
Doris OF	Hg	1997	August 20, 1997	1	0.000025	1
Doris OF	Hg	2000	June 20, 2000	1	0.000025	1
Doris OF	Hg	2000	June 20, 2000	2	0.000025	1
Doris OF	Hg	2000	September 14, 2000	1	0.000025	1
Doris OF	Hg	2000	September 14, 2000	2	0.000025	1
Doris OF	Hg	2003	July 28, 2003	1	0.000025	1
Doris OF	Mo	1997	June 19, 1997	1	0.000500	1
Doris OF	Mo	1997	July 19, 1997	1	0.000500	1
Doris OF	Mo	1997	July 19, 1997	2	0.000500	1
Doris OF	Mo	1997	August 20, 1997	1	0.000500	1
Little Roberts OF	Hg	2003	July 28, 2003	1	0.000025	1
Ref. B OF	Hg	2010	June 19, 2010	1	0.000025	1
Ref. B OF	Hg	2010	June 19, 2010	2	0.000025	1
Ref. D OF	Hg	2010	June 18, 2010	1	0.000025	1
Ref. D OF	Hg	2010	June 18, 2010	2	0.000025	1
Roberts OF	Hg	2010	June 18, 2010	1	0.000025	1
Roberts OF	Hg	2010	June 18, 2010	2	0.000025	1

***** *1 = yes (censored, i.e. below the detection limit); 0 = not censored.*

The results from the analysis that compared the means before and after Project construction are presented in Table Stream-3. There was evidence of a change in the mean between the before and after periods for CN (intermediate amounts of censoring) in all streams where data were present, Al in Doris OF stream, and Fe in Roberts OF stream.

The results of the BACI comparison of each Project stream against the reference streams (Table Stream-4) failed to find evidence of a differential response in the mean between Project and reference streams over the before and after periods. Unfortunately, CN was not measured in reference streams prior to Project impact, and so a BACI comparison cannot be performed for this parameter.

Table Steam-3. Summary of Test for No Difference in Mean between Before and After Periods for Chemical Parameters Measured on Streams

Parameter	Avg. Prop Censored after Removal of Outliers	Effect														
		Period Stream					Period*Season Stream					Season Stream				
		Doris OF Pr > F	Little Roberts OF Pr > F	Ref. B OF Pr > F	Ref. D OF Pr > F	Roberts OF Pr > F	Doris OF Pr > F	Little Roberts OF Pr > F	Ref. B OF Pr > F	Ref. D OF Pr > F	Roberts OF Pr > F	Doris OF Pr > F	Little Roberts OF Pr > F	Ref. B OF Pr > F	Ref. D OF Pr > F	Roberts OF Pr > F
Al	0.00	**0.006**	0.458	0.316	.	0.254	0.368	0.850	0.545	.	0.309	0.204	**<.001**	0.942	0.880	**<.001**
Alk	0.00	0.333	0.090	0.852	.	0.855	0.155	0.023	0.633	.	0.314	0.009	**<.001**	0.296	0.387	**<.001**
Ammonia	0.41	0.081	0.377	0.239	.	0.955	**<.001**	0.118	0.057	.	0.072	**<.001**	0.056	0.239	0.559	0.201
As	0.02	0.394	0.280	0.338	.	0.092	0.866	0.879	0.582	.	0.745	0.389	0.843	0.494	0.902	0.891
CN	0.40	**<.001**	**<.001**	.	.	**<.001**	**<.001**	0.056	.	.	**<.001**	**<.001**	0.035	0.318	0.206	**<.001**
Cd	0.71	0.700	0.737	.	.	0.739	0.616	0.948	.	.	0.898	0.616	0.948	.	.	0.898
Cu	0.00	0.090	0.131	0.508	.	0.412	0.067	0.120	0.643	.	0.690	0.310	0.466	0.544	0.114	0.570
Fe	0.00	0.030	0.170	0.523	.	**0.003**	0.639	0.866	0.386	.	0.064	0.412	**<.001**	0.662	0.659	**<.001**
Hardness	0.00	0.998	0.862	0.886	.	0.470	0.043	0.069	0.736	.	0.120	**0.006**	**<.001**	0.680	0.473	**<.001**
Hg	0.89	.	0.101	.	.	.	.	0.887	.	.	.	.	0.887	.	.	.
Mo	0.18	0.915	0.687	0.703	.	0.809	0.489	0.207	0.703	.	0.056	0.274	0.251	0.703	0.097	**0.007**
Ni	0.06	0.297	0.323	0.465	.	0.054	0.635	0.519	0.897	.	0.268	0.112	**<.001**	0.520	0.462	**<.001**
Nitrate	0.78	0.385	0.612	0.258	.	0.284	0.583	0.423	0.194	.	0.298	0.583	0.423	0.644	0.699	0.298
Pb	0.17	0.302	0.955	.	.	0.661	0.235	0.511	.	.	0.351	0.168	0.013	.	0.812	**0.003**
Ra	0.85	0.950	0.961	.	.	0.209	0.742	0.961	.	.	0.209	0.280	0.530	0.667	0.184	0.209
TSS	0.42	0.169	0.567	0.703	.	0.087	0.341	0.384	0.703	.	0.649	0.206	0.065	0.703	0.667	0.112
Zn	0.28	0.589	0.339	.	.	0.562	0.813	0.094	.	.	0.694	0.813	0.094	.	.	0.155
pH	0.00	0.317	0.207	0.587	.	0.308	0.840	0.123	0.584	.	0.427	0.451	0.042	0.917	0.573	0.115

To reduce the number of false positives, a smaller alpha level (.01) was used to screen for effects and p-values < .01 are bolded.
Seasonal effects are not of interest.
In some cases, no analysis can be done because of the high degree of censoring, no variation in results within seasons or years, or high levels of censoring.

Table Stream-4. Summary of BACI Comparisons for Individual Project Sites in the Stream Study

	Project Stream								
	Doris OF			Little Roberts OF			Roberts OF		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Al	0.1347	0.1195	0.264	-0.0101	0.0943	0.916	0.0140	0.1542	0.928
Alk	-1.0661	2.1971	0.629	-0.8278	1.9361	0.672	-0.2872	2.0530	0.891
Ammonia	0.0039	0.0082	0.639	-0.0002	0.0073	0.975	-0.0013	0.0065	0.848
As	-0.0001	0.0001	0.542	-0.0001	0.0001	0.295	-0.0002	0.0001	0.075
CN	.	.	.	.	.	.	.	.	.
Cd	0.0000	0.0000	0.334	0.0000	0.0000	0.928	0.0000	0.0000	0.873
Cu	0.0003	0.0004	0.403	0.0002	0.0003	0.506	-0.0001	0.0003	0.752
Fe	0.1618	0.1527	0.294	0.0155	0.1073	0.886	0.1232	0.1289	0.346
Hardness	2.2984	4.6012	0.619	1.3562	4.3081	0.755	1.2482	3.1708	0.697
Hg	.	.	.	0.0000	0.0000	0.634	.	.	.
Mo	0.0000	0.0000	0.892	-0.0000	0.0000	0.988	-0.0000	0.0000	0.559
Ni	0.0002	0.0002	0.426	-0.0000	0.0001	0.836	0.0000	0.0001	0.757
Nitrate	0.0024	0.0031	0.434	0.0028	0.0018	0.133	-0.0018	0.0087	0.842
Pb	0.0000	0.0001	0.523	-0.0000	0.0001	0.546	-0.0000	0.0001	0.856
Ra	.	.	.	.	.	.	.	.	.
TSS	3.9496	3.1976	0.221	-3.6050	2.0385	0.085	1.9481	1.6903	0.265
Zn	-0.0012	0.0021	0.549	-0.0010	0.0013	0.445	-0.0018	0.0018	0.340
pH	0.1386	0.2650	0.603	0.1319	0.1799	0.468	0.2217	0.3746	0.572

Some comparisons were not possible because data were missing or data were all constant over time.

2.2 MARINE DATA

A summary of the amount of censoring (below detection limit) for the site data is found in Table Marine-1. High levels of censoring in all sites were found for the Hg, Nitrate, and Ra parameters and the results of the analyses for these parameters will be non-informative and should be discarded. As noted earlier, many of the 2010 readings were also censored at a higher detection limit than in previous years.

Table Marine-1. Summary of Proportion of Measurements below Detection Limit (before Outliers Removed) for Marine Sampling

	Site		
Parameter	RBE Prop Censored	RBW Prop Censored	REF-MARINE Prop Censored
Al	0.07	0.33	0.00
Alk	0.00	0.00	0.00
Ammonia	0.50	1.00	0.40
As	0.24	0.56	0.60
CN	0.55	0.17	0.00
Cd	0.48	0.56	0.60

(continued)

Table Marine-1. Summary of Proportion of Measurements below Detection Limit (before Outliers Removed) for Marine Sampling (completed)

Parameter	Site		
	RBE Prop Censored	RBW Prop Censored	REF-MARINE Prop Censored
Cu	0.17	0.33	0.40
Fe	0.17	0.44	0.20
Hardness	0.00	0.00	0.00
Hg	0.78	1.00	1.00
Mo	0.11	0.11	0.00
Ni	0.21	0.11	0.40
Nitrate	0.78	0.67	1.00
Pb	0.48	0.78	1.00
Ra	0.86	1.00	1.00
TSS	0.04	0.11	0.00
Zn	0.28	0.67	0.80
pH	0.00	0.00	0.00

Preliminary plots of the data showed some outliers as shown in Table Marine-2 which were removed prior to analysis. Of particular concerns are As readings at the RBE site which were substantially elevated prior to 2007 but then fall to near or below detection limits post 2007. This may indicate a change in sampling methodology or physical processes within this marine site.

Table Marine-2. Summary of Potential Outliers from the Marine Data (Censored Values Were Replaced by Half of the Detection Limit

Site	Parameter	Year	Date	Rep	Reading	Censored*
RBE	Al	2005	July 21, 2005	1	0.989000	0
RBE	Ammonia	2007	July 23, 2007	1	0.214000	0
RBE	As	2004	July 19, 2004	1	0.008020	0
RBE	As	2004	August 14, 2004	1	0.015200	0
RBE	As	2004	August 16, 2004	1	0.013100	0
RBE	As	2004	September 9, 2004	1	0.022300	0
RBE	As	2005	July 21, 2005	1	0.004730	0
RBE	As	2005	August 18, 2005	1	0.022100	0
RBE	As	2005	September 14, 2005	1	0.021200	0
RBE	As	2006	May 31, 2006	1	0.015200	0
RBE	As	2006	July 20, 2006	1	0.013300	0
RBE	As	2006	August 12, 2006	1	0.025600	0
RBE	As	2006	September 11, 2006	1	0.023680	0
RBE	CN	2007	July 23, 2007	1	2.500000	1
RBE	Ni	2006	September 11, 2006	1	0.006500	0
RBE	Ra	2004	August 14, 2004	1	0.020000	0
REF-MARINE	Nitrate	2010	July 13, 2010	1	1.250000	1

The results from the analysis that compared the means before and after Project construction are presented in Table Marine-3. There was evidence of a change in the mean between the before and after periods for Pb in RBE (intermediate amount of censoring).

Table Marine-3. Summary of Test for No Difference in Mean between Before and After Periods for Chemical Parameters Measured on Marine Areas

		Effect								
		Period Site			Period*Season Site			Season Site		
Para meter	Avg Prop Censored After Removal of Outliers	RBE Pr > F	RBW Pr > F	REF-MARINE Pr > F	RBE Pr > F	RBW Pr > F	REF-MARINE Pr > F	RBE Pr > F	RBW Pr > F	REF-MARINE Pr > F
Al	0.14	0.649	0.750	0.362	0.308	0.761	.	0.214	0.747	.
Alk	0.00	0.090	.	.	0.993	.	.	0.034	0.277	.
Ammonia	0.46	0.305	.	0.492	0.653	.	.	0.653	.	.
As	0.51	0.728	0.059	0.037	0.612	0.089	.	0.456	0.130	.
CN	0.23	0.193	.	.	0.116	.	.	0.116	0.030	.
Cd	0.55	0.320	0.166	0.105	0.891	0.307	.	0.878	0.185	.
Cu	0.30	0.617	0.643	0.657	0.867	0.654	.	0.337	0.754	.
Fe	0.27	0.968	0.696	0.478	0.712	0.775	.	0.207	0.750	.
Hardness	0.00	0.392	0.929	.	0.847	.	.	0.172	0.176	.
Hg	0.78	0.258	.	.	0.487	.	.	0.487	.	.
Mo	0.07	0.369	0.137	0.516	0.794	0.040	.	0.110	0.017	.
Ni	0.24	0.812	0.829	0.596	0.787	0.224	.	0.370	0.434	.
Nitrate	0.81	0.702	0.827	0.667	0.726	0.738	.	0.404	0.981	.
Pb	0.75	**0.003**	0.294	0.423	0.394	0.899	.	0.831	0.673	.
Ra	0.92	0.220	.	.	.	.	.	0.420	.	.
TSS	0.05	0.956	0.853	0.088	0.114	0.439	.	0.453	0.628	.
Zn	0.58	0.901	0.127	0.457	0.946	0.671	.	0.450	0.815	.
pH	0.00	0.707	0.018	0.092	0.851	0.087	.	0.826	**0.008**	.

To reduce the number of false positives, a smaller alpha level (.01) was used to screen for effects with statistically significant differences bolded.
Seasonal effects are not of interest.

The results of the BACI comparison (Table Marine-4) failed to find evidence of a differential response in the mean between any marine Project site and the reference site over the before and after periods. As the increased detection limit occurred in all streams in 2010, this common "effect" may have masked any changes.

2.3 SMALL LAKE DATA

A summary of the amount of censoring (below detection limit) for the small lake data is found in Table Small Lake-1. High levels of censoring in all streams were found for Cd, Hg, Nitrate, and Ra parameters and the results of the analyses for these parameters will be non-informative and should be discarded.

Table Marine-4. Summary of BACI Comparisons for Individual Project Sites in the Marine Areas

	Marine Project Site					
	RBE			RBW		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Al	0.1030	0.1439	0.482	0.0903	0.1910	0.661
Alk	.	.	.	.	.	.
Ammonia	0.0029	0.0090	0.749	0.0030	0.0036	0.452
As	-0.0004	0.0002	0.037	-0.0002	0.0002	0.356
CN	.	.	.	.	.	.
Cd	-0.0000	0.0000	0.611	-0.0000	0.0000	0.879
Cu	-0.0004	0.0017	0.841	0.0001	0.0007	0.933
Fe	0.0155	0.2548	0.952	0.0636	0.2220	0.789
Hardness	.	.	.	.	.	.
Hg	.	.	.	.	.	.
Mo	-0.0001	0.0028	0.969	0.0040	0.0017	0.075
Ni	-0.0003	0.0009	0.711	-0.0000	0.0006	0.994
Nitrate	-0.0752	0.1303	0.571	.	.	.
Pb	-0.0000	0.0002	0.969	0.0000	0.0004	1.000
Ra	.	.	.	.	.	.
TSS	-1.1290	9.9793	0.911	0.7167	8.7575	0.939
Zn	0.0005	0.0027	0.865	0.0017	0.0019	0.411
pH	-0.0514	0.3195	0.874	-0.0500	0.0478	0.355

Some comparisons were not possible because data were missing or data were all constant over time.

Table Small Lake-1. Summary of the Proportion Censored (before Outliers are Removed) in Each Small Lake for Each Chemical Parameter

	Lake	
Parameter	Little Roberts Prop Censored	Reference D Prop Censored
Al	0.00	0.00
Alk	0.03	0.00
Ammonia	0.27	0.83
As	0.09	0.00
CN	0.61	0.00
Cd	0.73	1.00
Cu	0.00	0.00
Fe	0.00	0.00
Hardness	0.00	0.00
Hg	0.70	1.00
Mo	0.06	0.00
Ni	0.03	0.00

(continued)

Table Small Lake-1. Summary of the Proportion Censored (before Outliers are Removed) in Each Small Lake for Each Chemical Parameter (completed)

	Lake	
Parameter	Little Roberts Prop Censored	Reference D Prop Censored
Nitrate	0.70	0.67
Pb	0.09	0.00
Ra	0.80	0.83
TSS	0.21	1.00
Zn	0.21	0.83
pH	0.00	0.00

Preliminary plots of the data showed some outliers that were primarily censored data from the early 1990s. The observations listed in Table Small Lake-2 were discarded prior to analysis to ensure that these observations don't artificially inflate the variance estimates leading to a reduced power to detect effects.

Table Small Lake-2. Summary of Potential Outliers from the Small Lake Data (Censored Values Were Replaced by Half of the Detection Limit)

Lake	Parameter	Year	Date	Rep	Reading	Censored*
Little Roberts	Ammonia	2007	May 24, 2007	1	0.240000	0
Little Roberts	Cd	1995	June 7, 1995	1	0.000100	1
Little Roberts	Cd	1996	August 27, 1996	1	0.000025	1
Little Roberts	Cd	1996	August 27, 1996	2	0.000025	1
Little Roberts	Cd	1997	July 15, 1997	1	0.000100	1
Little Roberts	Cd	1997	July 15, 1997	2	0.000100	1
Little Roberts	Fe	2007	May 24, 2007	1	1.700000	0
Little Roberts	Hg	2003	July 27, 2003	1	0.000230	0
Little Roberts	Mo	1997	July 15, 1997	1	0.000500	1
Little Roberts	Mo	1997	July 15, 1997	2	0.000500	1
Little Roberts	Nitrate	2004	September 13, 2004	1	5.300000	0
Little Roberts	Ra	2004	September 13, 2004	1	0.060000	0

***** *1 = yes (censored, i.e. below the detection limit); 0 = not censored*

There was evidence of a change in the mean of the CN parameter between the before and after period in the Project lakes (Table Small Lake-3). In this case, all of the readings prior to Project construction were at or below detection limit and none of the readings post-construction are below the detection limit.

Because only the Project lake was measured before and after construction started, no BACI analysis is possible.

Table Small Lake-3. Summary of Test for No Difference in Mean between Before and After Periods for Chemical Parameters Measured on Small Lakes

Parameter	Avg Prop Censored after Removal of Outliers	Effect					
		Period Lake		Period*Season Lake		Season Lake	
		Little Roberts Pr > F	Reference D Pr > F	Little Roberts Pr > F	Reference D Pr > F	Little Roberts Pr > F	Reference D Pr > F
Al	0.00	0.593	.	0.565	.	0.477	0.657
Alk	0.01	0.882	.	0.903	.	**0.003**	0.029
Ammonia	0.56	0.243	.	0.113	.	**<.001**	0.667
As	0.05	0.471	.	0.146	.	0.034	0.150
CN	0.30	**<.001**	.	**<.001**	.	**<.001**	0.065
Cd	0.74	0.122	.	0.016	.	0.020	.
Cu	0.00	0.055	.	0.412	.	0.590	**<.001**
Fe	0.00	0.614	.	0.535	.	0.008	0.933
Hardness	0.00	0.816	.	0.575	.	**<.001**	0.017
Hg	0.78	0.248	.	0.657	.	0.657	.
Mo	0.00	0.078	.	0.264	.	**<.001**	0.698
Ni	0.02	0.882	.	0.613	.	0.003	0.388
Nitrate	0.71	0.272	.	0.167	.	0.167	.
Pb	0.05	0.823	.	0.177	.	0.537	0.356
Ra	0.86	.	.	.	.	.	.
TSS	0.36	0.165	.	0.072	.	0.398	.
Zn	0.34	0.457	.	0.633	.	0.235	.
pH	0.00	0.012	.	0.234	.	0.287	0.636

To reduce the number of false positives, a smaller alpha level (.01) was used to screen for effects and statistically significant effects are bolded.
Seasonal effects are not of interest

2.4 LARGE LAKE DATA

A summary of the amount of censoring (below detection limit) for the large lake data is found in Table Large Lake-1. High levels of censoring in all streams were found for Cd, Nitrate, and Ra parameters and the results of the analyses for these parameters will be non-informative and should be discarded. High levels of censoring were also found for the reference lake only in Mo, TSS, and Zn. This will make the BACI comparison difficult to interpret.

Preliminary plots of the data showed some potential outliers (Table Large Lake-2) that were excluded from the analysis.

There was evidence of a difference in the means between the before and after periods for As in Doris North (the mean As appears to have decreased in 2010), and CN in Doris North and Doris South (Table Large Lake-3).

Table Large Lake-1. Summary of the Proportion Censored (before Outliers are Removed) in Each Large Lake for Each Chemical Parameter

	Lake		
Parameter	Doris North Prop Censored	Doris South Prop Censored	Reference B Prop Censored
Al	0.00	0.13	0.00
Alk	0.00	0.00	0.00
Ammonia	0.28	0.73	0.23
As	0.08	0.33	0.15
CN	0.66	0.33	0.00
Cd	0.74	0.93	0.77
Cu	0.01	0.00	0.08
Fe	0.05	0.00	0.69
Hardness	0.00	0.00	0.00
Hg	0.59	1.00	0.92
Mo	0.07	0.20	0.85
Ni	0.00	0.00	0.38
Nitrate	0.68	0.60	0.69
Pb	0.17	0.20	0.31
Ra	0.89	1.00	0.75
TSS	0.12	0.33	1.00
Zn	0.21	0.47	0.85
pH	0.00	0.00	0.00

Table Large Lake-2. Summary of Potential Outliers from the Large Lake Data (Censored Values Were Replaced by Half of Detection Limit)

Lake	Parameter	Year	Date	Rep	Reading	Censored*
Doris North	As	1995	August 20, 1995	-	0.003000	0
Doris North	Fe	1995	August 20, 1995	-	0.720000	0
Doris North	Ni	2005	July 19, 2005	1	0.028300	0
Doris North	Pb	2004	June 5, 2004	1	0.006690	0
Doris North	Ra	2004	September 10, 2004	1	0.060000	0
Doris North	TSS	2004	September 10, 2004	1	29.000000	0
Doris South	Al	2009	April 24, 2009	1	0.329000	0
Doris South	Fe	2009	April 24, 2009	1	0.629000	0

** 1 = yes (censored, i.e. below the detection limit); 0 = not censored.*

The BACI comparison (Table Large Lake-4) failed to find evidence of a differential response in the mean between any Project site and the reference site over the before and after periods. Unfortunately, CN was not measured in reference lakes prior to Project impact, and so a BACI comparison cannot be performed for this parameter.

Table Large Lake-3. Summary of Test for No Difference in Mean between Before and After Periods for Chemical Parameters Measured on Large Lakes

Parameter	Avg. Prop Censored after Removal of Outliers	Effect								
		Period Lake			Period*Season Lake			Season Lake		
		Doris North Pr > F	Doris South Pr > F	Reference B Pr > F	Doris North Pr > F	Doris South Pr > F	Reference B Pr > F	Doris North Pr > F	Doris South Pr > F	Reference B Pr > F
Al	0.05	0.643	0.240	0.230	0.490	0.173	0.194	**0.001**	**0.004**	0.098
Alk	0.00	0.520	0.497	0.578	0.523	0.273	0.845	0.042	**0.004**	0.161
Ammonia	0.41	0.127	0.088	0.336	0.395	0.130	0.584	0.620	0.151	0.337
As	0.19	**0.006**	0.625	0.101	0.062	0.135	0.130	0.135	0.108	0.826
CN	0.33	**0.009**	**0.001**	.	0.890	.	.	0.577	0.124	0.318
Cd	0.84	0.519	0.802	.	0.590	0.732	.	0.590	0.534	.
Cu	0.03	0.922	0.458	0.186	0.875	0.811	0.581	0.095	<.001	0.142
Fe	0.03	0.996	0.189	.	0.261	0.430	.	0.012	0.013	.
Hardness	0.00	0.221	0.518	0.895	0.981	0.174	0.491	**<.001**	**0.008**	**0.008**
Hg	0.59	0.396	.	.	0.993	.	.	0.993	.	.
Mo	0.37	0.086	0.385	0.782	0.100	0.142	0.782	0.657	0.139	0.782
Ni	0.13	0.917	0.556	0.527	0.239	0.362	0.798	0.393	0.754	0.486
Nitrate	0.64	0.660	0.091	.	0.506	**0.002**	.	**<.001**	**0.002**	.
Pb	0.23	0.399	0.656	0.800	0.440	0.976	0.722	0.683	0.749	0.756
Ra	0.84	0.753	.	.	0.753	.	.	0.501	.	0.150
TSS	0.23	0.644	0.533	.	0.542	0.419	.	**0.008**	0.014	.
Zn	0.34	0.548	0.354	.	0.466	0.376	.	0.466	0.381	.
pH	0.00	0.242	0.579	0.389	0.877	0.460	0.959	0.734	0.296	0.550

To reduce the number of false positives, a smaller alpha level (.01) was used to screen for effects and statistically significant effects are bolded.
Seasonal effects are not of interest.

Table Large Lake-4. Summary of BACI Comparisons for Individual Project Sites in the Large Lake Areas

Parameter	Large Project Lake					
	Doris North			Doris South		
	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Al	0.0026	0.0186	0.890	0.0481	0.0162	0.021
Alk	0.3364	3.6799	0.928	-0.0349	2.0004	0.987
Ammonia	-0.0132	0.0062	0.043	-0.0239	0.0118	0.077
As	-0.0003	0.0001	0.017	-0.0001	0.0000	0.193
CN	.	.	.	.	.	.
Cd	0.0000	0.0000	0.950	0.0000	0.0001	0.535
Cu	-0.0003	0.0006	0.679	-0.0001	0.0003	0.687
Fe	0.0275	0.0467	0.561	0.0665	0.0277	0.047

(continued)

Table Large Lake-4. Summary of BACI Comparisons for Individual Project Sites in the Large Lake Areas (completed)

	Large Project Lake					
	Doris North			Doris South		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Hardness	2.6225	3.1301	0.411	3.7481	2.1379	0.123
Hg	0.0000	0.0000	0.039	0.0000	0.0000	0.089
Mo	0.0000	0.0000	0.273	0.0000	0.0000	0.789
Ni	-0.0001	0.0001	0.494	-0.0002	0.0002	0.386
Nitrate	-0.0047	0.0201	0.816	-0.0237	0.0092	0.033
Pb	-0.0005	0.0003	0.145	-0.0007	0.0005	0.208
Ra	.	.	.	.	.	.
TSS	0.2650	1.5617	0.866	2.0250	1.4145	0.190
Zn	-0.0044	0.0193	0.823	-0.0512	0.0550	0.378
pH	-0.0347	0.4991	0.945	-0.2826	0.2902	0.362

Some comparisons were not possible because data were missing or data were all constant over time.

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Appendix C2-2

Statistical Methodology and Results for Sediment Quality Evaluation of Effects, Doris North Project, 2010

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APPENDIX C2-2
STATISTICAL METHODOLOGY AND RESULTS FOR SEDIMENT QUALITY EVALUATION OF EFFECTS, DORIS NORTH PROJECT, 2010

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1. Analysis Methods

1.1 ASSUMPTIONS

There are several assumptions made for the analyses in this report. The key assumption is that the samples taken are a random sample of the body's sediment for that monitoring period. There is no way to assess this assumption other than by a careful consideration of the landscape and sampling protocol. In particular, one need to consider both spatial and temporal separation of the samples. For example, sediment samples taken 1 m apart from the bottom of the body are less likely to be independent that samples taken several km apart.

For the marine environment, the sampling years before construction are quite different (2002 and 2009) for the two sites. Consequently, care must be taken in the interpretation of any comparisons between sites as the results may be artifacts of the specific years chosen.

1.2 DEALING WITH CENSORING (VALUES BELOW DETECTION LIMITS)

The proportion of data with readings below the detection limit varied by habitat (i.e., stream, lake, or marine site) and by chemical parameter. The analyses below follow the advice of McBride (2005, Section 11.4.3).

- When the dataset had a small number of below detection values, these values were replaced by the detection limit or by ½ of the detection limit and conducted the analyses under both substitutions. In this report, only the results from using ½ of detection limit are presented as the substitution value for censored readings analyses using the full detection limit did not differ in any great way.
- When the data set had mostly values below the detection limit (e.g., more than about 70% below detection limit), there is very little that can be done as there is essentially no information (other than the values are below the detection limit). The analyses were performed as above, but interpreting the results should be done carefully. Helsel (2005) has other suggestions for analysis (e.g. comparing the proportions below the detection limits), but these tests will require much larger sample sizes than available here.
- When there are intermediate amount of censoring, a more complex analysis can be conducted that fully integrates the information from the censored values with the known values. This is most easily done using Bayesian methods using MCMC methods as likelihood methods would require integration of the likelihood for each censored value over and above dealing with the other random effects in the model. There is currently, no readily available software available for the latter. Fortunately, most chemical parameters fall into one of the two previous categories.

1.3 TRANSFORMATIONS

For most parameters, the values were fairly homogeneous and no obvious transformation was suggested, i.e., metals analyzed on the ppm scale (mg/kg).

1.4 COMPOSITIONAL DATA

The measurements on the constituents of the sediment (sand, gravel, etc.) are compositional with the values necessarily adding to 100%. Each component has been analyzed separately, but it is impossible to have changes in the percent composition of one component without changes in other components.

Alternative methods dealing with compositional data (Aitchison 1986) are available, but have not been used in this report because they cannot easily deal with censoring and because the number of samples is limited.

1.5 OUTLINE OF ANALYSIS PLAN

There are several classes of statistical tests that can be done to assess evidence of change in the mean of the chemical parameter over time and to assess if changes in the means may reflect an impact of the Project.

1.5.1 Before vs. After Analysis for Each Body

The first analysis conducted compares the mean readings before and after Project initiation, i.e. the mean for 2010 (after initiation of construction) is compared to the mean reading in 2009 (or 2002 for one site in the marine environment) before initiation of construction. Each body of water is treated independently and each chemical parameter is treated separately.

The final statistical model (in standard shorthand notation) is:

$$SQ = Period$$

where *SQ* is the reading for a chemical parameter in a year; *Period* is the effect of before vs. after Project initiation. This model is equivalent to a two-sample t-test comparing measurements before and after Project construction.

This model is fit using Proc Mixed in SAS 9.2. In order to reduce the number of "false positives" because a large number of statistical tests are done, a reduced significance level (e.g., 0.01) should be used when reviewing the results. Estimates of the differences in means between the two periods are not presented in this report, but are available if needed.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, i.e., the sediment readings in 2010 could be worse than expected because of long term climate change that is unrelated to the Project. Consequently, if a statistically significant effect is detected, it will require further investigation.

1.5.2 BACI Analysis

The standard method to assess an environmental impact is through a Before-After-Control-Impact (BACI) analysis (Smith 2002). The analysis of these designs looks for non-parallelism in response over time between the Project and reference streams.

For the lake environments, two Project sites were measured and only one year was measured before (2009) and after Project initiation (2010). No before information was measured at the reference sites. Consequently, only a before-after analysis as above could be run.

For the marine environment, only one site has been measured in each of the Project and reference classes and only one year has been measured before and after Project initiation. The formal statistical model (in standard shorthand notation) is:

$$SQ = Period\ Class\ Period*Class$$

where *SQ* is the sediment reading; *Period* is the effect of period (before or after construction); *Class* is the effect of waterbody classification (Project or reference); and *Period*Class* is the BACI effect of interest, i.e., is the effect of *Period* the same (parallel) for both classes of waterbody.

For the stream environments, two Project and one reference site were measured, but all sites were measured only in 2009 and 2010. The formal statistical model (in standard shorthand notation) for each stream-reference comparison is the same as for the marine sites.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (After-Before) over the two classes of waterbodies (Project or reference).

The BACI estimate is computed as the "difference in the differences", i.e.,

$$BACI = \left(\mu_{PA} - \mu_{PB}\right) - \left(\mu_{RA} - \mu_{RB}\right)$$

where $\mu_{PB}$is the mean sediment quality reading in the *Project* class of bodies *after* Project construction with a similar definition for the other population means. The BACI contrast is estimated by replacing the population means above by the model-based estimates. Estimated differences close to 0 would indicate no evidence of non-parallelism.

Note that the hypothesis that the BACI contrast has the value of zero is identical to the hypothesis that the Period*Class interaction is zero with identical p-values. Consequently, only the results for the BACI contrast are reported in the tables.

This model was fit using Proc Mixed in SAS 9.2.

It is possible to do a BACI analysis using a single reference vs. a single Project stream. In this case, the results are specific to those particular streams. In the event of a detected impact, one could argue that you just happened to pick two streams where the BACI effect occurred for some peculiar reason for these streams (e.g., special geomorphology). The results of the BACI analysis for each individual stream are also presented in the results below.

1.5.3 Multivariate Approaches

All of the approaches above analyze each chemical parameter independently of each other. However, the chemical constituents do not occur independently of each other, and presumably higher power would result if a multivariate approach were used. However, because of the censoring and missing data, no simple multivariate approach is possible and such an analysis would likely require the use of full Bayesian MCMC method to attack the problem. This has not been attempted in this report.

2. Results

2.1 STREAM DATA

A summary of the amount of censoring (below detection limit) for the stream data is found in Table Stream-1. High levels of censoring in all streams were found for the Cd parameter and the results of the analyses for this parameters will be non-informative. Preliminary plots of the data (not shown) failed to show any outliers.

Table Stream-1. Proportion of Observations that Were Censored in Each Site

Parameter	Site			All Sites
	Doris OF Prop. Censored	Little Roberts OF Prop. Censored	Ref. B OF Prop. Censored	Prop. Censored
% Clay (<4um)	0.33	0.00	0.17	0.17
% Gravel (>2mm)	0.00	0.83	0.00	0.28
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00	0.00
% Silt (0.063mm - 4um)	0.17	0.00	0.00	0.06
Arsenic (As)	0.00	0.00	0.00	0.00
Cadmium (Cd)	1.00	1.00	1.00	1.00
Chromium (Cr)	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00
Lead (Pb)	0.50	0.00	0.67	0.39
Mercury (Hg)	0.50	0.00	0.83	0.44
Total Organic Carbon	0.17	0.00	0.33	0.17
Zinc (Zn)	0.00	0.00	0.00	0.00

The results from the analysis that compared the means before and after Project construction are presented in Table Stream-2. There was evidence of a differential response in the mean composition of gravel in the Little Roberts OF.

Table Steam-2. Summary of Test for no Difference in Mean between Before and After Periods for Chemical Parameters Measured on Streams

Parameter	Prop. Censored	Doris OF Pr > F	Little Roberts OF Pr > F	Ref. B OF Pr > F
% Clay (<4um)	0.17	0.944	0.072	0.343
% Gravel (>2mm)	0.28	0.014	0.021	0.418
% Sand (2.0mm - 0.063mm)	**0.00**	0.022	0.289	0.054
% Silt (0.063mm - 4um)	0.06	0.163	0.598	0.264
Arsenic (As)	**0.00**	0.495	0.492	0.791
Cadmium (Cd)	1.00	1.000	1.000	1.000
Chromium (Cr)	**0.00**	0.400	0.386	0.922
Copper (Cu)	**0.00**	0.969	0.036	0.453

(continued)

Table Steam-2. Summary of Test for no Difference in Mean between Before and After Periods for Chemical Parameters Measured on Streams (completed)

Parameter	Prop. Censored	Doris OF Pr > F	Little Roberts OF Pr > F	Ref. B OF Pr > F
Lead (Pb)	0.39	0.803	0.534	0.586
Mercury (Hg)	0.44	0.432	0.280	0.374
Total Organic Carbon	**0.00**	0.195	0.195	0.893
Zinc (Zn)	0.17	0.262	0.955	0.017

To reduce the number of false positives, a smaller alpha level (.01) was used to screen for effects and p-values < .01 are bolded.

The results of the BACI comparison (Table Stream-3, Table-Stream-4) failed to find evidence of a differential response in the mean between reference and control streams over the before and after periods.

2.2 MARINE DATA

A summary of the amount of censoring (below detection limit) for the site data is found in Table Marine-1. High levels of censoring in all sites were found for the Cd, Hg, and % Gravel parameters and the results of the analyses for these parameters will be non-informative. Preliminary plots of the data (not shown) showed no outliers except for one very high reading of % Gravel in 2002 in RBW (this reading was retained as the analysis is moot in any case because of censoring). The results from the analysis that compared the means before and after Project construction are presented in Table Marine-2. There was evidence of a differential response across the periods for many parameters.

The results of the BACI comparison (Table Marine-3) found evidence of a differential change in the means between before and the after periods and reference and control for the composition of the sediments and the TOC parameters; however, TOC increased to a greater extent at REF-MARINE than at RBW. Note that RBW was measured in 2002 and 2010 and REF-MARINE was measured in 2009 and 2010 so the BACI comparison must be interpreted carefully as different pre-construction years are used.

2.3 LAKE DATA

A summary of the amount of censoring (below detection limit) for the lake data is found in Table Lake-1. High levels of censoring were found for the % Gravel parameter and the results of the analyses for this parameter will be non-informative. Preliminary plots of the data showed some outliers in the %Gravel parameter, but the high level of censoring makes it moot. There was evidence of a change in the mean of the %Clay and %Silt parameter in both lakes, and the Pb parameter in the Doris Lake North between the before and after period (Table Lake-2).

Table Stream-3. Summary of BACI Comparison for Sediment Parameters in Streams

Parameter	Prop. Censored	Proj. After Est.	SE	Proj. Bef. Est.	SE	Ref. After Est.	SE	Ref. Bef. Est.	SE	BACI Est.	SE	p-value
% Clay (<4um)	0.17	7.2067	4.5564	8.6667	4.5564	0.6100	6.4437	2.5000	6.4437	-0.4300	2.6173	0.872
% Gravel (>2mm)	0.28	10.7500	22.9765	34.8333	22.9765	21.4000	32.4936	35.3333	32.4936	10.1500	17.2034	0.565
% Sand (2.0mm - 0.063mm)	0.00	60.8667	6.1225	37.0000	6.1225	76.1000	8.6585	49.3333	8.6585	2.9000	13.5223	0.834
% Silt (0.063mm - 4um)	0.06	21.1883	13.3929	19.9167	13.3929	1.8633	18.9404	13.0000	18.9404	-12.408	8.2229	0.155
Arsenic (As)	0.00	2.7437	0.9142	1.7200	0.9142	0.8670	1.2928	0.7387	1.2928	-0.8953	2.2392	0.695
Cadmium (Cd)	1.00	.	.	.	.	.	.	.	.	.	.	.
Chromium (Cr)	0.00	24.6667	4.3461	30.3667	4.3461	19.7000	6.1463	20.8333	6.1463	4.5667	9.5911	0.642
Copper (Cu)	0.00	13.0167	2.4007	15.5000	2.4007	7.0333	3.3952	10.9667	3.3952	-1.4500	5.8806	0.809
Lead (Pb)	0.39	3.1333	1.0004	3.5667	1.0004	2.5333	1.4148	1.5667	1.4148	1.4000	1.7309	0.433
Mercury (Hg)	0.44	0.0084	0.0034	0.0087	0.0034	0.0074	0.0048	0.0025	0.0048	0.0051	0.0048	0.301
Total Organic Carbon	0.00	13.3667	1.7555	17.7667	1.7555	11.7667	2.4826	12.4667	2.4826	3.7000	4.3000	0.404
Zinc (Zn)	0.17	1.4400	0.6594	1.1100	0.6594	0.0800	0.9326	0.3967	0.9326	-0.6467	0.4752	0.197

The mean and SE for each period (before and after) and class (Project and reference) are reported along with the estimated BACI contrast.

Table Stream-4. Summary of BACI Comparisons for Individual Project Sites in the Stream Study

	Body					
	Doris OF			Little Roberts OF		
Parameter	BACI Est	BACI SE	p-value	BACI Est	BACI SE	p-value
% Clay (<4um)	-2.1100	3.4305	0.556	1.2500	2.1815	0.582
% Gravel (>2mm)	33.6167	19.1278	0.117	-13.317	15.4433	0.414
% Sand (2.0mm - 0.063mm)	-13.667	14.9420	0.387	19.4667	11.5662	0.131
% Silt (0.063mm - 4um)	-17.547	9.3583	0.098	-7.2700	10.9191	0.524
Arsenic (As)	-2.2690	3.2252	0.502	0.4783	0.6481	0.482
Cadmium (Cd)	0.0000	.	.	0.0000	.	.
Chromium (Cr)	6.4667	13.4998	0.645	2.6667	11.4964	0.822
Copper (Cu)	-3.6333	8.6638	0.686	0.7333	4.9666	0.886
Lead (Pb)	1.4667	2.4895	0.572	1.3333	1.7214	0.461
Mercury (Hg)	0.0019	0.0060	0.764	0.0084	0.0056	0.175
Total Organic Carbon	5.1000	6.1341	0.430	2.3000	5.2389	0.672
Zinc (Zn)	-0.9500	0.4919	0.090	-0.3433	0.4559	0.473

Some comparisons were not possible because data were all constant over all replicates.

Table Marine-1. Proportion of Observations that Were Censored in Each Site

	Site		
	RBW Prop. Censored	REF-MARINE Prop. Censored	All Sites Prop. censored
Parameter			
% Clay (<4um)	0.00	0.00	0.00
% Gravel (>2mm)	0.88	0.67	0.79
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00
% Silt (0.063mm - 4um)	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00
Cadmium (Cd)	1.00	1.00	1.00
Chromium (Cr)	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00
Lead (Pb)	0.00	0.50	0.21
Mercury (Hg)	0.88	1.00	0.93
Total Organic Carbon	0.63	0.00	0.36
Zinc (Zn)	0.00	0.00	0.00

Table Marine-2. Summary of Test for No Difference in Mean between Before and After Periods for Chemical Parameters Measured on Marine Areas

		Effect Period	
Parameter	Prop. Censored	RBW Pr > F	REF-MARINE Pr > F
% Clay (<4um)	0.00	**<.001**	0.415
% Gravel (>2mm)	0.77	0.482	0.065
% Sand (2.0mm - 0.063mm)	0.00	**<.001**	**0.001**
% Silt (0.063mm - 4um)	0.00	0.204	**<.001**
Arsenic (As)	0.00	**0.002**	**<.001**
Cadmium (Cd)	1.00	**<.001**	1.000
Chromium (Cr)	0.00	**0.001**	**0.002**
Copper (Cu)	0.00	**<.001**	**0.010**
Lead (Pb)	0.25	0.851	**<.001**
Mercury (Hg)	0.94	0.039	.
Total Organic Carbon	0.08	0.959	0.024
Zinc (Zn)	0.31	**<.001**	**0.005**

To reduce the number of false positives, a smaller alpha level (.01) was used to screen for effects with statistically significant differences bolded.
Note that RBW was measured in 2002 and 2010; REF-MARINE was measured in 2009 and 2010.

Table Marine-3. Summary of BACI Comparison for Marine Areas

Parameter	Prop. Censored	Proj. After Est.	SE	Proj. Bef. Est.	SE	Ref. After Est.	SE	Ref. Bef. Est.	SE	BACI Est.	SE	p-value
% Clay (<4um)	0.00	4.4267	0.5771	19.7400	0.4470	3.6900	0.5771	3.3333	0.5771	15.6700	1.0950	<.001
% Gravel (>2mm)	0.79	0.0500	0.4460	0.5400	0.3455	0.0500	0.4460	1.1667	0.4460	-0.6267	0.8463	0.476
% Sand (2.0mm - 0.063mm)	0.00	69.7333	1.6420	52.2800	1.2719	57.4667	1.6420	82.0000	1.6420	-41.987	3.1154	<.001
% Silt (0.063mm - 4um)	0.00	25.8333	1.3474	27.4800	1.0437	38.8667	1.3474	14.0000	1.3474	26.5133	2.5564	<.001
Arsenic (As)	0.00	2.8700	0.1190	1.9000	0.0922	2.2133	0.1190	0.6033	0.1190	0.6400	0.2258	0.018
Cadmium (Cd)	1.00	0.0500	0.0000	0.1000	0.0000	0.0500	0.0000	0.0500	0.0000	0.0500	0.0000	<.001
Chromium (Cr)	0.00	23.1333	0.6975	18.2000	0.5402	16.2667	0.6975	9.4000	0.6975	1.9333	1.3233	0.175
Copper (Cu)	0.00	13.2667	0.4030	8.4000	0.3122	8.0667	0.4030	4.9000	0.4030	-1.7000	0.7647	0.050
Lead (Pb)	0.21	2.6667	0.2134	2.6000	0.1653	2.4000	0.2134	1.0000	0.2134	1.3333	0.4050	0.008
Mercury (Hg)	0.93	0.0025	0.0008	0.0060	0.0006	0.0025	0.0008	0.0025	0.0008	0.0035	0.0015	0.047
Total Organic Carbon	0.07	11.5667	0.6213	11.6000	0.4812	8.3333	0.6213	4.4333	0.6213	3.9333	1.1788	0.008
Zinc (Zn)	0.36	0.4233	0.0336	0.2500	0.0261	0.5567	0.0336	0.2000	0.0336	0.1833	0.0638	0.017

The mean and SE for each period (before and after) and class (Project and reference) are report along with the estimated BACI contrast.

Table Lake-1. Proportion of Observations That Were Censored in Each Site

Parameter	Site		All Sites
	Doris North Prop. Censored	Little Roberts Prop. Censored	Prop Censored
% Clay (<4um)	0.00	0.00	0.00
% Gravel (>2mm)	0.83	1.00	0.92
% Sand (2.0mm - 0.063mm)	0.17	0.00	0.08
% Silt (0.063mm - 4um)	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00
Cadmium (Cd)	0.00	0.00	0.00
Chromium (Cr)	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00
Lead (Pb)	0.00	0.00	0.00
Mercury (Hg)	0.00	0.00	0.00
Total Organic Carbon	0.00	0.00	0.00
Zinc (Zn)	0.00	0.00	0.00

Table Lake-2. Summary of Test for No Difference in Mean between Before and After Periods for Chemical Parameters Measured on Lakes

Parameter	Prop. Censored	Doris North Pr > F	Little Roberts Pr > F
% Clay (<4um)	0.00	**<.001**	**0.001**
% Gravel (>2mm)	0.92	0.238	**<.001**
% Sand (2.0mm - 0.063mm)	0.08	0.754	0.788
% Silt (0.063mm - 4um)	0.00	**<.001**	**<.001**
Arsenic (As)	0.00	0.705	0.356
Cadmium (Cd)	0.00	0.011	0.023
Chromium (Cr)	0.00	0.124	0.580
Copper (Cu)	0.00	0.104	0.123
Lead (Pb)	0.00	**0.009**	0.164
Mercury (Hg)	0.00	0.330	0.028
Total Organic Carbon	0.00	0.057	0.591
Zinc (Zn)	0.00	0.027	0.059

To reduce the number of false positives, a smaller alpha level (.01) was used to screen for effects and statistically significant effects are bolded.

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