Hope Bay Mining Limited

DORIS NORTH GOLD MINE PROJECT
2012 Aquatic Effects Monitoring Program Report

NEWMONT
NORTH AMERICA

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2012 AQUATIC EFFECTS MONITORING PROGRAM REPORT

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Executive Summary

Engineers and Scientists

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. As of January 2012, HBML announced that it will be transitioning the Project into care and maintenance.

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* (Rescan 2010c), was submitted to the Nunavut Water Board (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 third year of the AEMP. As outlined in the Plan, three stream sites, three lake sites, and two marine exposure sites were monitored along with two reference stream sites, two reference lake sites, and one marine reference site. Roberts Lake was not part of the approved AEMP program, but was also sampled in 2012 to characterize any influence from North Arrow Minerals Inc. exploration camp.

Aquatic components evaluated in 2012 included: lake and marine under-ice dissolved oxygen levels; lake Secchi depth; stream, lake, and marine water and sediment quality; stream periphyton biomass; lake and marine phytoplankton biomass; and stream, lake, and marine benthic invertebrate community descriptors (total density, taxa richness, evenness, diversity, and the Bray-Curtis Index). Lake and marine fish communities were surveyed in 2010 (Rescan 2011) and were not scheduled to be resurveyed in 2012.

<u>Streams</u>

There were no apparent Project-related effects in 2012 on water or sediment quality parameters, periphyton biomass levels, or benthic invertebrate communities in the AEMP streams.

There was evidence of an increase in alkalinity, hardness, and concentrations of total molybdenum in Doris Outflow and total arsenic in Roberts Outflow in 2012 compared to baseline concentrations. However, the Before-After/Control-Impact (BACI) analysis indicated that parallel increases from baseline means also occurred at the reference streams. Thus, there was no evidence that these increases were due to Project activities. There was evidence of increases in the 2012 concentrations of radium-226 (Roberts Outflow) and nitrate (Roberts and Little Roberts Outflow). However, these results should be interpreted carefully because a high proportion of the data were below analytical detection limits. Furthermore, there were corresponding increases in the reference outflows, therefore the observed increases in the exposure streams were due to natural variability and not related to Project activities.

There were no apparent effect of 2012 Project activities on sediment quality, periphyton biomass, or benthos invertebrate communities.

Lakes

There were no apparent Project-related effects on under-ice dissolved oxygen concentrations, Secchi depths, water or sediment quality parameters, phytoplankton biomass levels, or benthic invertebrate communities in the AEMP lakes.

There was evidence of an increase in Doris Lake North total aluminum and molybdenum concentrations in water in 2012 compared to baseline concentrations. However, in these instances, the BACI analysis indicated that parallel increases from baseline means also occurred at the reference lake. Thus, there was no evidence that these increases were due to Project activities. There was also evidence of a slight increase in pH and total molybdenum concentrations in Little Roberts Lake in 2012 compared to baseline concentrations. No BACI was possible because of a lack of data from the small reference lake (Reference Lake D). However, the change in pH levels and molybdenum concentrations were likely due natural variability as similar changes were also observed in other lakes. Therefore, there was no apparent effect of 2012 Project activities on either pH levels or total molybdenum concentrations in Little Roberts Lake.

Total arsenic concentrations in the sediments from Little Roberts Lake increased in 2012 compared to baseline concentrations. No BACI was possible due a lack to reference data. However, there was a generally increasing trend in the concentration of total arsenic in the sediments collected from the small reference lake. Therefore, there was no evidence that 2012 Project activities increased total arsenic concentrations.

There were differences in 2010 to 2012 trends for some benthic community descriptors between exposure and reference lakes. However, these differences in trends were unlikely Project-related, and probably reflected natural annual variability or patchiness in the composition and distribution of the benthos community within lakes.

Marine

There were no apparent Project-related effects on winter dissolved oxygen levels, water and sediment quality parameters, phytoplankton biomass levels, or benthic invertebrate communities at the AEMP marine sites.

All dissolved oxygen concentrations and water quality parameters measured at the marine exposure sites during 2012 remained similar to baseline conditions, indicating that 2012 Project activities had no effect on the water chemistry in the surrounding marine habitat.

The concentrations of several metals were higher in RBW sediments in 2012 than in 2002. These increases were likely related to the higher silt content collected in the 2012 sediment samples compared to 2002, since silt has a high affinity for metals. Increased metal concentrations were also observed in the sediments from the reference site. This suggests that the increase in metal concentrations that occurred in sediments from RBW in 2012 was unrelated to 2012 Project activities. All measured sediment quality parameters in marine exposure sites were below CCME ISQGs and PELs, except total copper concentrations at RBW which were above the ISQG, but well below the PEL.

Similar to lake benthos communities, there were differences in 2010 to 2012 trends for some benthic community descriptors between marine exposure and reference sites. However, these differences in trends were unlikely Project-related, and probably reflected natural annual variability or patchiness in the composition and distribution of the benthos community within marine sites.

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. 2012 results indicated that these mitigation measures were successful in preventing adverse effects to dissolved oxygen levels, Secchi depths, water and sediment quality parameters, periphyton and phytoplankton biomass levels, and benthic invertebrate communities in Project area waterbodies.

Acknowledgements

Engineers and Scientists

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The 2012 aquatic fieldwork was conducted by Rescan scientists Soleil Switzer (M.Sc., R.P.Bio.), Annette Muttray (Ph.D., M.A.Sc., R.P.Bio.), and Mark Welsh (M.Sc.). Fieldwork was completed with the enthusiastic and competent assistance of Amos Kamookak and Mark Ullikataq (field assistants of Hope Bay Mining Limited (HBML)) and Tony Hoare (Rescan contractor).

Extensive support was provided by the HBML Environment and Social Responsibility (ESR) Department, the Health, Safety and Loss Prevention (HSLP) Department, and camp management, as well as Great Slave Helicopters, Braden Burry Expediting, and Nuna Logistics.

This report was prepared for HBML by Rescan Environmental Services Limited (Rescan) and was written by Jessica Clasen (Ph.D.) and Mike Henry (Ph.D.) and reviewed by Mike Henry and Clem Pelletier (B.Sc.). The Project was managed by Deborah Muggli (Ph.D., M.Sc., R.P.Bio.).

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DORIS NORTH GOLD MINE PROJECT

2012 AQUATIC EFFECTS MONITORING PROGRAM REPORT

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Glossary and Abbreviations

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**
AEMP	Aquatic Effects Monitoring Program
ALS	ALS Laboratory Group
ANOVA	Analysis of Variance
BA	Before-after
BACI	Before-after-control-impact
BC	Bray-Curtis Dissimilarity Index (also known as Bray-Curtis Similarity Index) or British Columbia
Benthos	Benthic invertebrates
CCME	Canadian Council of Ministers of the Environment
Censored value	A value that is only partially known, e.g., a parameter concentration that is reported as being below a specified detection limit, although the actual concentration is not known.
Chl *a*	Chlorophyll *a*
Chlorophyll *a*	An essential light-harvesting pigment for photosynthetic organisms including phytoplankton. Because of the difficulty involved in the direct measurement of plant carbon, chlorophyll *a* is routinely used as a 'proxy' estimate for plant biomass in aquatic studies.
CTD	Conductivity, temperature, depth probe
D	Simpson's Diversity Index
DO	Dissolved oxygen
D_s	Secchi depth
E	Simpson's Evenness Index
EEM	Environmental Effects Monitoring
Epontic	Occurring in or on the bottom of the ice layer.
ESR	Environment and Social Responsibility Department
Exposure areas	Areas anticipated to be potentially influenced by mining-related activities as part of the Doris North Project.
F	Family richness
GA	Graphical analysis
HBML	Hope Bay Mining Limited

Abbreviation/Acronym	Definition
HSLP	Health, Safety and Loss Prevention Department
ILBT	Impact level-by-time
ISQG	Interim sediment quality guideline
k	Light extinction coefficient
MMER	Metal Mining Effluent Regulations
NA	Not applicable
NC	Not collected
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
OF	Outflow
PEL	Probable effects level
QA/QC	Quality assurance/quality control
RBE	Roberts Bay East
RBW	Roberts Bay West
RDL	Realized detection limit
Reference areas	Areas located beyond any Project influence.
Rescan	Rescan Environmental Services Limited
Salinity	No units, dimensionless. Historically, many units have been assigned to salinity, for example, parts per thousand (ppt or ‰), Practical Salinity Units (PSU), and Practical Salinity Scale (PSS 78). Salinity is defined on the Practical Salinity Scale (PSS) as the conductivity ratio of a sea water sample to a standard KCl solution. As PSS is a ratio, it has no units.
SD	Standard deviation
SE	Standard error of the mean
TIA	Tailings Impoundment Area
TOC	Total organic carbon
TSS	Total suspended solids
$Z_{1\%}$	The 1% euphotic depth, i.e., the depth of the water column at which 1% of the surface irradiance reaches.

1. Introduction

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The Doris North Gold Mine Project (the Project) is 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. As of January 2012, HBML announced that it will be transitioning the Project into care and maintenance.

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This report presents the results from the third year of the AEMP. 2012 is considered the third year of construction of the Doris North Project.

1.1 2012 CONSTRUCTION ACTIVITIES

Construction work in the area continued into 2012. Figure 1.1-1 presents the existing infrastructure for the Doris North Project.

The main Project activities in 2012 that could have affected the Doris North aquatic environment include the following:

- Continued construction on the Doris-Windy Road;
- Completion of the North Dam and instrumentation;
- Installation of ground temperature cables at the Windy Road bridges;
- Installation of two Doris Camp power generators (one commissioned);

Figure 1-1

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Regional Location of the Doris North Project

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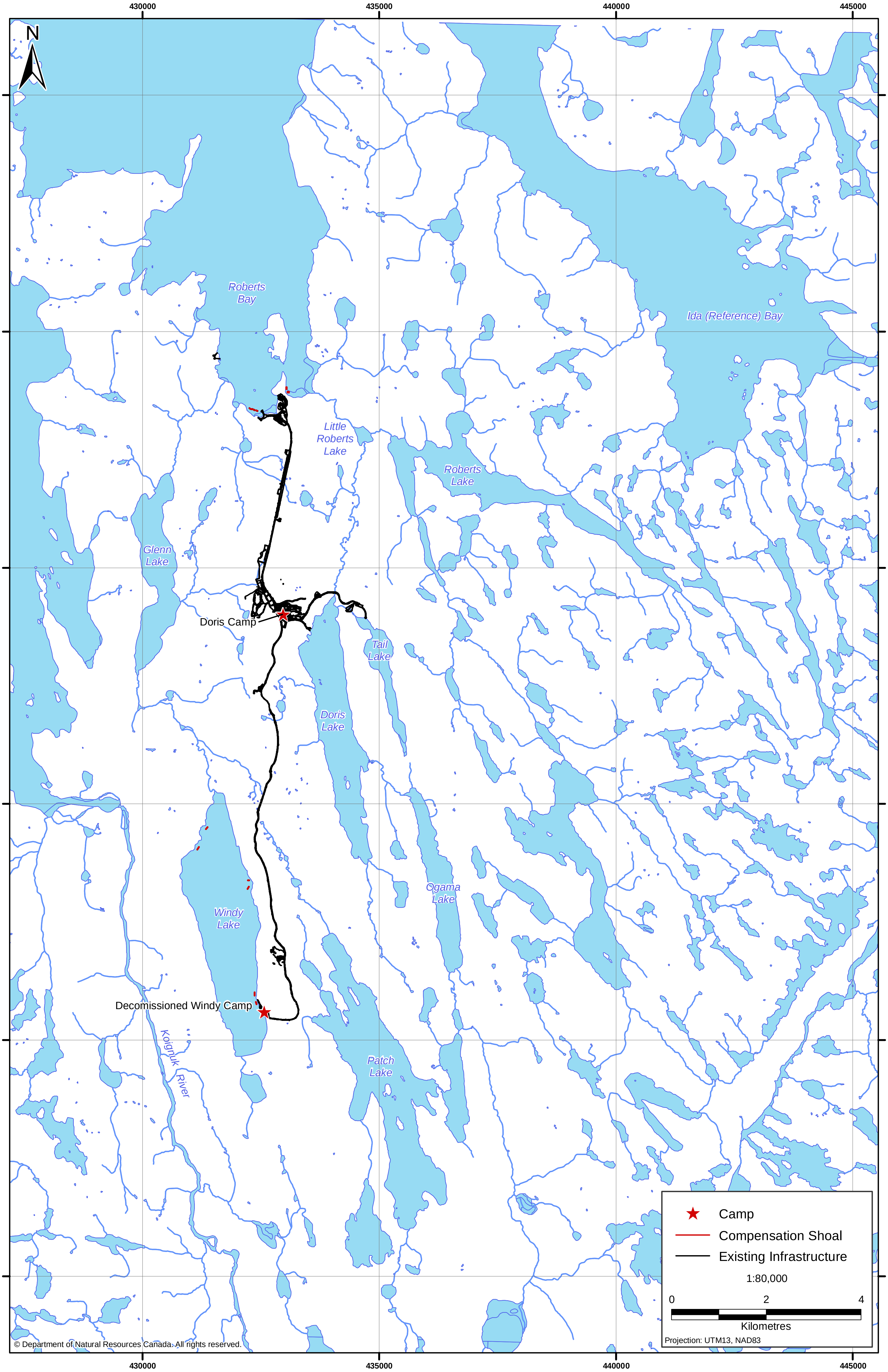

Figure 1.1-1

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Existing Infrastructure, Doris North Project

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- Doris North water diversion berm;
- Ground temperature cables along perimeter of pollution control pond;
- Construction of Sumps 1 and 2;
- Completion of Doris vent raise;
- Highwall remediation at Roberts Bay bulk fuel tank farm;
- Operation of a winter ice strip on Doris Lake; and
- Disposal, by detonation, of explosives in Quarry B (second quarry along the Windy Road towards Windy camp).

Infrastructure that already existed in 2012 included the following: the Roberts Bay jetty, the accommodation barges in Roberts Bay, the 5,000,000 L tank and berm at Roberts bay, the 20,000,000 L tank farm at Roberts Bay, the Roberts Bay pad, the road and associated airstrip between Roberts Bay and Doris Camp, the access road to the Doris Lake pump house, the 2,500,000 L tank farm at Doris Camp, Doris Camp Pads X and Y (including the camp, generator, and sewage and water treatment system), Doris Camp Pads B, C, E/P, F, G, H/J, I, Q, the helipad, and the lower reagent pad.

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). Under the current Type A water licence and Mine Certificate, 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. However, to date no tailings have been placed in this facility;
- 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.

1.2 REPORT STRUCTURE

This document presents the methods, evaluation of effects, and conclusions of the 2012 AEMP. Raw data and results from the 2012 AEMP (including water column structure, water quality, sediment quality, primary producers, and benthic invertebrates) are provided in Appendix A, and supplemental information relevant to the 2012 evaluation of effects is provided in Appendix B.

2. Methods

2. Methods

2.1 SUMMARY OF AEMP STUDY DESIGN

The 2012 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 (NWB No. 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 are 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 (density and taxonomy); and
- fish.

Fish were last sampled in 2010 (Rescan 2011) and were not scheduled to be resampled in 2012.

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. Roberts Lake was also sampled in 2012, although not an AEMP site (as per approved Plan), to capture any influence from the North Arrow Minerals Inc. exploration camp. 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

The principal exposure sites in the AEMP study area are those waterbodies that will be downstream of the future discharge from the TIA. From upstream to downstream, these locations include: Doris Outflow, Little Roberts Lake, Little Roberts Outflow, and Roberts Bay East (RBE; Figure 2.1-1). The Doris Outflow sampling site is within 100 m of the projected discharge location to best measure the potential effects of the TIA discharge. Little Roberts Lake, a small, shallow lake (0.1 km^2, < 5 m depth) receiving outflow from Doris Lake and Roberts Lake, is the only lake along the projected TIA discharge path. A receiving environment site is in eastern Roberts Bay where Little Roberts Outflow enters the marine habitat (Roberts Bay East).

Table 2.1-1. AEMP Sampling Locations, Descriptions, and Purpose, Doris North Project, 2012

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 TIA discharge location
Little Roberts Lake	434624E 7562747N	Small lake downstream of Doris Outflow	First and only lake exposed to upstream TIA discharge
Little Roberts Outflow	434367E 7563094N	Stream downstream of Little Roberts Lake	Second exposure stream downstream of TIA discharge location
Roberts Bay East (RBE)	433430E 7563850N	Marine bay into which Little Roberts Lake drains	Marine receiving environment for freshwater system downstream of TIA 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 and current neighbouring exploration activity (North Arrow Minerals Inc.) on Roberts Outflow and potentially downstream in Little Roberts Lake and Little Roberts Outflow, and to be able to differentiate this from potential effects of TIA discharge upstream
Roberts Lake	435298E 7562756N	Western appendage of large lake, upstream of Roberts Outflow. Next to exploration camp.	Not an AEMP site, but included in 2012 to characterize any influence from North Arrow Minerals Inc. exploration camp
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	434288E 7555935N	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; RBW)	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
Ida (Reference) Bay (REF-Marine 1)	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))

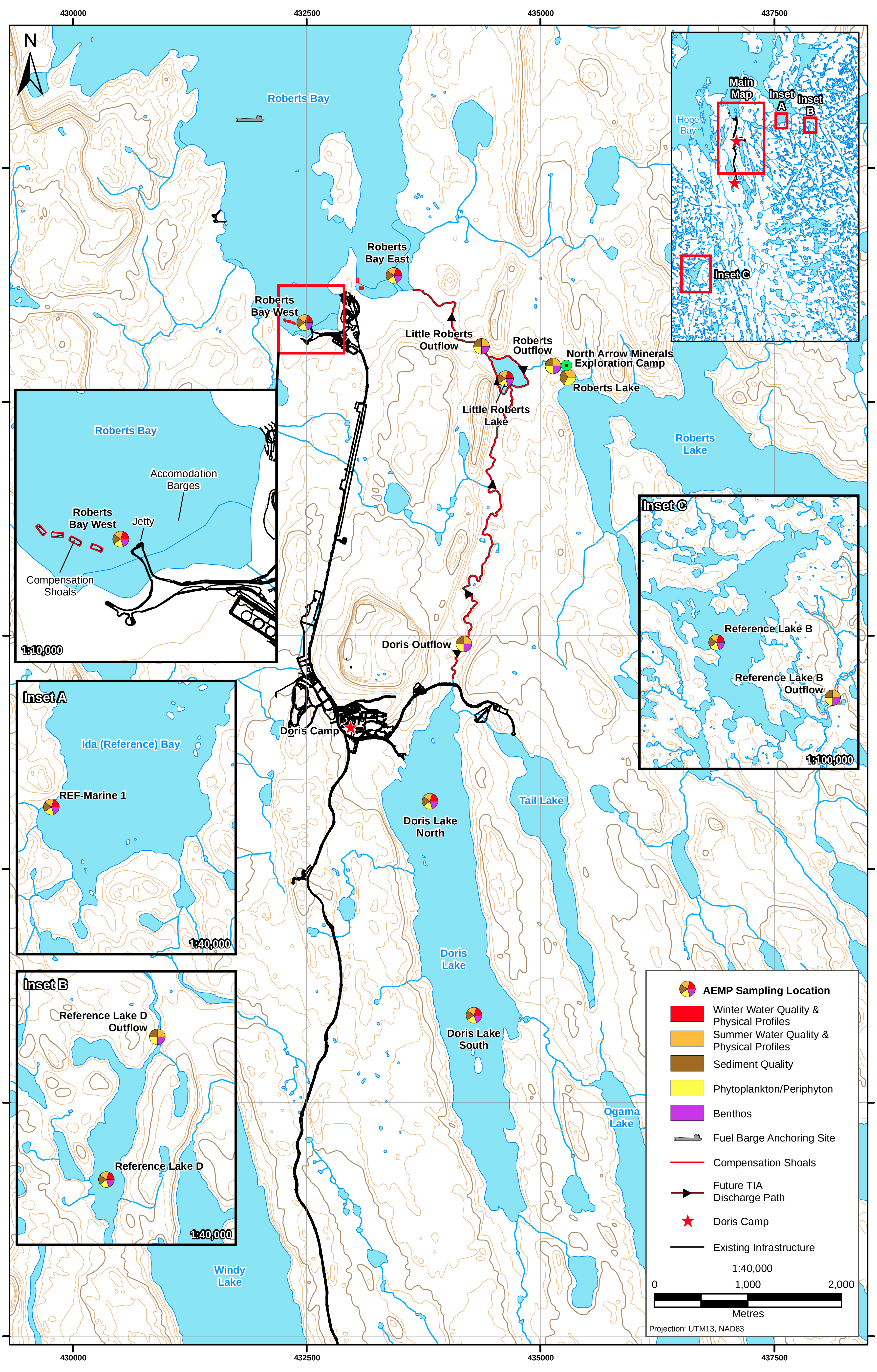

Figure 2.1-1

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2012 AEMP Sampling Locations, Doris North Project

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Figure 2.1-1

Because there has been both historical mining activity (an abandoned silver mine) and recent exploration activity (North Arrow Minerals Inc.) occurring in the Roberts Watershed and lake area, a sampling site in Roberts Lake (adjacent to the North Arrow exploration camp) were also included in the 2012 plan. This station is not an AEMP site, but was meant to identify any potential confounding influence of non-HBML activities.

In addition to the sampling sites that could potentially be affected by future TIA discharge, sites also exist to capture other potential effects of the Doris North Project. These sites include two sampling locations in Doris Lake (adjacent to site infrastructure and roads), and a single site in western Roberts Bay (Roberts Bay West; RBW) near the marine jetty (roads, site infrastructure, marine loading/unloading activities). In all, there are three stream exposure sites, four lake exposure sites, and two marine exposure sites. Note that the 2010 Doris South sampling location was moved approximately 800 m to the north to a deeper basin (> 10 m deep) for 2011 and 2012 sampling for improved comparability with the Doris North sampling location, which is also in a deep basin (> 10 m deep) (Figure 2.1-1).

2.1.2.2 Reference Sites

Three reference areas have been approved for the AEMP: two lake/stream outflow systems (Reference Lakes/Outflows B and D) and one marine site (Ida Bay; Figure 2.1-1). The two lake/stream outflow areas (Reference Lake B/Reference B Outflow and Reference Lake D/Reference D Outflow) were used as reference sites for comparability with exposure freshwater sites. 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 environment. Reference Lake B (7.7 km^2) was selected as a comparable lake to Doris Lake (3.4 km^2). A marine reference site in southern Ida Bay (REF-Marine 1) was selected for comparability with the two marine exposure sites in Roberts Bay. These reference areas were chosen with two features in mind:

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

There were no Project activities near the selected reference sites. The major consideration was to place the reference locations beyond any potential wind-borne particulates from mine sources. Reference Lake D is located 15 km from Doris North infrastructure, Reference Lake B is located 25 km away, and the marine reference site in Ida Bay is 10 km away.

2.1.3 2012 Sampling Schedule

The AEMP schedule is outlined in the current Plan (Rescan 2010c). For 2012, 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, dissolved oxygen (DO), salinity) and water quality (e.g., nutrients and metals) were collected in streams, lakes, and the marine environment four times during the sampling period, at least one month apart (whenever possible), thereby complying with MMER guidelines (Schedule 5, s.7 (1-2)). Phytoplankton and periphyton biomass (as chlorophyll *a*) were also collected during these surveys. Sediment quality and benthos samples were collected once in August. A summary of the 2012 sampling schedule is provided in Table 2.1-2.

Table 2.1-2. Summary of the 2012 AEMP Sampling Dates, Doris North Project

Waterbody	Parameter	Sampling Dates
Streams	Water Quality	June 16
		July 21
		August 21-25
		September 20
	Sediment Quality	August 21-25
	Periphyton Biomass	July 21*
		August 21-25*
		September 20*
	Benthos	August 21-25
Lakes	Physical Limnology	April 14-18
		July 23-26
		August 14-22
		September 15-16
	Water Quality	April 14-18
		July 23-26
		August 14-22
		September 15-16
	Sediment Quality	August 14-22
	Phytoplankton Biomass	April 14-18
		July 23-26
		August 14-22
		September 15-16
	Benthos	August 14-22
Marine	Physical Oceanography	April 19
		July 22-26
		August 17-19
		September 17-19
	Water Quality	April 19
		July 22-26
		August 17-19
		September 17-19
	Sediment Quality	August 17-19
	Phytoplankton Biomass	April 19
		July 22-26
		August 17-19
		September 17-19
	Benthos	August 17-19

** Periphyton biomass sampling dates indicate the dates of sample retrieval. Artificial samplers were installed in streams for approximately one month.*

2.2 DETAILED 2012 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.

Table 2.2-1. Summary of the 2012 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×	Lakes: n = 1/site @ 1 m below the surface and 2 m above water-sediment interface + 20% replication; Marine: n = 2/site @ 1 m	April, July, August, September	GO-FLO sampling bottle; Conductivity-Temperature-Depth (CTD) probe; DO meter
Lake and Marine Phytoplankton				
Biomass (chlorophyll *a*)	4×	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				
Density and taxonomy	1×	n = 5/site (3 composite subsamples/replicate)	August; coincident with August lake and marine survey	Ekman grab (lake); Petite Ponar grab (marine); 500 μm sieve
Lake and Marine Sediment Quality				
Physical, particle size, nutrients, metals, total organic carbon	1×	n = 3/site	August; coincident with August lake and marine survey	Ekman grab (lake); Petite Ponar grab (marine)
Stream Water Quality				
Physical, nutrients, total metals, temperature	4×	n = 2/site	June, July, August, September	Clean water sampling bottles; Temperature meter
Stream Periphyton				
Biomass (chlorophyll *a*)	3×	n = 3/site	June-July, July-August, August-September; coincident with stream water quality	Artificial Samplers (Plexiglas plates) installed for ~1 month
Stream Benthos				
Density and taxonomy	1×	n = 5/site (3 composite subsamples/replicate)	August; coincident with August stream survey	Hess sampler; 500 μm sieve

2.2.1 Physical Limnology and Oceanography

Physical limnological (e.g., temperature and dissolved oxygen) and oceanographic (e.g., salinity, temperature, and dissolved oxygen) profiles were collected once during the under-ice season (April) and three times during the open-water season (July, August, and September) in 2012. The under-ice sampling was designed to collect water during a period when dissolved oxygen concentrations were expected to be lowest due to reduced photosynthesis and the absence of oxygen diffusion from the atmosphere, and concentrations of nutrients and metals were expected to be highest due to limited biological uptake and solute extrusion from the formation of the ice cover.

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 Humminbird 570 portable depth sounder. 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 Pro-ODO temperature and optical dissolved oxygen meter. Temperature and dissolved oxygen values were recorded at 0.5 or 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 extended from the surface to approximately 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, and were collected from an aluminum boat. In addition, 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 recorded as the Secchi depth (D_s). The 1% euphotic zone depth ($Z_{1\%}$) was computed by first calculating the light extinction coefficient (k) from D_s, and then calculating the euphotic zone depth based on the appropriate light extinction coefficient. The 1% euphotic depth is the depth of the water column at which 1% of the surface irradiance reaches. It represents the depth at which the integrated gross water column photosynthetic production is equivalent to the integrated gross water column respiration; thus, there is net photosynthesis above this depth. The 1% euphotic depth is often referred to as the compensation depth, and is calculated as follows (Parsons, Takahashi, and Hargrave 1984):

Light extinction coefficient:

$$k\ (m^{-1}) = 1.7/D_s$$

Euphotic Depth (1%):

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

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; model RBR-420) fitted with an Aanderaa Optode dissolved oxygen sensor. The probe was lowered through the water column on a cable at approximately 0.5 m/s 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.

Open Water

CTD and dissolved oxygen 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. The 1% euphotic zone depth was calculated from the Secchi depth as described above for lakes.

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 2012. Stream water quality samples were collected during the June freshet in addition to the three open water months listed above. Whenever possible, samples at a specific site were collected at least one month apart to conform to MMER/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, 2012

Habitat	Site	Sampling Date	Depth(s) (m)
Stream	Doris Outflow	16-Jun-12	Surface
		21-Jul-12	Surface
		25-Aug-12	Surface
		20-Sep-12	Surface
	Roberts Outflow	16-Jun-12	Surface
		21-Jul-12	Surface
		22-Aug-12	Surface
		20-Sep-12	Surface
	Little Roberts Outflow	16-Jun-12	Surface
		21-Jul-12	Surface
		24-Aug-12	Surface
		20-Sep-12	Surface
	Reference B Outflow	16-Jun-12	Surface
		21-Jul-12	Surface
		25-Aug-12	Surface
		20-Sep-12	Surface
	Reference D Outflow	16-Jun-12	Surface
		21-Jul-12	Surface
		21-Aug-12	Surface
		20-Sep-12	Surface
Lake	Doris Lake North	15-Apr-12	1.0, 11.5
		24-Jul-12	1.0, 12.5
		20-Aug-12	1.0, 12.0
		16-Sep-12	1.0, 12.0
	Doris Lake South	14-Apr-12	1.0, 8.5
		24-Jul-12	1.0
		20-Aug-12	1.0, 8.5
		16-Sep-12	1.0, 9.0
	Roberts Lake	17-Apr-12	1.0
		23-Jul-12	1.0
		14-Aug-12	1.0
		15-Sep-12	1.0

(continued)

Table 2.2-2. AEMP Stream, Lake, and Marine Water Quality Sampling Dates and Depths, Doris North Project, 2012 (completed)

Habitat	Site	Sampling Date	Depth (m)
	Little Roberts Lake	15-Apr-12	1.0
		23-Jul-12	1.0
		16-Aug-12	1.0
		15-Sep-12	1.0
	Reference Lake B	18-Apr-12	1.0, 7.5
		24-Jul-12	1.0, 8.0
		15-Aug-12	1.0, 9.0
		16-Sep-12	1.0, 9.0
	Reference Lake D	16-Apr-12	1.0
		26-Jul-12	1.0
		16-Aug-12	1.0
		15-Sep-12	1.0
Marine	RBE (Roberts Bay)	19-Apr-12	1.0
		22-Jul-12	1.0
		18-Aug-12	1.0
		19-Sep-12	1.0
	RBW (Roberts Bay)	19-Apr-12	1.0
		22-Jul-12	1.0
		18-Aug-12	1.0
		19-Sep-12	1.0
	REF-Marine 1 (Ida Bay)	19-Apr-12	1.0
		26-Jul-12	1.0
		17-Aug-12	1.0
		17-Sep-12	1.0

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 16 and September 20, 2012. Locations of the 2012 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. Sampling personnel stood facing upstream to minimize sample contamination from resuspended sediments, and capped bottles were plunged just below the water surface and opened underwater to avoid the collection of surface material. Samples were collected using appropriate verified-clean bottles provided by ALS Laboratory Group, Burnaby, BC (ALS). All samples were collected in duplicate and the appropriate preservatives provided by ALS were added in the field after sample 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 realized detection limits are presented in Table 2.2-3.

Table 2.2-3. AEMP Water Quality Parameters and Realized Detection Limits, Doris North Project, 2012

		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	Chromium (Cr)	mg/L	0.0005	0.0001 or 0.0005
Alkalinity, Total (as $CaCO_3$)	mg/L	2	2	Cobalt (Co)	mg/L	0.00005	0.00005
				Copper (Cu)	mg/L	0.0005	0.00005
Hardness (as $CaCO_3$)	mg/L	0.5	2.2 or 4.3	Gallium (Ga)	mg/L	0.00005	0.0005
Conductivity	µS/cm	2	-	Iron (Fe)	mg/L	0.03	0.01
Total Suspended Solids	mg/L	1	2	Lead (Pb)	mg/L	0.00005	0.00005
Turbidity	NTU	0.1	0.1	Lithium (Li)	mg/L	0.0002	0.02
Salinity		-	1	Magnesium (Mg)	mg/L	0.1	0.5 or 1
				Manganese (Mn)	mg/L	0.0002	0.00005
Anions				Mercury (Hg)	mg/L	0.0000005	0.0000005
Bromide (Br)	mg/L	0.05	5.0	Molybdenum (Mo)	mg/L	0.00005	0.002
Chloride (Cl)	mg/L	0.5	50	Nickel (Ni)	mg/L	0.0002 to 0.0007	0.00005
Fluoride (F)	mg/L	0.02	0.03 or 0.75				
Sulphate (SO_4)	mg/L	0.5	50	Phosphorus (P)	mg/L	0.30	1
				Potassium (K)	mg/L	2	10 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	0.006	Selenium (Se)	mg/L	0.00020	0.0005
Nitrite (as N)	mg/L	0.001	0.002	Silicon (Si)	mg/L	0.05	0.25 or 0.5
Total Phosphorus	Mg/L	0.002	0.002	Silver (Ag)	mg/L	0.000005 or 0.00001	0.0001
Cyanides				Sodium (Na)	mg/L	2	10 or 20
Cyanide Total	mg/L	0.001	0.001 or 0.005	Strontium (Sr)	mg/L	0.00005	0.025 or 0.05
				Tellurium (Te)	mg/L	0.00001	0.0005
Cyanide, Free	mg/L	0.001	0.001 or 0.005	Thallium (Tl)	Mg/L	0.000002 or 0.00002	0.0005
				Thorium (Th)	mg/L	0.000005 to 0.000035	0.0005
Organic Carbon							
Total Organic Carbon	mg/L	0.5	0.5	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 to 0.021	0.005	Uranium (U)	mg/L	0.000002	0.00005
Antimony (Sb)	mg/L	0.00001 to 0.00003	0.0005	Vanadium (V)	mg/L	0.00005	0.0005
Arsenic (As)	mg/L	0.00005 to 0.002	0.0004	Yttrium (Y)	mg/L	0.000005	0.0005
Barium (Ba)	mg/L	0.0001	0.001	Zinc (Zn)	mg/L	0.003	0.0008
Beryllium (Be)	mg/L	0.000005 or 0.00001	0.0005	Zirconium (Zr)	mg/L	0.00005	0.0005
Bismuth (Bi)	mg/L	0.00005	0.0005	**Speciated Metals**			
Boron (B)	mg/L	0.005 to 0.035	0.1	Methylmercury	µg/L	-	0.00005
Cadmium (Cd)	mg/L	0.000005	0.00002				
Calcium (Ca)	mg/L	0.05	0.25 or 0.5	**Radiochemistry**			
Cesium (Cs)	mg/L	0.000005 or 0.00001	0.0005	Radium-226	Bq/L	0.005 to 0.010	0.005 to 0.010

2.2.2.2 Lakes and Marine

Water quality samples were collected in both lakes and the marine environment during the 2012 AEMP program. Lake samples were collected from four sites in three lakes within the Doris and Roberts watersheds (Doris Lake South, Doris Lake North, Roberts Lake, 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, Ida (Reference) Bay (REF-Marine 1). Locations of the 2012 AEMP lake and marine sampling sites are presented in Figure 2.1-1.

Samples were collected once during the ice-covered season (April), and three times during the open water season (July, August, September) between April 14 and September 19, 2012. Within each lake, samples were collected at ~1 m depth over the deepest part of the lake. At the deepest lake sites (Doris Lake North and South 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 was designed to 'trip' and collect discrete samples during freezing temperatures. To avoid metal contamination, the tripping mechanism used acid-cleaned silicone tubing within the interior of the bottle. A dual rope system was used to 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 securely attached to a metred cable line and was lowered to the appropriate sampling depth and allowed to equilibrate for one minute. It was then triggered closed using a brass messenger and brought aboard 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, 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 sample 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 for stream water quality samples. The parameters analyzed and their realized 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 samples were consistently diluted to reduce matrix effects from the high concentrations of cations (e.g., sodium).

2.2.2.3 Quality Assurance and Quality Control

The quality assurance and quality control (QA/QC) program for water quality sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track all samples. A set of travel, field, and equipment blanks (~20% of total samples) was also processed and submitted with the water samples as part of the QA/QC program. These blanks were used to identify potential sources of contamination to the field samples. 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 2012. 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, 2012

Habitat	Site	Sampling Date	Depth (m)
Stream	Doris Outflow	25-Aug-12	NA
	Roberts Outflow	22-Aug-12	NA
	Little Roberts Outflow	24-Aug-12	NA
	Reference B Outflow	25-Aug-12	NA
	Reference D Outflow	21-Aug-12	NA
Lake	Doris Lake North	21-Aug-12	13.5
	Doris Lake South	22-Aug-12	10.3
	Roberts Lake	14-Aug-12	2.0
	Little Roberts Lake	16-Aug-12	1.8
	Reference Lake B	15-Aug-12	10.1
	Reference Lake D	16-Aug-12	2.5
Marine	RBE (Roberts Bay)	18,19-Aug-12	0.6
	RBW (Roberts Bay)	18-Aug-11	4.2
	REF-Marine-1 (Ida Bay)	17-Aug-11	3.9

NA - not applicable

2.2.3.1 Streams

Three replicate sediment samples were collected at each stream site. At each site, except Roberts Outflow, a replicate sample was a 1 L composite of several spoonfuls (plastic) of sediments, with each replicate taken at least three times the channel width apart. The sediment was fully homogenized, slowly drained of excess water, and transferred into separate pre-labelled Whirl-Pak bags: one for particle size analysis, and one for sediment chemistry analysis. Each bag was then placed into another Whirl-Pak bag as a protective measure.

At Roberts Outflow, replicate samples were collected by plunging an Ekman grab sampler (surface sampling area of 0.0225 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 tray, and photographed. 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 as described for the other streams.

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.

Table 2.2-5. AEMP Sediment Quality Parameters and Realized Detection Limits, Doris North Project, August 2012

Parameter	Units	Realized Detection Limit		Parameter	Units	Realized Detection Limit	
		Freshwater	Marine			Freshwater	Marine
Physical Tests				**Total Metals (continued)**			
Moisture	%	0.25	0.25	Bismuth (Bi)	mg/kg	0.2	0.2
pH	pH	0.1	0.1	Cadmium (Cd)	mg/kg	0.05	0.05
				Calcium (Ca)	mg/kg	50	50
Particle Size				Chromium (Cr)	mg/kg	0.5	0.5
% Gravel (>2 mm)	%	0.1	0.1	Cobalt (Co)	mg/kg	0.1	0.1
% Sand (2.0 - 0.063 mm)	%	0.1	0.1	Copper (Cu)	mg/kg	0.5	0.5
% 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	0.5	0.5
				Lithium (Li)	mg/kg	5	5
Organic Carbon				Magnesium (Mg)	mg/kg	20	20
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	0.5	0.5
Total Nitrogen	%	0.02	0.02	Nickel (Ni)	mg/kg	0.5	0.5
Total Available Nitrogen	mg/kg	2.6 to 8.2		Phosphorus (P)	mg/kg	50	50
Plant Available Nutrients				Potassium (K)	mg/kg	100	100
Available Ammonium-N	mg/kg	1.0 to 2.4	1.0 or 1.6	Selenium (Se)	mg/kg	0.2	0.2
Available Nitrate-N	mg/kg	2.0 to 6	2.0 or 4.0	Silver (Ag)	mg/kg	0.1	0.1
Available Nitrite-N	mg/kg	0.4 to 1.2	0.4 or 0.8	Sodium (Na)	mg/kg	100	100
Available Phosphate-P	mg/kg	2.0 to 6.0	2.0	Strontium (Sr)	mg/kg	0.5	0.5
				Sulphur (S)	mg/kg	500	500
Total Metals				Thallium (Tl)	mg/kg	0.05	0.05
Aluminum (Al)	mg/kg	50	50	Tin (Sn)	mg/kg	2	2
Antimony (Sb)	mg/kg	0.1	0.1	Titanium (Ti)	mg/kg	1	1
Arsenic (As)	mg/kg	0.05	0.05	Uranium (U)	mg/kg	0.05	0.05
Barium (Ba)	mg/kg	0.5	0.5	Vanadium (V)	mg/kg	0.2	0.2
Beryllium (Be)	mg/kg	0.2	0.2	Zinc (Zn)	mg/kg	1	1

2.2.3.2 Lakes

Lake sediments were obtained in the deepest section of the lake (except Doris Lake South) using an Ekman grab 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 the sediment surface 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 described for stream sediment quality.

2.2.3.3 Marine

Marine sediment quality samples were collected in triplicate using a Petite Ponar grab sampler (surface sampling area of 0.023 m^2), with replicates spaced 20 to 50 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 particle size, and one for sediment chemistry.

All samples were refrigerated (in darkness) until they were shipped to ALS (Burnaby, BC) 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.

2.2.3.4 Quality Assurance and Quality Control

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

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 for approximately one month before sample collection and processing, i.e., those plates collected in July, August, and September, were installed in June, July, and August, respectively. The complete installation and retrieval schedule is outlined in Table 2.2-6.

Table 2.2-6. Periphyton Sampling Dates, Doris North Project, 2012

Stream Site	Installation Date	Retrieval Date
Doris Outflow	16-Jun-12	21-Jul-12
	21-Jul-12	25-Aug-12
	25-Aug-12	20-Sep-12
Roberts Outflow	16-Jun-12	21-Jul-12
	21-Jul-12	22-Aug-12
	22-Aug-12	20-Sep-12
Little Roberts Outflow	16-Jun-12	21-Jul-12
	21-Jul-12	24-Aug-12
	24-Aug-12	20-Sep-12
Reference B Outflow	16-Jun-12	21-Jul-12
	21-Jul-12	25-Aug-12
	25-Aug-12	20-Sep-12
Reference D Outflow	16-Jun-12	21-Jul-12
	21-Jul-12	21-Aug-12
	21-Aug-12	20-Sep-12

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. 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 scraped using 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. The filters were kept frozen until they were sent to ALS Burnaby for analysis.

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 during July, August, and September. In April, a 2.5 L Niskin bottle was used to collect a sample from ~1 m beneath the ice layer. 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 using gentle vacuum filtration (hand pump). The samples were filtered onto 47 mm diameter, 0.45 μm pore size nitrocellulose 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. Several of the April chlorophyll *a* samples were lost due to a freezer malfunction, as a result there is not three replicates of April chlorophyll *a* data from Doris Lake North (n = 2), Roberts Lake (n = 1) and Reference Lake B (n = 2) and the three marine sites (n = 2).

2.2.4.3 Quality Assurance and Quality Control

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

2.2.5 Benthos

Benthic invertebrate (benthos) samples were collected at the stream, lake, and marine sites during the open-water season in August 2012. 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 2011). Sampling procedures for each aquatic habitat are described below.

2.2.5.1 Streams

Benthos samples were collected at all AEMP streams from August 21 to August 25, 2012. To comply with EEM requirements, three separate subsamples were collected and pooled for each replicate sample, and five replicates were collected at each site. 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 buffered formalin to a final concentration of 10%. All benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification.

Several community descriptors were calculated from the taxonomic results, including benthos density, family richness, Simpson's Diversity and Evenness indices, and the Bray-Curtis Index. Cladocerans and cyclopoid and calanoid copepods were not included in the community metrics as these groups are generally planktonic. Nematodes and harpacticoid copepods were excluded as they are typically considered to be meiofauna (invertebrates ranging in size between 63 μm and 500 μm) and are not adequately sampled using a 500 μm sieve bucket. Organisms that could not be identified to the family level and made up a minor proportion (< 2%) of the benthos counts in each replicate were excluded from the community analysis. Any terrestrial organisms or fish that were identified in the benthos samples were also excluded from the calculations of community descriptors.

Benthos counts were normalized to three times the surface area of the of the Hess sampler (i.e., $3 \times 0.096\ m^2$) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Hess samples).

Family richness was calculated as the total number of benthic invertebrate families present in each replicate sample.

The Simpson's Diversity Index (D) was calculated as:

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

where F was the number of families present (i.e., family richness), and p_i was the relative abundance of each family calculated as n_i/N, where n_i is the number of individuals in family i, and N was the total number of all individuals. Simpson's Evenness Index (E) was calculated as:

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

A complete dissimilarity matrix was also generated that included pairwise comparisons of all samples using the Bray-Curtis Index. The Bray-Curtis Index compares the community composition within a benthos sample to the median reference community composition (Environment Canada 2011). 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 combined reference site replicates, the comparison of a single 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. The Bray-Curtis Index ranges from 0 to 1, with 1 representing completely dissimilar communities, and 0 representing identical communities. This index is calculated as:

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

where BC is the Bray-Curtis distance between sites 1 and 2, n was the total number of families present at the two sites, y_{i1} was the count for family i at site 1, and y_{i2} was 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 combined for the determination of the 'median reference composition'. Because lakes can have dramatically different physico-chemical and biological function based on their morphologies, median reference compositions were created for each reference lake (large lake: Reference Lake B; small lake: Reference Lake D). Bray-Curtis distances were then calculated by comparing the Reference Lake B median community to the large lake sites, Doris Lake North, Doris Lake South and Roberts Lake, and the Reference Lake D median community to Little Roberts Lake. For the marine sites, the REF-Marine 1 median community composition was compared to the RBW and RBE benthos communities.

Standard summary statistics (minimum, maximum, median, mean, standard deviation, and standard error) were calculated for all 2012 benthic invertebrate endpoints described above. These summary statistics are presented in Appendix A.

2.2.5.2 Lakes

Benthos samples were collected during the summer season at all AEMP lakes from August 14 to August 22, 2012. 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 grab sampler (surface sampling area of 0.0225 m^2), 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 preserved with buffered formalin to a final concentration of 10%. All benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification. Benthos counts were normalized to the surface area of three times the surface area of the of the Ekman sampler (i.e., 3 × 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Ekman samples). Community descriptors and summary statistics were calculated as described for stream benthos.

2.2.5.3 Marine

Benthos samples were collected during the summer season at the two sites in Roberts Bay (RBW and RBE; August 18, 2012) and at the reference site in Ida Bay (REF-Marine 1; August 17, 2012). Samples were collected with a Petite Ponar grab sampler (surface sampling area of 0.023 m^2). Five replicates were collected approximately 20 to 50 m apart at each site, with each replicate consisting of three pooled grab samples. 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 preserved with saline, buffered formalin to a final concentration of 10%. All benthos samples were sent to Columbia Science (Courtney, BC) for enumeration and identification. Benthos counts were normalized to the surface area of three times the surface area of the of the Petite Ponar sampler (i.e., 3 × 0.023 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Petite Ponar grab samples). Community descriptors and summary statistics were calculated as described for stream benthos.

2.2.5.4 Quality Assurance and Quality Control

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

A re-sorting of randomly selected sample residues was conducted by taxonomists on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. The criterion for an acceptable sorting was that more than 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). Any sample not meeting the 90% removal criterion was re-sorted a third time. The 90% minimum efficiency was always attained. Results for all benthos QA/QC are provided in Appendix A.

2.3 EVALUATION OF EFFECTS

Select baseline data collected between 1995 and 2009 in the Doris North Project area were compared against 2012 data to determine whether there were adverse changes to the aquatic environment that could be directly attributed to 2012 Project activities. 2010 and 2011 was not included in the baseline years of the evaluation of effects as they were Year 1 and 2 of construction.

2.3.1 Parameters Subjected to Evaluation

Table 2.3-1 presents the physical, chemical, and biological parameters that were evaluated for 2012. 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 many of the assessed parameters. As per the MMER and EEM requirements, the benthic invertebrate community and associated sediment parameters (sediment particle size and total organic carbon content) were evaluated. Additional sediment parameters for which there are CCME sediment quality guidelines for the protection of aquatic life were included in the assessment. Periphyton and phytoplankton biomass were also evaluated.

Table 2.3-1. Parameters Subjected to Effects Analysis, Doris North Project, 2012

Category	Parameter
Water Quality	
Deleterious Substances[a]	Total Suspended Solids[d]
	Cyanide, Total[d]
	Arsenic, Total[d]
	Copper, Total[d]
	Lead, Total[d]
	Nickel, Total[d]
	Zinc, Total[d]
	Radium-226
Effluent Characterization and Water Quality Parameters[b]	pH[d]
	Alkalinity, Total
	Hardness
	Ammonia (as N)[d]
	Nitrate (as N)[d]
	Aluminum, Total[d]
	Cadmium, Total[d]
	Iron, Total[d]
	Mercury, Total[d]
	Molybdenum, Total[d]
Physical Limnology	
Effluent Characterization and Water Quality Parameters[b]	Dissolved Oxygen[d]
	Secchi Depth

(continued)

Table 2.3-1. Parameters Subjected to Effects Analysis, Doris North Project, 2012 (completed)

Category	Parameter
Sediment Quality	
	Particle Size[c]
	Total Organic Carbon[c]
	Arsenic[d]
	Cadmium[d]
	Chromium[d]
	Copper[d]
	Lead[d]
	Mercury[d]
	Zinc[d]
Biology	
	Phytoplankton and Periphyton Biomass, Benthic Invertebrate Density[c], Taxa Richness[c], Evenness Index[c], Similarity Index[c]

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 as per Schedule 5 of the MMER
[d] Parameters that have CCME water or sediment quality guidelines for the protection of aquatic life
2010 was Year 1 of fish data collection. Fish sampling was not undertaken in 2012.

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 baseline data that could be used for comparison with the 2012 data.

The approaches used to assemble the appropriate baseline datasets and to determine whether there were any effects on evaluated parameters in 2012 are discussed below. Key determining factors for the inclusion of baseline data included the proximity of baseline sampling sites to 2012 sampling sites, the depth of sampling (for sediment quality and benthos), and sampling methodology (for sediment quality, periphyton, phytoplankton, and benthos). Historical data used for the effects analyses were from the following reports: Klohn-Crippen Consultants Ltd. (1995), Rescan (1997, 1998, 1999, 2001, 2010a, 2010b, 2011), RL&L Environmental Services Ltd. and Golder Associates Ltd. (2003a, 2003b), and Golder Associates Ltd. (2005, 2006, 2007, 2008, 2009).

Note that although data from the Roberts Lake site are graphed, they are not included in any effect analysis because there was no comparable baseline data in the immediate area, and the site is not part of the approved Plan.

Full descriptions of statistical methods and results are provided in Appendix B.

2.3.2.1 Under-ice Dissolved Oxygen

Data Selection

Potential effects on physical limnology and oceanography were evaluated using April, May, or early June 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 TIA effluent was discharged into the aquatic environment in 2012.

Baseline (pre-2010) under-ice dissolved oxygen measurements have been collected several times at the AEMP exposure lake sites since 1998. Under-ice dissolved oxygen data are available from 2009 and 2010 for Reference Lake B, and from 2010 for Reference Lake D. 2010 data collected from the reference lakes were considered in the evaluation of effects because these lakes would not have been influenced by Project activities.

In the marine environment, baseline under-ice dissolved oxygen profiles were collected at RBE in May 2006 and at RBW in April 2009. No baseline or 2010 under-ice dissolved oxygen data exists for REF-Marine 1.

Effects Analysis

The potential for effects on under-ice dissolved oxygen levels was assessed by graphical analysis. For winter dissolved oxygen levels to warrant concern and be considered an effect, concentrations from 2012 had to be noticeably different from all available baseline years (pre-2010). For example, if 2012 dissolved oxygen levels were different from 2005, but similar to 2007, it was concluded that there were no 2012 Project effects at that exposure site. Dissolved oxygen concentrations were also compared against CCME guidelines for the protection of aquatic life (CCME 2012b) to determine if baseline or 2012 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 2012. The formation of the ice cover in November 2011 isolated lakes, streams, and Roberts Bay from any atmospheric inputs such as dust that could have been generated by Project activities between November 2011 and June/July 2012. Therefore, the water column that was profiled in April 2012 reflects activities from 2011 rather than 2012.

2.3.2.2 Secchi Depth

Data Selection

Secchi depths have been measured at lake sites in the Doris North Project area since 1995. The selection of historical lake data to include in the effects evaluation was based on similarity of baseline sampling locations to 2012 sampling locations. At least three years of baseline (pre-2010) Secchi depth data are available for Doris Lake South, Doris Lake North, Roberts Lake and Little Roberts Lake. Baseline Secchi depth was recorded once in August 2009 at Reference Lake B, and no pre-2010 data were available for Reference Lake D

Marine sites RBE and RBW are shallow (< 5 m) and typically contain low levels of phytoplankton biomass. Secchi depths measured at these sites in 2012 almost always reached the bottom (Appendix A), indicating that water clarity was high and that the euphotic zone often extended throughout the entire water column. The purpose of evaluating Secchi depth is to determine whether there is any evidence of reduced water clarity caused by either an increase in phytoplankton biomass as a result of eutrophication or an increase in suspended sediments. As water clarity at marine sites was high in 2012, Secchi depth was not evaluated for the Roberts Bay sites RBE and RBW.

Effects Analysis

Annual mean Secchi depth graphs were used to compare before (pre-2010)-after (2012) trends at the exposure sites to before-after trends at the reference sites and to supplement the results of the statistical analyses.

For each lake site, a before-after comparison between the mean baseline Secchi depth and the mean Secchi depth for 2012 was conducted. A mixed model ANOVA using R version 2.15.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season*, and a random effect of *year* to account for variability in the Secchi depth 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 (2012). For the *season* effect, data were grouped into one of three seasons depending on the timing of Secchi depth measurement: 1) July, 2) August, 3) September, since Secchi depth can vary over the open-water season depending on sediment and nutrient inputs and phytoplankton growth. 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 the mean Secchi depth in 2012 was not significantly different from the baseline mean it was concluded that there was no effect of 2012 Project activities on Secchi depth and no further statistical analysis results are discussed.

If the before-after comparison revealed that the mean Secchi depth in 2012 was different from the baseline 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 corresponding reference site, to see if the trends are parallel and thus attributable to a natural process. A BACI analysis could only be performed if baseline and 2012 data were available for both the exposure site and the reference site. Because there was no baseline data available for Secchi depth in Reference Lake D, it was not possible to conduct a BACI analysis for Secchi depth in Little Roberts Lake.

The BACI 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* (before vs. after) and *class* (exposure vs. reference) effects reveals whether any before-after change in the mean Secchi depth 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 before-after comparison, but the BACI analysis revealed that a parallel 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 2012 Project activities. Note that BACI results are only discussed in the text if a difference is detected by the before-after analysis, but all BACI results are included in Appendix B. A complete description of the statistical methodology and results used to assess the Project effects on Secchi depth is included in Appendix B.

2.3.2.3 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 effects evaluation was based on the similarity of baseline sampling locations to 2012 sampling locations, methodology (e.g., shoreline grabs were excluded from dataset), sampling depth (e.g., for marine data, baseline samples collected from just above the sediment were excluded because all 2012 samples were collected from the surface zone), and professional judgement. Note that for Doris Lake South, historical water quality data collected between 1996 and 2000 were excluded from the evaluation of effects presented in the 2010 AEMP because the 1996-2000 sampling site was more than 1 km away to the north of the 2010 Doris Lake South sampling site (Figure 2.3-1). However, the Doris Lake South sampling site was moved slightly further to the north in 2011, and approximately 500 m away from the 1996-2000 sampling site. Therefore, these historical data were considered comparable to the 2012 water quality data and were included in the 2012 evaluation of effects for Doris Lake South. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix B.

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 2012b). 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 baseline mean and the 2012 mean was conducted for each of the 18 evaluated parameters (provided that baseline data were available). A mixed model ANOVA using R version 2.15.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season* (early vs. late), and a 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 (2012). 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 2012 parameter mean was not significantly different from the baseline mean, it was concluded that there was no effect of 2012 Project activities on this parameter, and no further statistical analysis results were discussed.

If the before-after comparison revealed that a 2012 parameter mean was different from the baseline mean, the next step of the analysis was to conduct a BACI analysis to determine if the observed difference in the before-after parameter mean was also seen at the reference site (which would indicate that the difference was due to a natural process). A BACI analysis could only be performed if both baseline and 2012 data were available for both the exposure site and the reference site. The BACI 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 at the exposure site also occurred at 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 before-after analysis, but the BACI analysis revealed that a parallel change occurred at the reference site, it is reasonable to assume that this change was likely a natural phenomenon and was unrelated to the 2012 Project activities. Note that BACI results are only discussed in the text if a difference was detected by the before-after analysis, but all BACI results are included in Appendix B.

For lake and marine water quality parameters, the before-after trend for each exposure site was compared against the trend at the corresponding reference site for the BACI analysis. For stream water quality parameters, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2012 contributed some information on the year-effect, which improved the precision of the BACI estimate.

All sample replicates collected on the same date and from the same depth in the 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 for the calculation of the parameter mean 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 B).

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 baseline 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 2012 data that were treated as outliers were from the July arsenic samples from the streams sites (10 samples) and one Cadmium sample from Reference B OF (September).

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

2.3.2.4 Sediment Quality

<u>Data Selection</u>

Baseline sediment quality sampling has been conducted five times in the AEMP freshwater and marine habitats since 1997 (Figure 2.3-2). The most important criterion in the historical sediment quality data selection process was that pre-2010 samples had to be collected from the same depth strata as the 2012 samples, since higher metal concentrations are often associated with higher proportions of fine sediments (silts and clays; e.g., Lakhan, Cabana, and LaValle 2003), and this in turn is affected by the depth of sampling (i.e., deeper samples tend to contain higher proportions of fine sediments). Because the Doris Lake South sampling location was moved from a shallow site in 2010 (< 5 m deep) to a deep site in 2011 (> 10 m deep) for improved comparability with the Doris Lake North site (which is also a deep site), only baseline data collected from the deep depth strata were included in the comparison to 2012 Doris Lake South data.

The selection of historical data was also based on the proximity of baseline sampling sites to the 2012 sites and the similarity of sampling techniques. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix B.

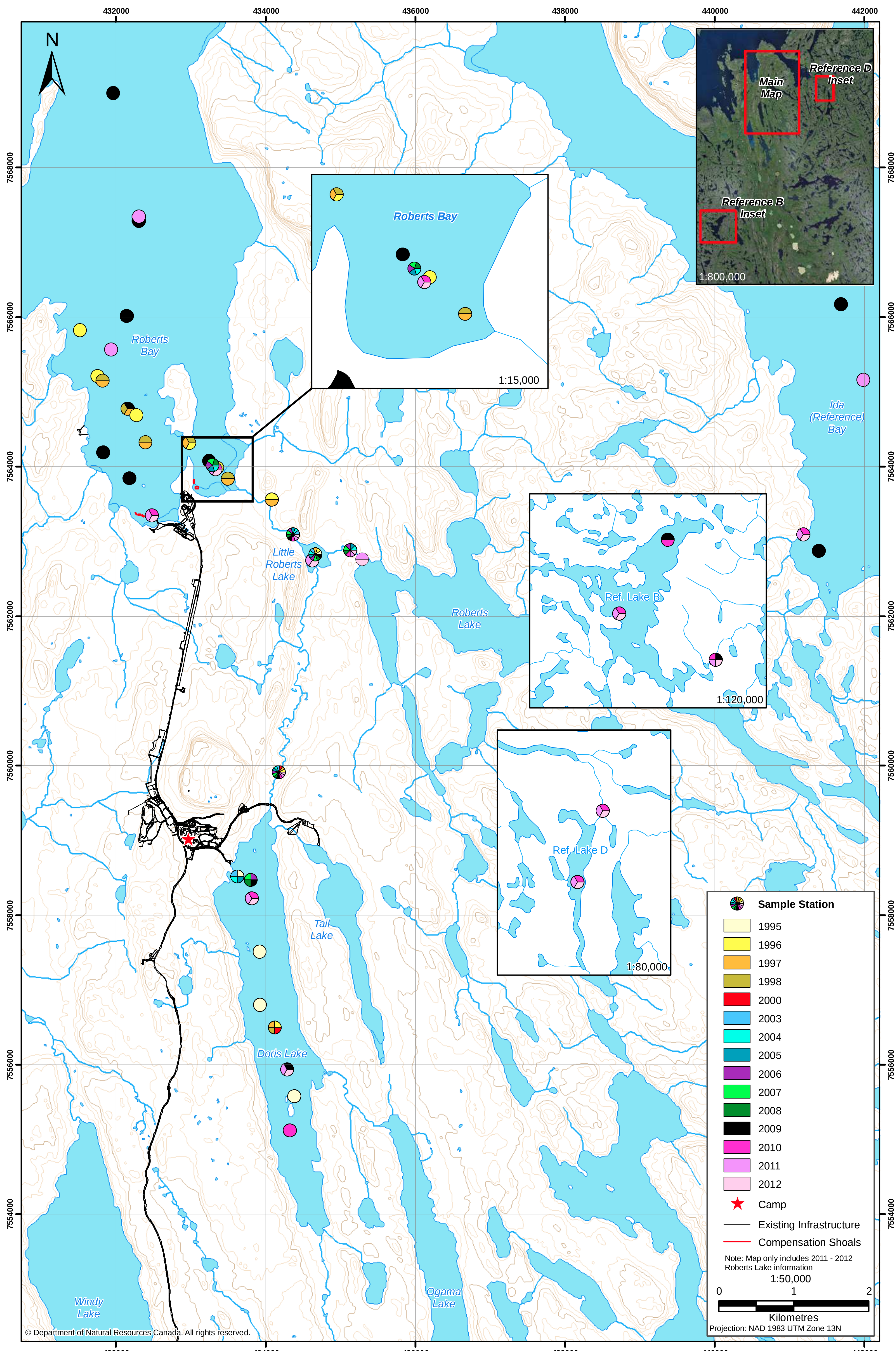

Figure 2.3-1

NEWMONT NORTH AMERICA

Historical Water Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1995-2012

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PROJECT #1009-008-05 GIS # HB-01-089 March 15 2013

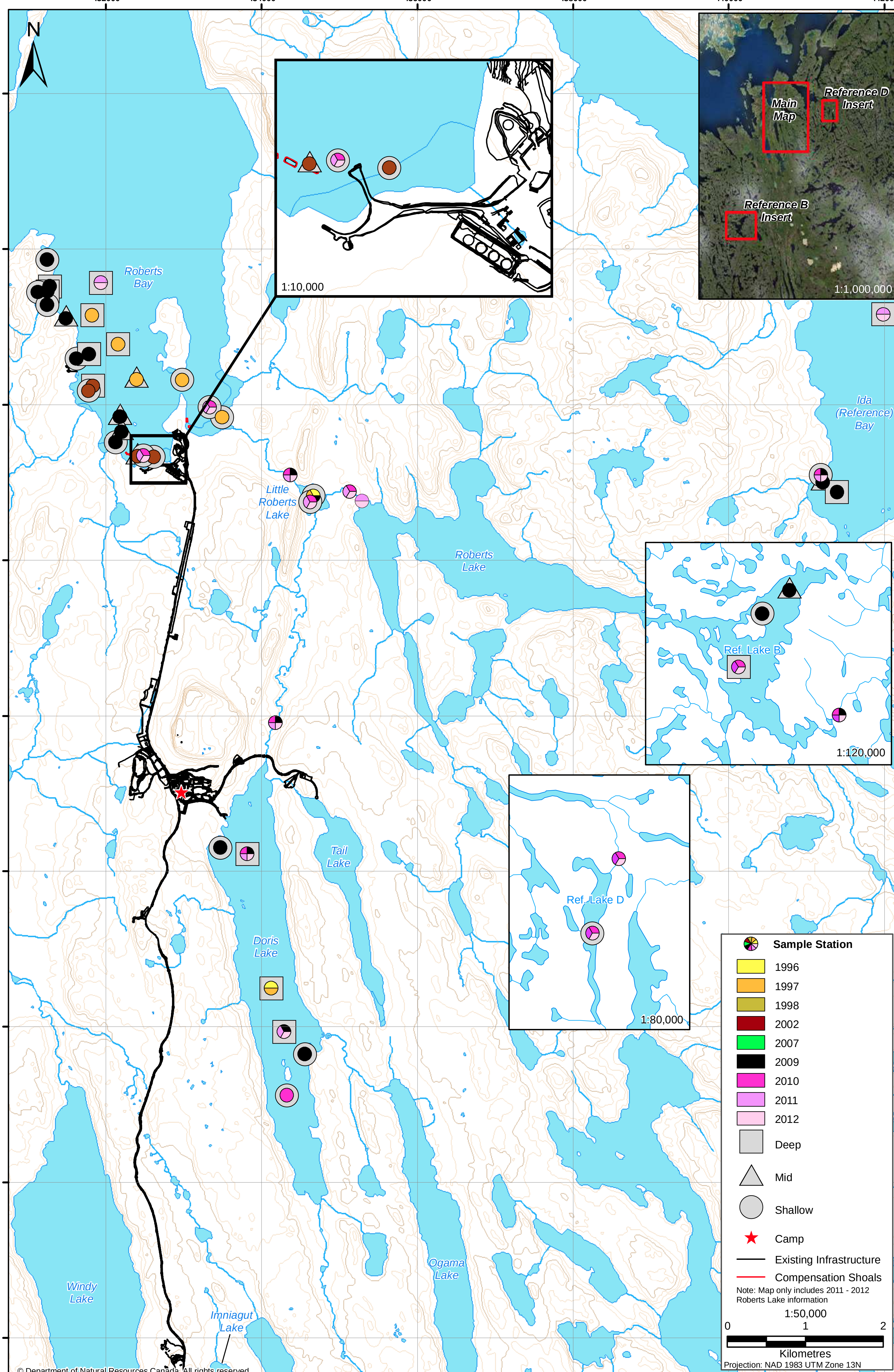

Figure 2.3-2

NEWMONT NORTH AMERICA

Historical Sediment Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2012

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Figure 2.3-2

Effects Analysis

The nine sediment quality parameters presented in Table 2.3-1 were evaluated 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 2012a). Relevant CCME guidelines are included on effects analysis graphs, as well as in Appendix A.

Before-after comparisons were used to determine if mean 2012 concentrations of sediment quality parameters differed from baseline means. A mixed model ANOVA using R version 2.15.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and a random effect of *year* to account for variability in sediment quality data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1996 to 2009) or *after* the start of construction (2012). 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 2012 parameter mean was not significantly different from the baseline mean, it was concluded that there was no effect of 2012 Project activities on this parameter and no further statistical analysis results were discussed.

If before-after comparisons determined that there was evidence of a statistically significant difference in means, a BACI analysis was performed to determine if changes in exposure sites also occurred at reference sites. To test this, a mixed model ANOVA was run using the using R version 2.15.2, 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 appropriate baseline sediment data available for the reference lakes; therefore, BACI comparisons of lake sediment quality parameters were not possible, and only before-after comparisons were undertaken.

The key effect of interest in this BACI design is the interaction effect. If exposure site parameters increase or decrease 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 natural episodic events (e.g., higher than average stream flow) 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 baseline 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 1). Therefore, caution must be exercised when interpreting BACI comparisons between these sites.

For marine sediment quality parameters, the before-after trend for each exposure site was compared against the trend at the corresponding reference site (REF-Marine 1) for the BACI analysis. For stream sediment quality parameters, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2012 contributed some information on the year-effect, which improved the precision of the BACI estimate.

Like water quality, highly censored parameters (i.e., > 70% of data below detection limit) were considered unreliable and were not subjected to effects analysis. Censored data that were included in the analyses were substituted with one half the detection limit concentration. A complete description of the statistical effects analysis of sediment quality, including all methodology and results, is presented in Appendix B.

2.3.2.5 Primary Producers

Data Selection

Historical primary producer biomass (phytoplankton and periphyton) sampling has been conducted in the Doris North Project area since 1997 (Figure 2.3-3). The main criteria for the selection of historical periphyton and phytoplankton biomass data for inclusion in the evaluation of effects were the proximity of baseline sampling sites to 2012 AEMP sampling sites, and the comparability of sampling methodologies (e.g., phytoplankton biomass samples collected throughout the euphotic zone using an integrated sampler were excluded from the evaluation of effects as these were not comparable to the discrete surface samples collected in 2012). For Doris Lake South, historical phytoplankton biomass data collected in 1997 and 2000 were excluded from the evaluation of effects presented in the 2010 AEMP because the 1997 and 2000 sampling site was more than 1 km away to the north of the 2010 Doris Lake South sampling site (Figure 2.3-3). However, the Doris Lake South sampling site was moved slightly further to the north in 2011, and approximately 500 m away from the 1997 and 2000 sampling site. Therefore, these historical data were considered comparable to the 2012 phytoplankton biomass and were included in the 2012 evaluation of effects for Doris Lake South. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix B.

Effects Analysis

Graphs showing annual mean phytoplankton or periphyton biomass and comparing before-after trends at the exposure sites to before-after trends at the reference sites were used to identify trends and to supplement the results of the statistical analyses.

For each waterbody, a before-after comparison between the baseline biomass mean and the 2012 biomass mean was conducted (provided that baseline data were available). A mixed model ANOVA using R version 2.15.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season*, and random effect of *year* to account for variability in primary producer data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1996 to 2009) or *after* the start of construction (2012). For the *season* effect, samples were grouped into one of four seasons depending on the date of sample collection: 1) April or May (under ice), 2) July, 3) August, 4) September to account for within-year variability in biomass levels. 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 the 2012 mean periphyton or phytoplankton biomass was not significantly different from the baseline mean, it was concluded that there was no effect of Project activities on periphyton or phytoplankton biomass and no further statistical analysis results were discussed.

If the before-after comparison revealed that the 2012 biomass mean was different from the baseline mean, the next step of the analysis was to conduct a BACI analysis to determine if the observed change in the before-after mean was also seen at the reference site. A BACI analysis could only be performed if both baseline and 2012 data were available for both the exposure site and the reference site. The BACI 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 biomass that occurred at the exposure site was paralleled at 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. Note that BACI results are only discussed in the text if a difference is detected by the before-after analysis, but all BACI results are included in Appendix B.

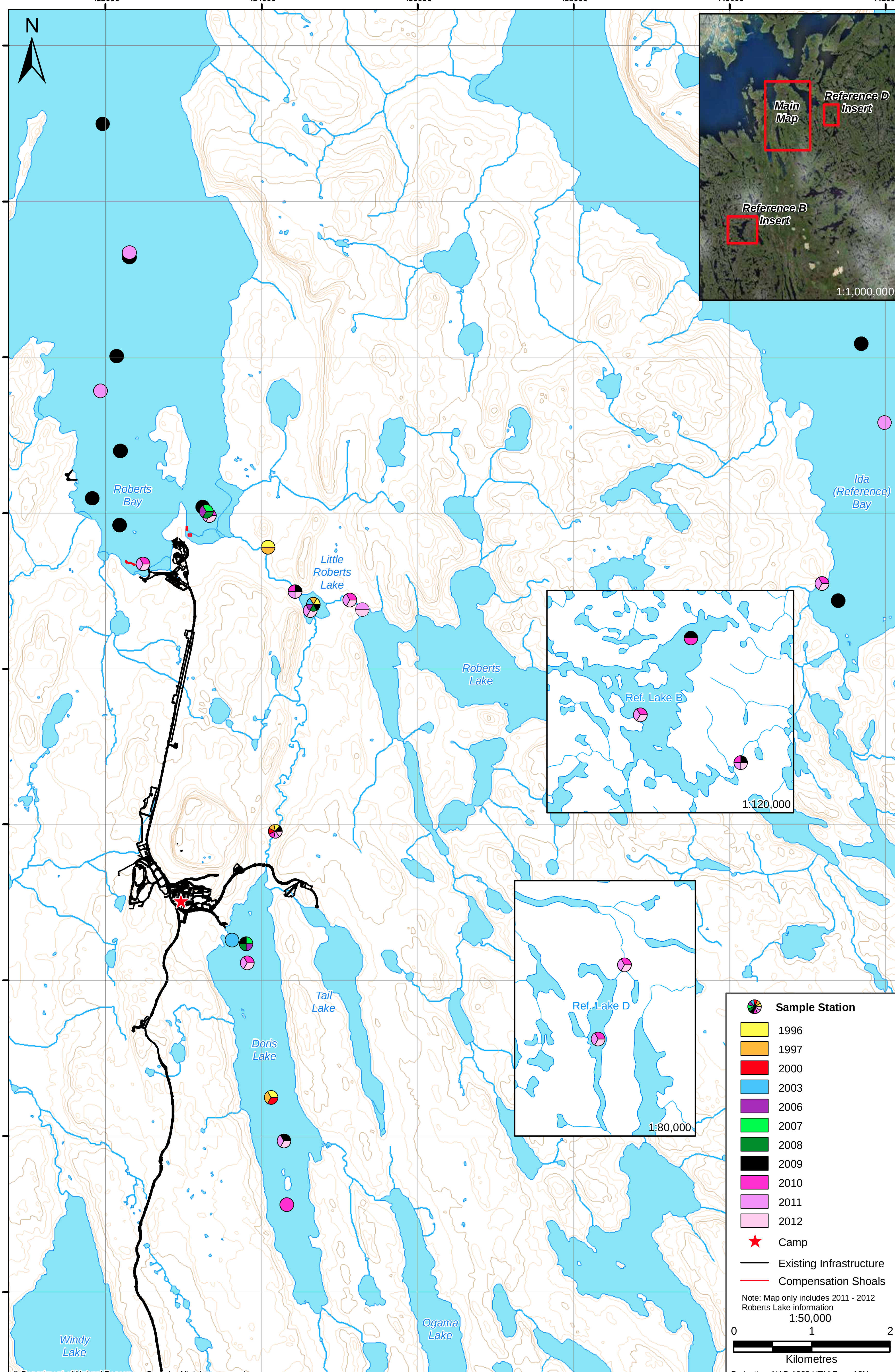

Figure 2.3-3

Historical Phytoplankton and Periphyton Sampling Stations in AEMP Waterbodies, Doris North Project, 1996 to 2012

NEWMONT. NORTH AMERICA

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Figure 2.3-3

For lake and marine phytoplankton biomass, the before-after trend for each exposure site was compared against the trend at the corresponding reference site for the BACI analysis. For stream periphyton biomass, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2012 contributed some information on the year-effect, which improved the precision of the BACI estimate.

All phytoplankton and periphyton biomass replicates collected on the same date were treated as pseudo-replicates and were averaged prior to graphical and statistical analysis. A complete description of the statistical analyses used to assess the construction effects on primary producer biomass, including methodology, results, and a list of outliers (only one outlier was identified: a periphyton chlorophyll *a* sample collected at Doris Outflow in 1997) is presented in Appendix B.

2.3.2.6 Benthos

Data Selection

Benthos data have been collected since 1996 in the Doris North Project area (Figure 2.3-4). Prior to 2010, historical benthos sampling consisted of collecting one to five replicates per site with no composite sampling. In 2010, 2011 and 2012, this approach was changed to accommodate the EEM methodologies as required under the Type A Water Licence for the Doris North Project. The 2010, 2011 and 2012 sampling procedure required the pooling of three subsamples per replicate, and the collection of five replicates per site. Because the pooling of subsamples for each replicate affects sample variability, as well as various diversity components (e.g., richness and evenness), baseline benthos community descriptors were not considered comparable to 2010, 2011 and 2012 data.

Effects Analysis

Because of methodological differences, no baseline benthos data are available for comparison against 2012 data; therefore, neither before-after nor BACI analyses were possible for benthos data. The absence of appropriate baseline data for benthos complicates the determination of potential effects of the Project on benthos community descriptors. Comparing reference site data to exposure site data is not an ideal approach because of the potential natural differences between sites that are unrelated to Project activities. A preferred approach recommended by Wiens and Parker (1995) is an impact level-by-time analysis, where the benthos trends at exposure sites are compared to the trends at reference sites to determine if there is evidence of non-parallelism over time (in this case, from 2010 to 2012). Because of the limited data available, evidence of non-parallelism between 2010 and 2012 may simply indicate patchiness in the environment or natural yearly variation and does not necessarily imply a Project-related effect. As more years of data become available, trends (if present) should become more apparent.

The impact level-by-time model included a *year* effect, a *class* effect (i.e., the classification of the waterbody as an exposure or a reference site), and a *year*class* interaction term, which is the effect of interest representing non-parallelism over time between the two classes of sites. This model was fit using R version 2.15.2. As with the other analyses, a reduced significance level (0.01) was used when reviewing the results to reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted. The complete methodology and results of the level-by-time analysis are provided in Appendix B.

For lake and marine benthos data, the 2010 to 2012 trend for each exposure site was compared against the trend at the corresponding reference site for the impact level-by-time analysis. For stream benthos data, the 2010 to 2012 trend for each exposure site was compared against the 2010 to 2012 trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the impact level-by-time analysis.

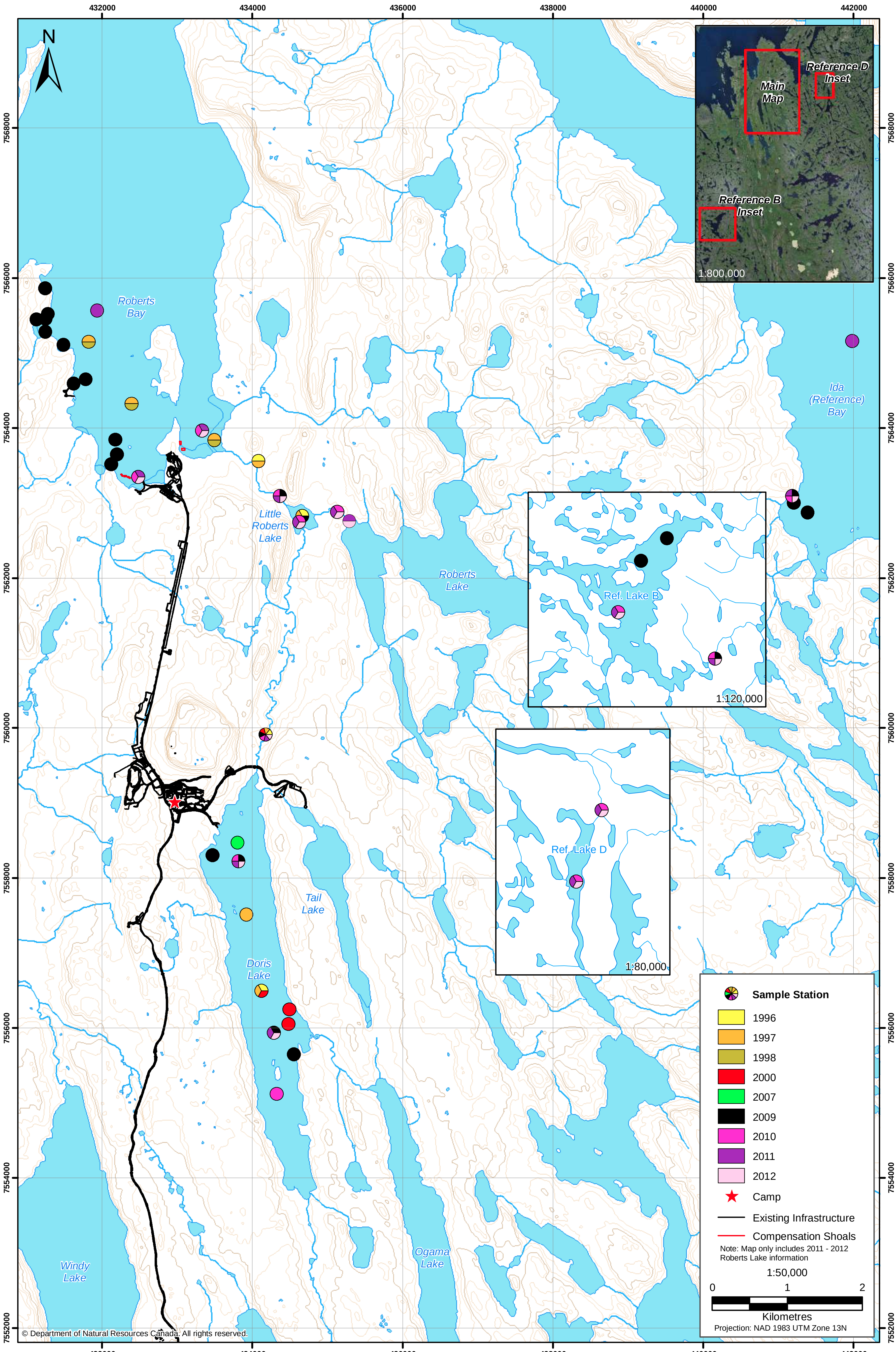

Figure 2.3-4

Historical Benthic Invertebrate Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2012

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Figure 2.3-4

3. Evaluation of Effects

3. Evaluation of Effects

3.1 UNDER-ICE DISSOLVED OXYGEN

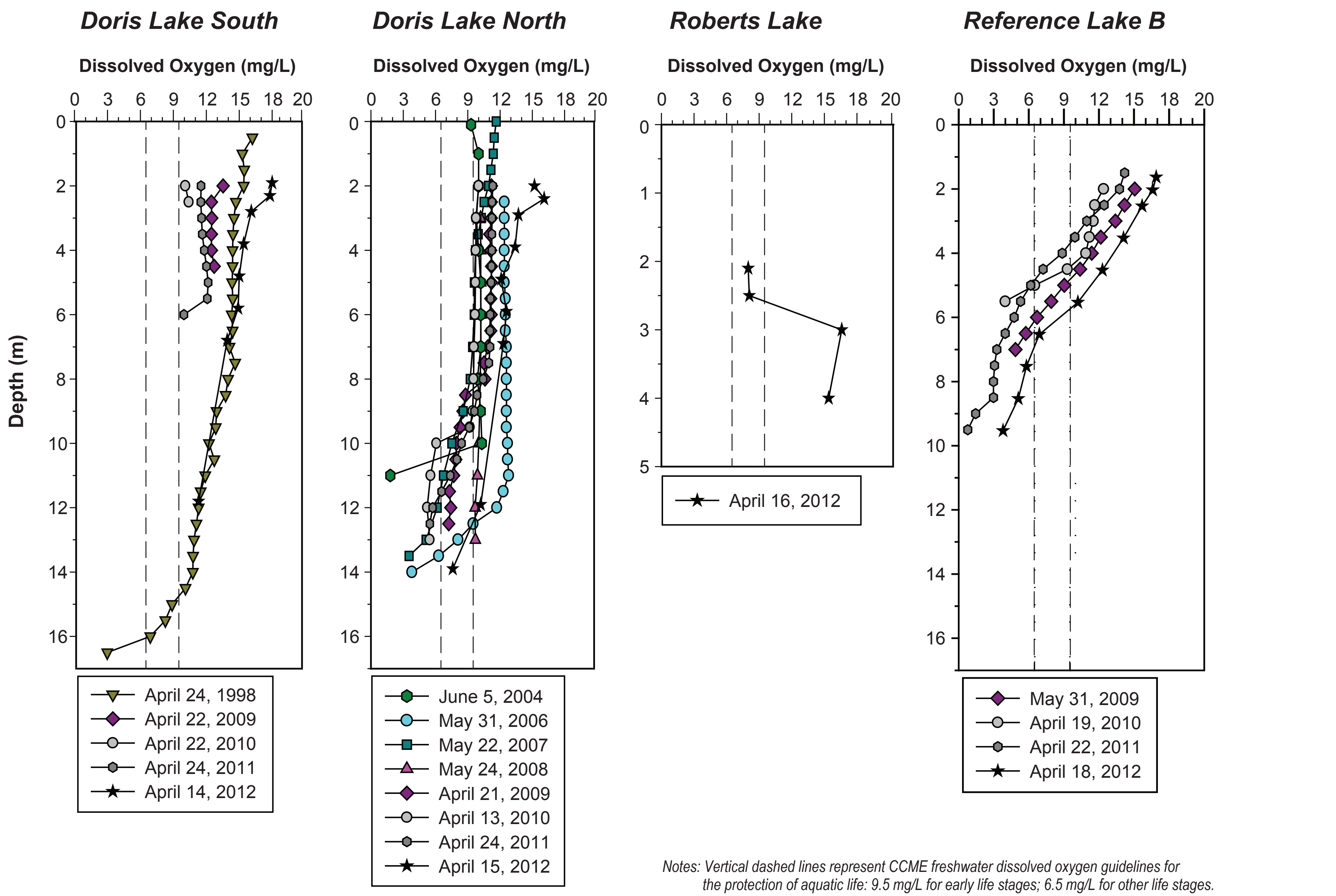
Potential effects on lake and ocean dissolved oxygen concentrations were evaluated using under-ice dissolved oxygen concentrations, since concentrations are lowest during this period and pose the greatest concern for aquatic life. Minimum oxygen levels are required for critical life stages of fish and other freshwater and marine organisms (CCME 2012b). Ice cover usually forms in October and November in the Doris North region, and under-ice oxygen profiles were collected in April 2012. The formation of the ice cover in November 2011 isolated lakes, streams, and Roberts Bay from any atmospheric inputs such as dust that could have been generated by Project activities between November 2011 and June/July 2012. Therefore, the water column that was profiled in April 2012 reflects activities from 2011 rather than 2012.

Figures 3.1-1, 3.1-2 and 3.1-3 present the 2012 and historical under-ice dissolved oxygen profiles for the lake and marine AEMP sites. 2012 under-ice profiles were collected in mid-April, and historical under-ice profiles were collected between late April and early June.

3.1.1 Lakes

The 2012 large lake (Doris South, Doris North and Reference B) dissolved oxygen profiles all fell within historical ranges, indicating no obvious Project effect. Although there are only two years of pre-2010 baseline data available for Doris Lake South, no obvious changes were apparent at this site, and all Doris South 2012 concentrations were above the CCME guideline for cold-water early life stages (9.5 mg/L; Figure 3.1-1). At Doris Lake North, historical (2004 to 2009) winter dissolved oxygen profiles have similar concentrations (9-12 mg/L) in the upper waters which decreased with depth to below the CCME guideline for cold-water early life stages (9.5 mg/L), and approached or dropped below the guideline for cold-water other life stages (6.5 mg/L) (Figure 3.1-1). 2012 dissolved oxygen profiles followed this general pattern. However, upper water concentrations were >12 mg/L. In fact, upper water dissolved oxygen concentrations in all the large lakes were higher in 2012 than historical concentrations (see Figure 3.1-1). Oxygen concentrations below the CCME guideline at depth 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 and was observed in three of the four large lake sites. 2012 was the first year where dissolved oxygen concentrations were determined in this near-shore region of Roberts Lake so comparison to previous years was not possible. However, all concentrations at this site were above CCME guidelines for cold-water other life stages (6.5 mg/L). In general, the April 2012 dissolved oxygen profiles were within the expected range of natural variability; hence, no adverse changes were detected.

The 2012 dissolved oxygen profile from the small exposure lake (Little Roberts Lake) fell within historical ranges, indicating no obvious Project effect. Winter dissolved oxygen concentrations varied widely at this shallow exposure site between 2006 and 2009 (range: <1 mg/L in May 2007 to 17.6 mg/L in May 2009; Figure 3.1-2). The 2012 concentrations fell within this wide range of baseline measurements. Like the large lakes directly under the ice, dissolved oxygen concentrations were higher than historical concentrations. However, all concentrations were above the CCME guideline for non-early life stages (6.5 mg/L). Therefore, no adverse changes to 2012 winter dissolved oxygen concentrations were apparent in Little Roberts Lake. In the shallow reference lake, Reference Lake D, the under-ice dissolved oxygen concentrations measured in April 2012 (1.4 to 3.9 mg/L) were below the CCME guideline for non-early life stages (6.5 mg/L), similar to the trend seen in 2011. Ice-covered shallow lakes are prone to large fluctuations in dissolved 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. Furthermore, data paucity at this site prevents analysis of trends or meaningful comparison to the corresponding exposure site.



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

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Figure 3.1-1

Winter Dissolved Oxygen Concentrations at AEMP Large Lake Sites, Doris North Project, 1998 to 2012

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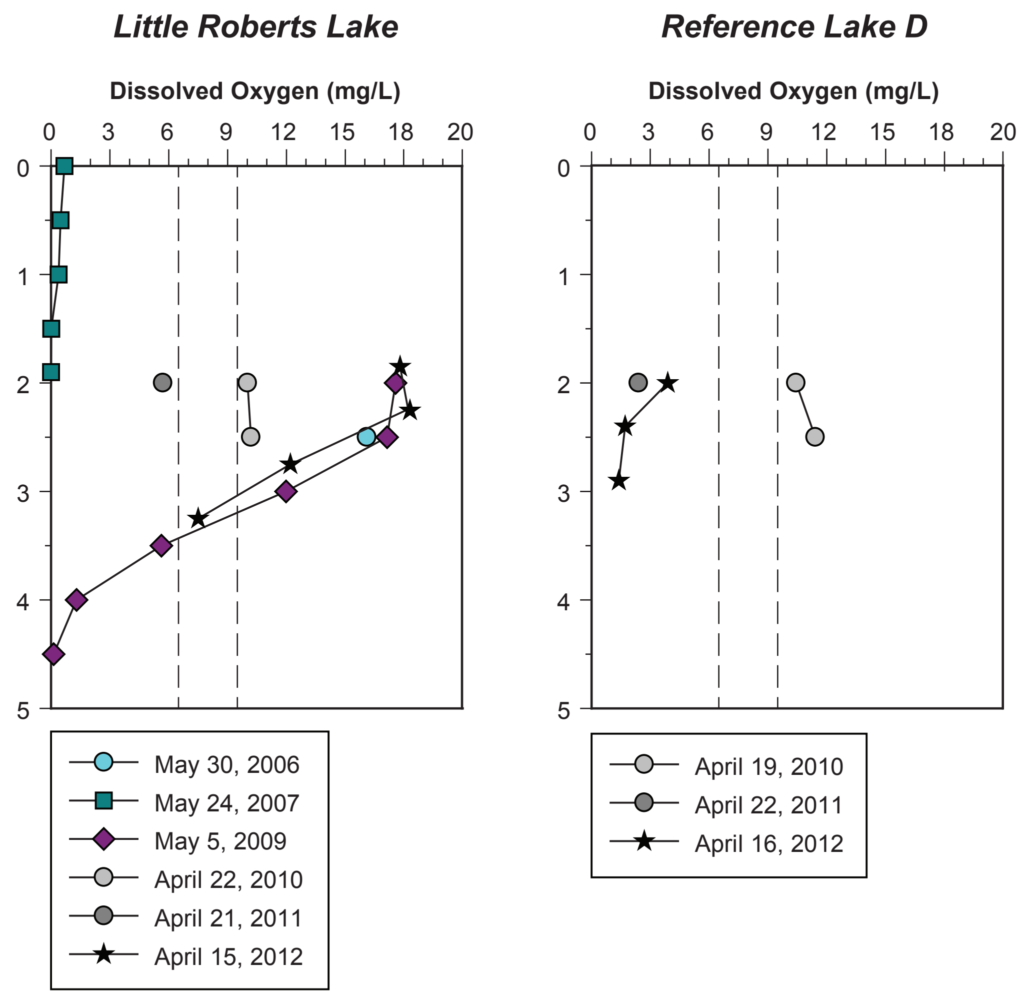

Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg/L for early life stages; 6.5 mg/L for other life stages.

Figure 3.1-2

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Winter Dissolved Oxygen Concentrations at AEMP Small Lake Sites, Doris North Project, 2006 to 2012

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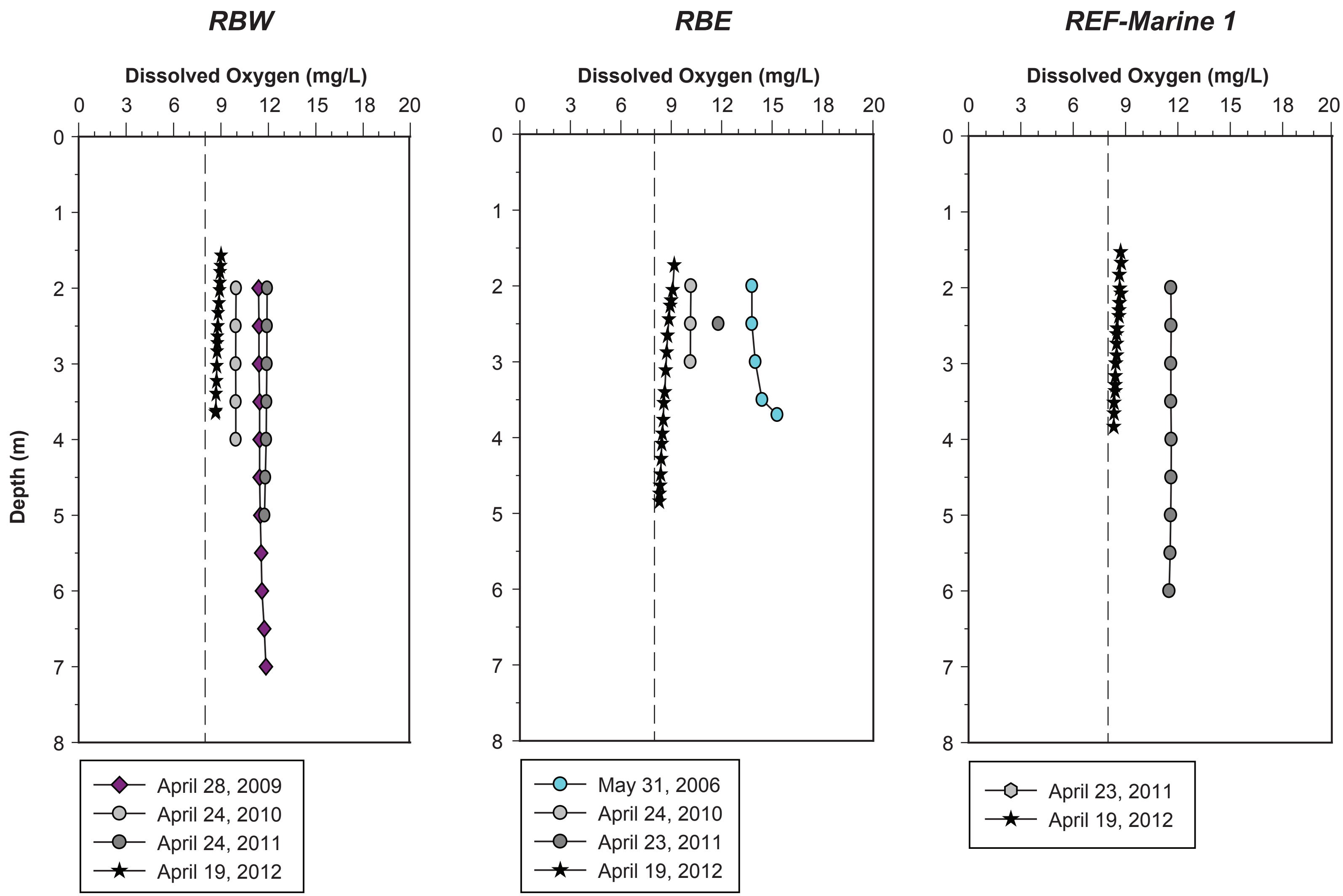

Notes: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).

Figure 3.1-3

NEWMONT NORTH AMERICA

Winter Dissolved Oxygen Concentrations at AEMP Marine Sites, Doris North Project, 2006 to 2012

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3.1.2 Marine

In the marine sites, there was no evidence of Project activities on marine dissolved oxygen levels. 2012 under-ice dissolved oxygen concentrations were similar (~9 mg/L) at all marine exposure and references sites (Figure 3.1-3). These concentrations were all above the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters for the protection of aquatic life (8.0 mg/L). Historical concentrations recorded in 2006 at RBE and 2009 and RBW were slightly higher than 2012 concentrations. However, since there was no difference between exposed and reference sites, there is no evidence of adverse effects on marine dissolved oxygen concentrations as a result of Project activities.

3.2 SECCHI DEPTH

Secchi depth, a measure of water transparency, was evaluated for lake sites to determine whether there was any evidence that 2012 Project activities negatively affected lake water clarity. The results of all statistical methods and analyses for the evaluation of effects for Secchi depth in lakes are provided in Appendix B.

The 2012 Secchi depth at the shallow marine sites RBE and RBW almost always (5 or 6 times) reached the bottom, indicating that light was able to penetrate the entire water column. As water clarity at marine sites was high in 2012, Secchi depth was not evaluated for RBE and RBW.

3.2.1 Lakes

Figure 3.2-1 shows the mean annual Secchi depth at lakes sites between 1995 and 2012. Mean Secchi depth was similar among years and among exposure lakes, generally ranging between 0.7 and 2.7 m at Doris Lake South, Doris Lake North, Roberts Lake and Little Roberts Lake. The Secchi depth recorded at Doris Lake South in August 2000 (4.2 m) was higher than other years. Secchi depths were generally higher at the reference lakes, ranging from 3.0 to 9.0 m in Reference Lake B and from 1.5 to 3.4 m in Reference Lake D.

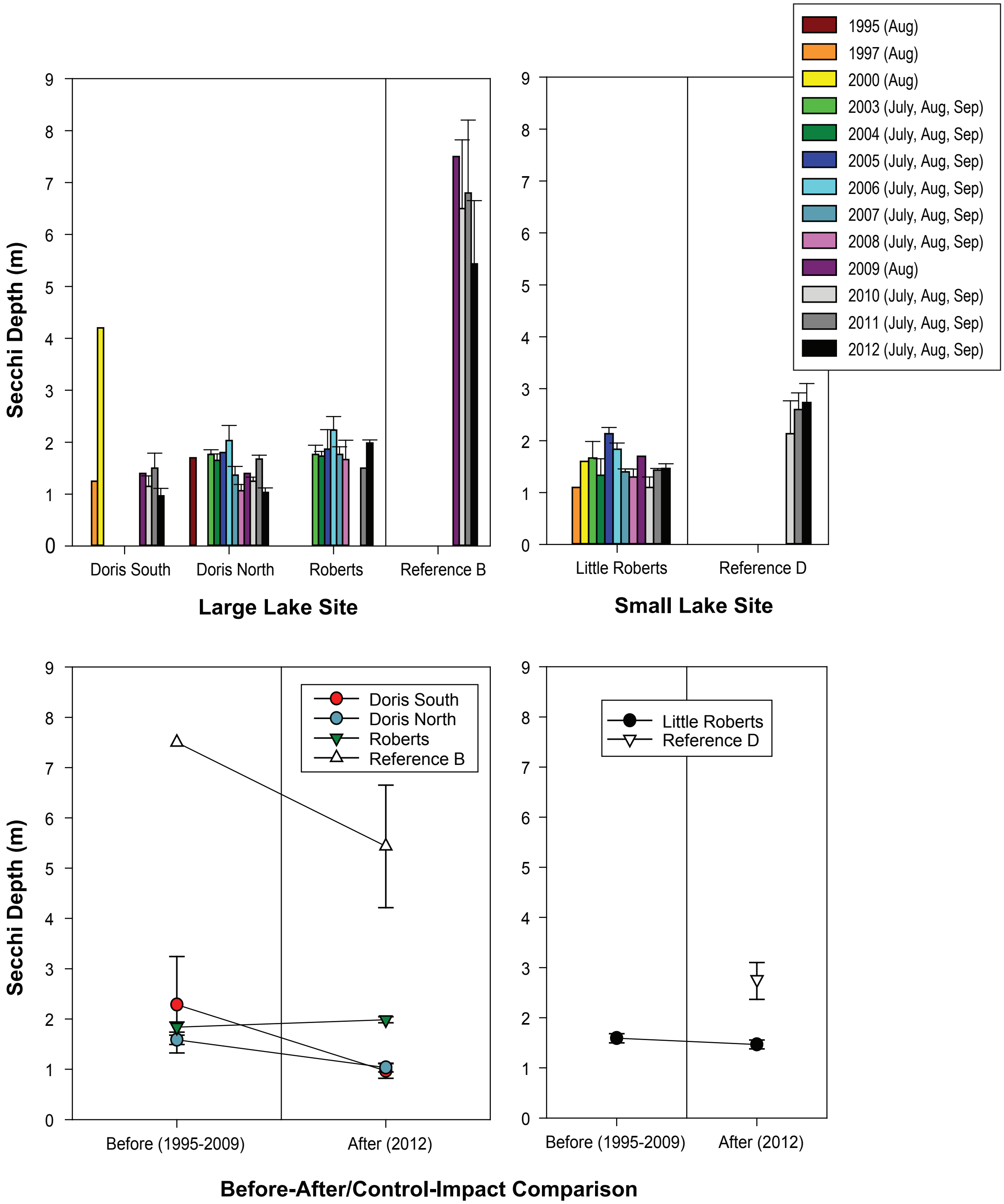
Mean 2012 Secchi depths in the exposure lakes were within the range of baseline measurements. There was no analysis of the small lakes because the Secchi depth always reached the bottom, indicating that light was able to penetrate the entire water column. As water clarity in the both small lakes was high in 2012, there was no apparent effect of 2012 Project activities on lake Secchi depth.

Although a before-after analysis was not possible for Reference Lake B because there was too few degrees of freedom in the before period (Appendix B), the before-after comparison of the large lakes indicated that the 2012 mean Secchi depth in the large exposure lakes was not distinguishable from the baseline mean Secchi depth ($p = 0.50$ for Doris Lake South and $p = 0.10$ for Doris Lake North). Therefore, there was no apparent effect of 2012 Project activities on lake Secchi depth.

3.3 WATER QUALITY

A specific set of water quality parameters (see Table 2.3-1) was evaluated to determine whether 2012 Project activities resulted in adverse changes to water quality. Historical data collected from 1995 to 2009 were included in the effects analysis.

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 B.



Notes: Error bars represent the standard error of the mean.
The Secchi depth at Reference Lake D on September 25, 2010 reached the lake bottom, so the bottom depth of 3.4 m was used as an estimate of the Secchi depth.

Figure 3.2-1

Secchi Depth in AEMP Lake Sites, Doris North Project, 1995 to 2012

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Water quality parameters were compared to CCME water quality guidelines for the protection of aquatic life (CCME 2012b) 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.

3.3.1 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 2012. For the exposure streams, relevant baseline 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 baseline data were from 2009, and no pre-2010 baseline data were available for Reference D Outflow. Graphs showing water quality trends in streams over time are shown in Figures 3.3-1 to 3.3-18. All statistical results are presented in Appendix B.

3.3.1.1 pH

pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. Mean 2012 stream pH levels were slightly higher in exposure streams (mean: 7.7) than reference streams (both with means of 7.5). However, 2012 pH levels in the exposure stream were within the range of baseline levels (Figure 3.3-1). The before-after comparison confirmed that the baseline (1996-2009) mean pH was not distinguishable from the 2012 mean pH in any exposure stream ($p = 0.13$ for Doris Outflow, $p = 0.17$ for Roberts Outflow, and $p = 0.04$ for Little Roberts Outflow). Therefore, there was no effect of 2012 Project activities on the pH of exposure streams. 2012 pH levels in exposure and reference streams were always within the recommended CCME guideline range of 6.5 to 9.0 (Figure 3.3-1).

3.3.1.2 Total Alkalinity

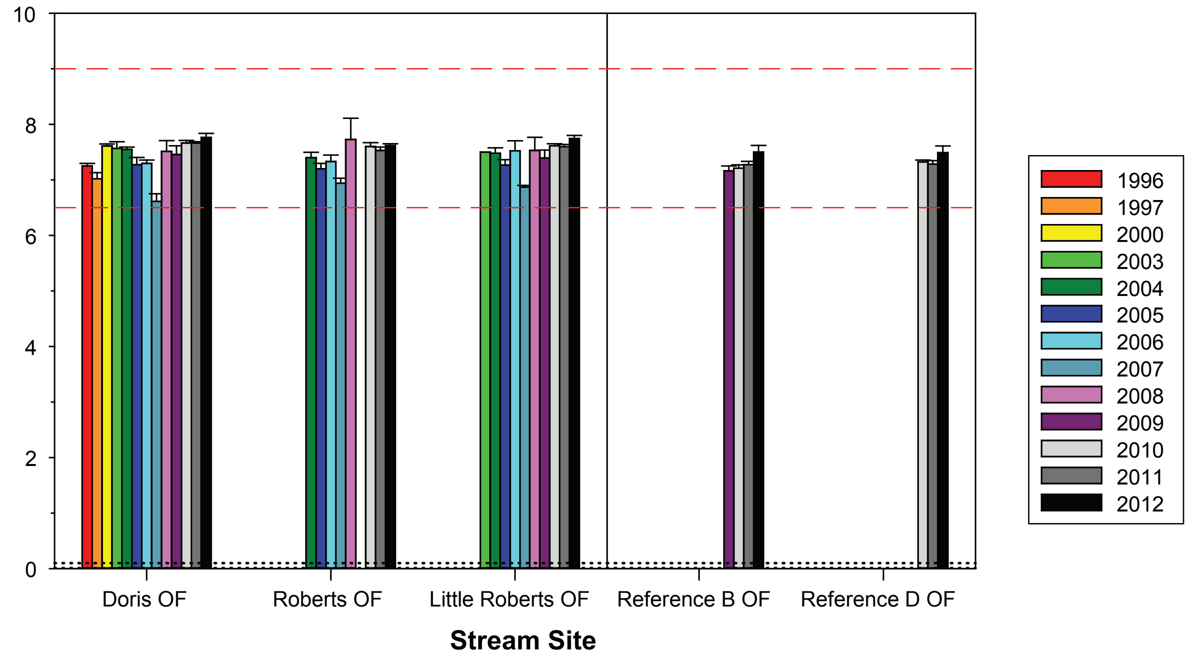
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Total alkalinity (as $CaCO_3$) varied among streams with consistently higher concentrations in the exposure streams (Figure 3.3-2). However, total alkalinity levels in the exposure streams in 2012 were within baseline ranges, except for Doris Outflow which had the highest alkalinity observed for that stream (30 mg/L). The before-after comparison confirmed that only the mean baseline alkalinity in Doris Outflow was statistically different from the mean 2012 alkalinity ($p = 0.003$ for Doris Outflow, $p = 0.64$ for Roberts Outflow, and $p = 0.34$ for Little Roberts Outflow). A further BACI comparison found parallel changes in total alkalinity between Doris Outflow and the reference stream (Reference B Outflow; $p = 0.32$). As a result, there was no effect of 2012 Project activities on exposure stream alkalinity.

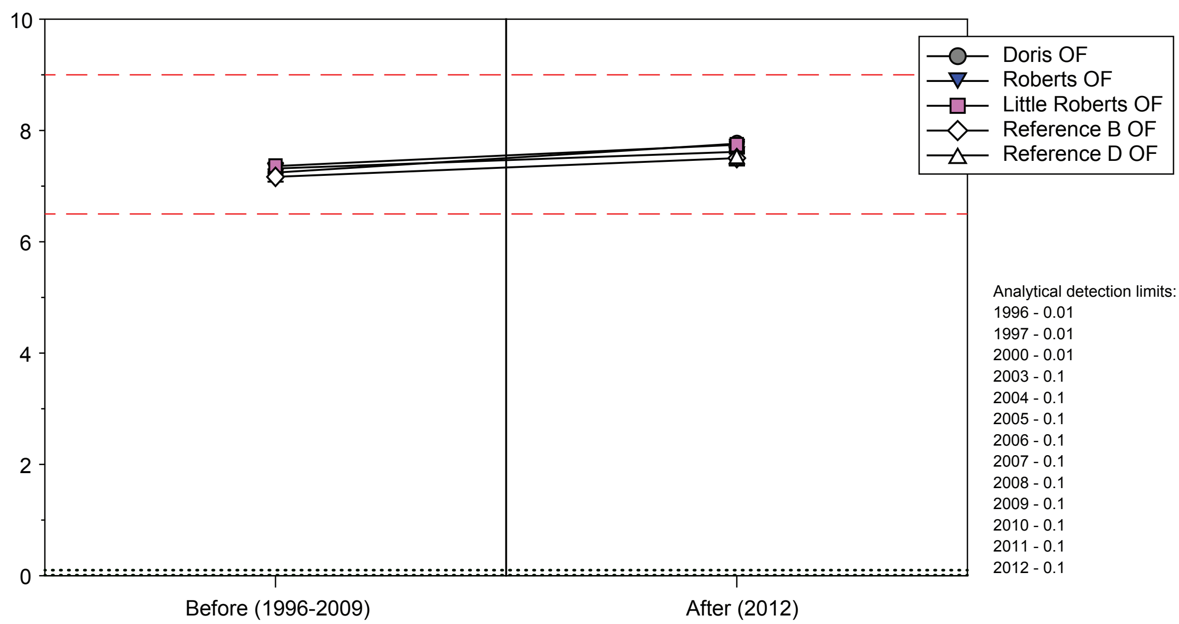
3.3.1.3 Hardness

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, with consistently higher concentrations in the exposure streams (Figure 3.3-3). The 2012 hardness levels in the exposure streams were within baseline ranges. The before-after comparison indicated that only the Doris Outflow 2012 mean was distinguishable from its baseline mean ($p = 0.0032$ for Doris Outflow, $p = 0.37$ for Roberts Outflow, and $p = 0.19$ for Little Roberts Outflow). However, a BACI comparison found parallel changes in the hardness of the reference stream (Reference B outflow; $p = 0.15$); as such, there was no apparent effect of 2012 Project activities on stream hardness.

3.3.1.4 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 3.3-4). It is therefore difficult to distinguish natural variability from potential effects resulting from Project activities.





Before-After/Control-Impact Comparison

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME freshwater 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 Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-1

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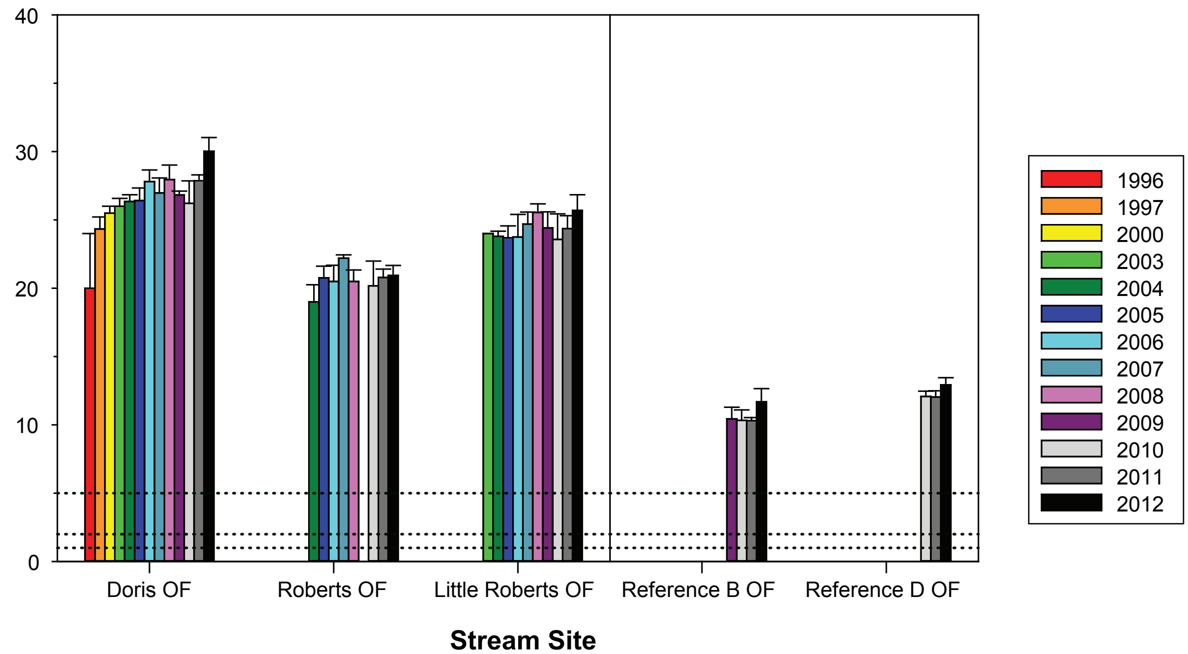

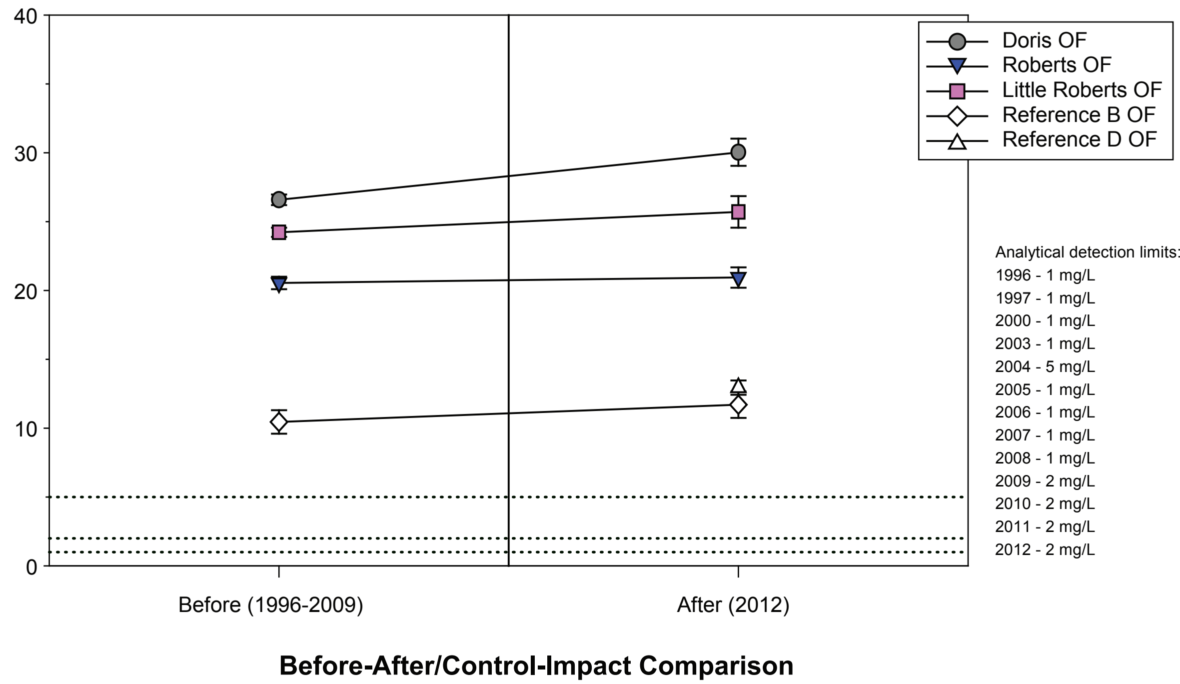

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as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

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Total Alkalinity in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-2

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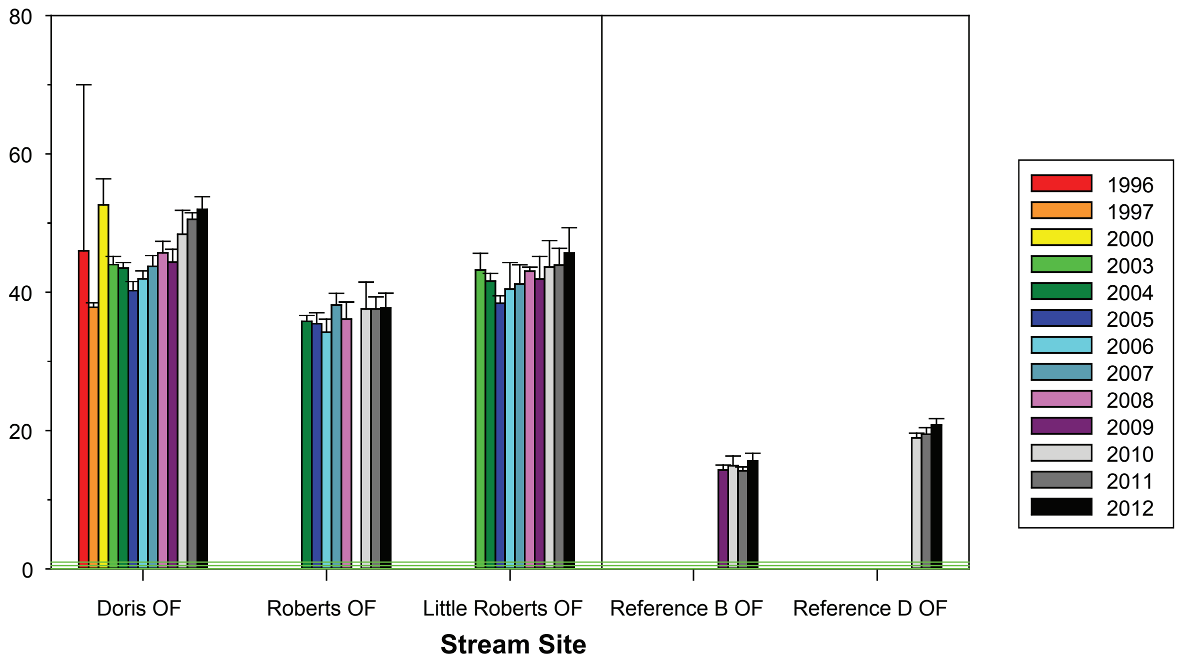

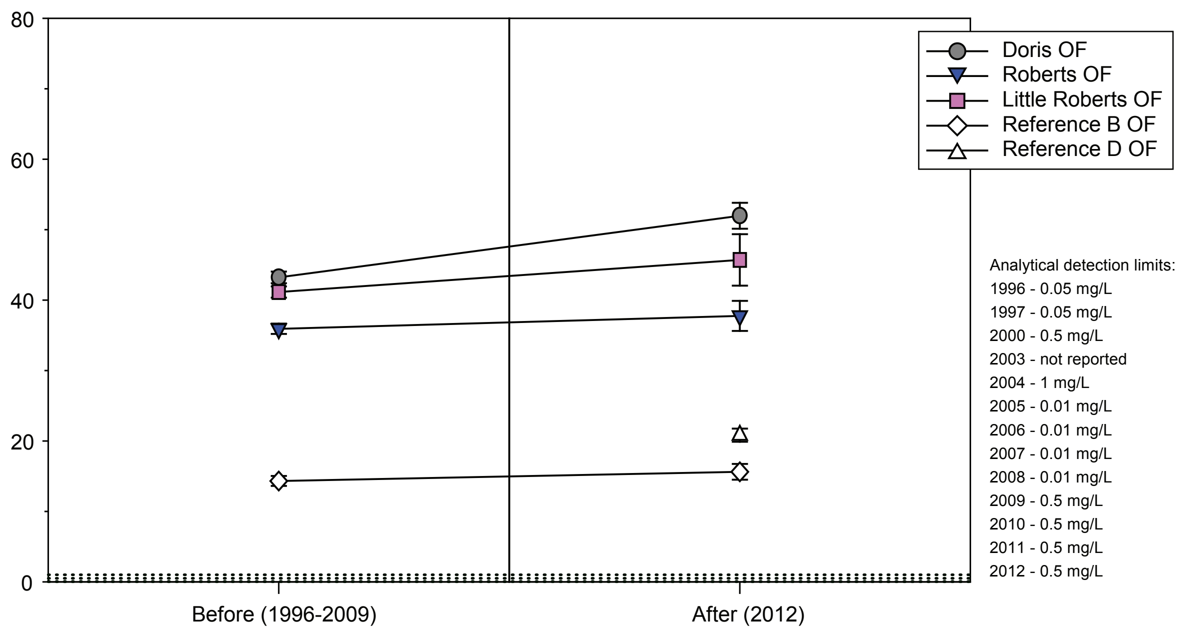

Before-After/Control-Impact Comparison

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.

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Hardness in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-3

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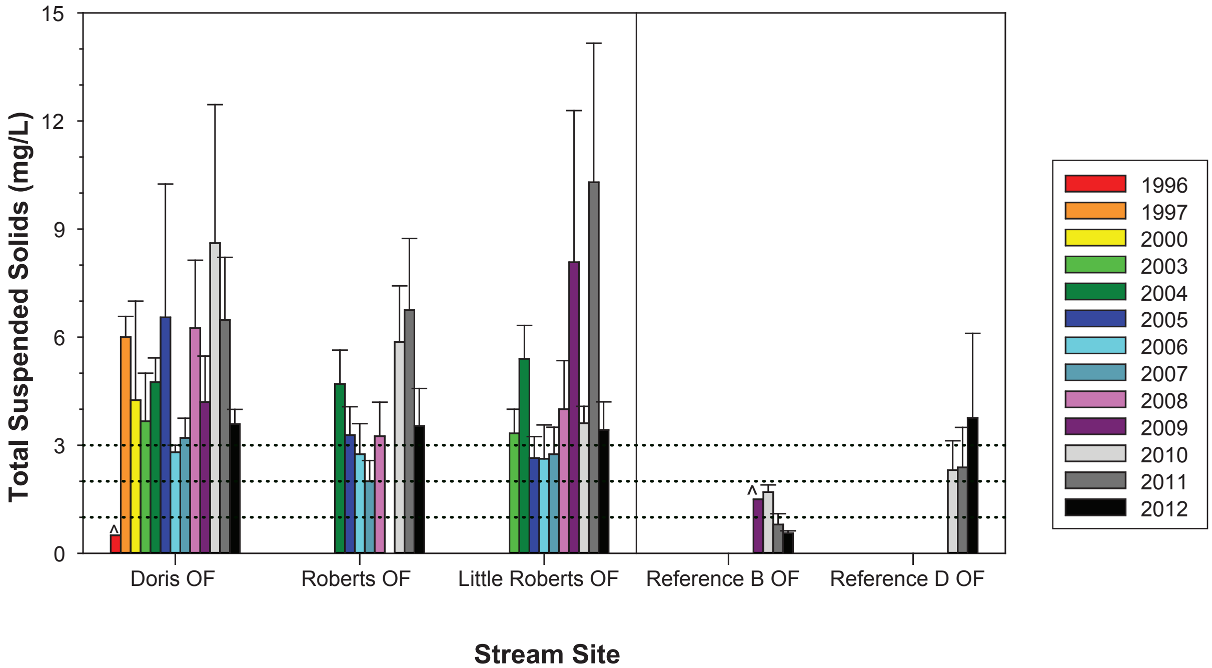

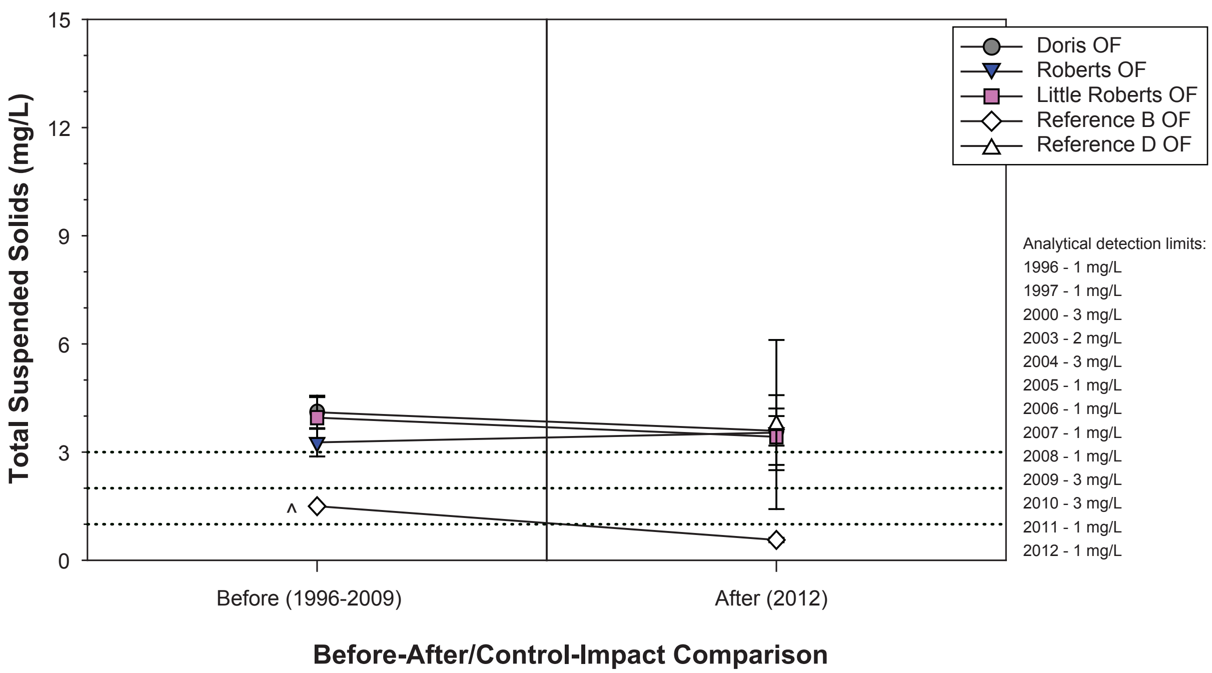

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline 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 Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-4

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The mean 2012 TSS concentrations in the exposed streams were similar to each other (range: 3.43 to 3.59 mg/L). Furthermore, the mean 2012 TSS concentrations in all three exposed streams (Doris, Roberts and Little Roberts Outflows) were within the range of the baseline means (Figure 3.3-4) and there was no evidence of a difference between 2012 and baseline in any of the exposure streams ($p = 0.84$ for Doris Outflow, $p = 0.48$ for Roberts Outflow and $p = 0.59$ for Little Roberts Outflow). Therefore, there was no significant effect of 2012 Project activities on TSS concentrations in the exposure streams.

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 2012b). Because there was no significant increase in TSS concentrations from baseline levels in Doris, Roberts or Little Roberts outflows, 2012 TSS concentrations in these streams were below the CCME guideline.

3.3.1.5 Total Ammonia

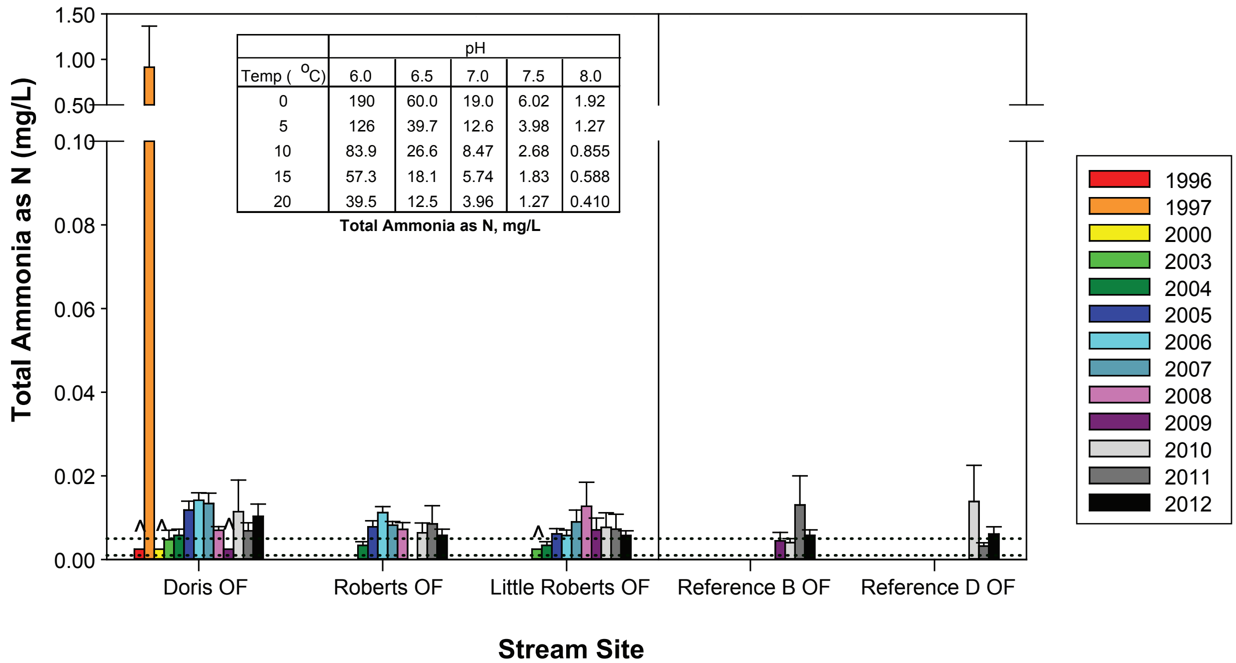
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Concentrations of total ammonia were variable within each stream over time and yet mean 2012 concentrations were remarkably similar between exposure and reference streams (exposure = 0.0073, reference = 0.0060). 2012 concentrations of total ammonia in exposure and reference streams were always well below the pH- and temperature-dependent CCME guideline (Figure 3.3-5).

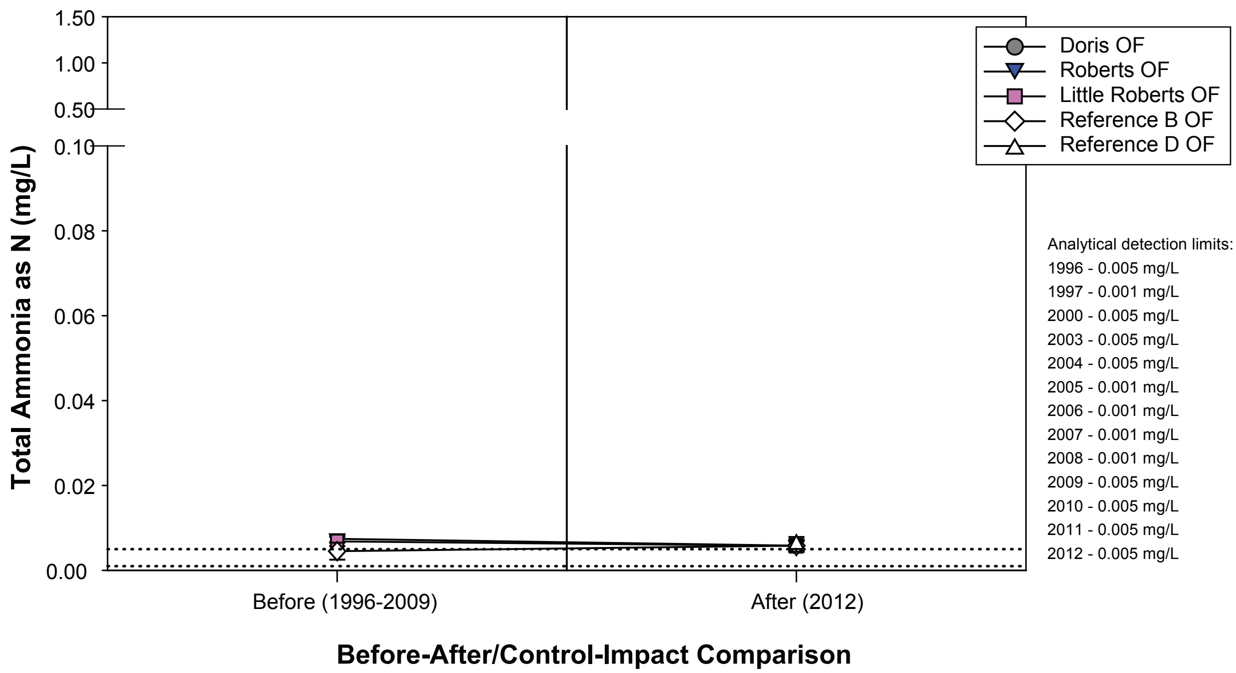
For each exposure stream, the mean 2012 total ammonia concentration was within the range of the baseline mean (Figure 3.3-5), suggesting that there was no effect of Project activities on ammonia concentrations. The before-after analysis confirmed no difference between 2012 and baseline means in any exposure stream ($p = 0.72$ for Doris Outflow, $p = 0.86$ for Roberts Outflow, and $p = 0.81$ for Little Roberts Outflow).

3.3.1.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All nitrate concentrations were well below the interim CCME guideline of 2.935 mg/L (Figure 3.3-6). All of 2012 Doris Outflow nitrate concentrations were below the analytical detection limit of 0.005 mg/L, while mean 2012 nitrate concentrations were elevated at the other two exposure sites. Nitrate concentrations at Little Roberts Outflow were higher than previous years, while concentrations at Roberts Outflow were higher than concentration in 2003, 2006, 2008, 2010 and 2011.

Pre-2010 measurements of nitrate were typically below detection limits, except for a few sporadically elevated readings (Figure 3.3-6). The before-after analysis indicated that mean 2012 nitrate concentrations were significantly lower than baseline means in Doris Outflow. However, a decrease in nitrate is not of concern. The same analysis found 2012 means to be significantly higher than baseline means in Roberts and Little Roberts and Reference B outflows ($p < 0.0001$ for both exposure streams and $p = 0.0065$ for Reference B Outflow). A further BACI comparison found non-parallel changes in the nitrate concentrations between Roberts and Little Roberts Outflows and Reference B Outflow ($p <0.0001$, $p = 0.0001$, respectively). The BACI interaction was significant because the increase that occurred in Reference B Outflow was greater than the increase in that occurred in Roberts Outflow or Little Roberts Outflow. Therefore, the increased concentrations of nitrate observed at Roberts and Little Roberts Outflow cannot be attributed to 2012 Project activities, since there were greater increases at Reference B Outflow over time. Results from 2012 indicate that on-site management of surface waters and quarry rock were successful in keeping ammonium nitrate salt and residues out of surface waters.





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 freshwater 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 Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-5

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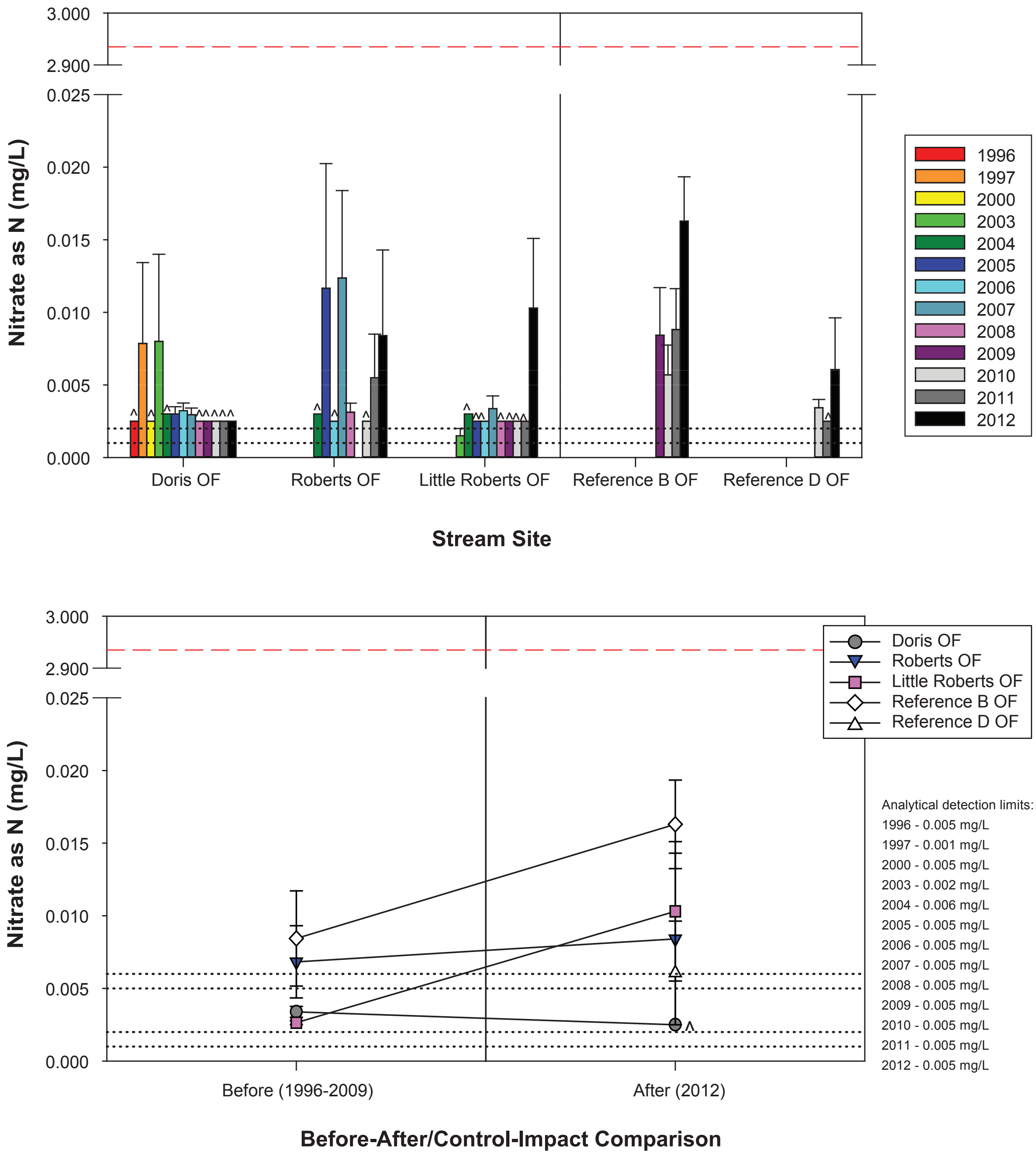

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME freshwater 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 Concentrations in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-6

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3.3.1.7 Total Cyanide

Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. All 2012 cyanide concentrations in exposure and reference streams were below the analytical detection limit of 0.001 mg/L (Figure 3.3-7). These very low concentrations were similar to baseline concentrations, and the before-after analysis confirmed that there was no difference between 2012 and baseline means in any exposure stream ($p = 0.63$ for Doris Outflow, $p = 0.31$ for Roberts Outflow, and $p = 0.32$ for Little Roberts Outflow). Therefore, there was no effect of Project activities on total cyanide concentrations in the exposed streams.

Free cyanide concentrations (cyanide existing in the form of HCN and CN-) in stream samples were also measured in 2012 to allow for direct comparisons with the CCME guideline (0.005 mg/L as free cyanide). The 2012 free cyanide concentrations in the stream samples were always below the detection limits (0.001 mg/L) and the CCME guideline for free cyanide (Appendix A). There was no effect of Project activities on free cyanide concentrations in the exposed streams.

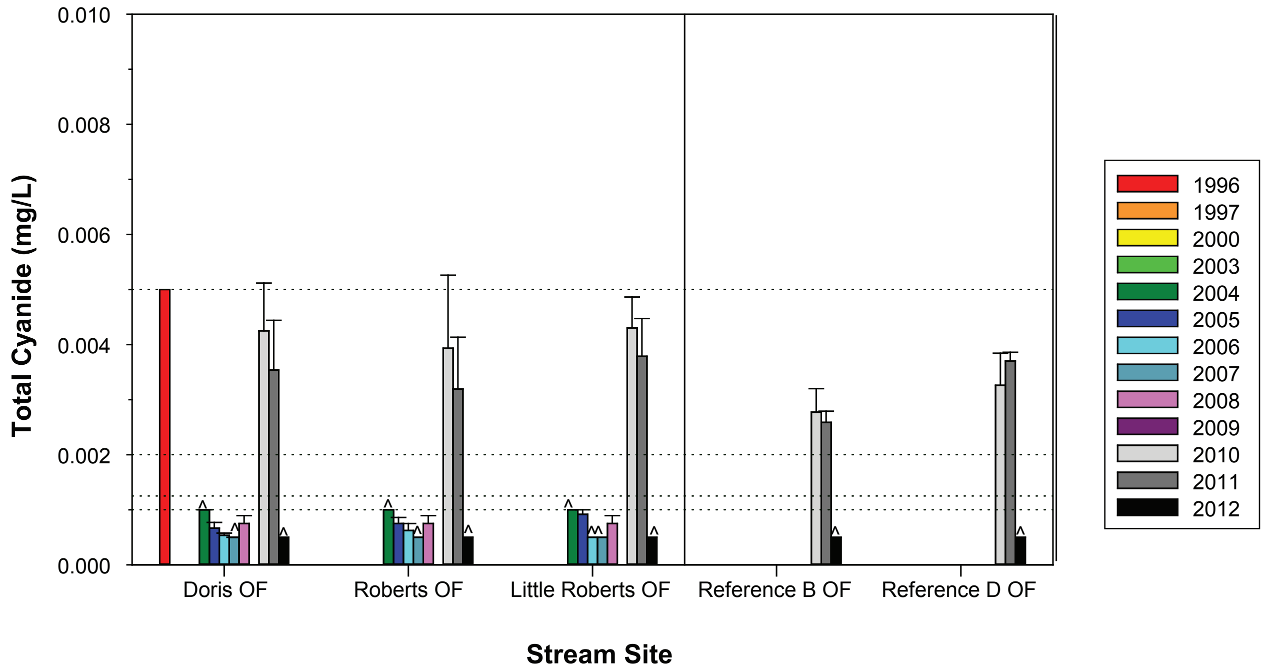
3.3.1.8 Radium-226

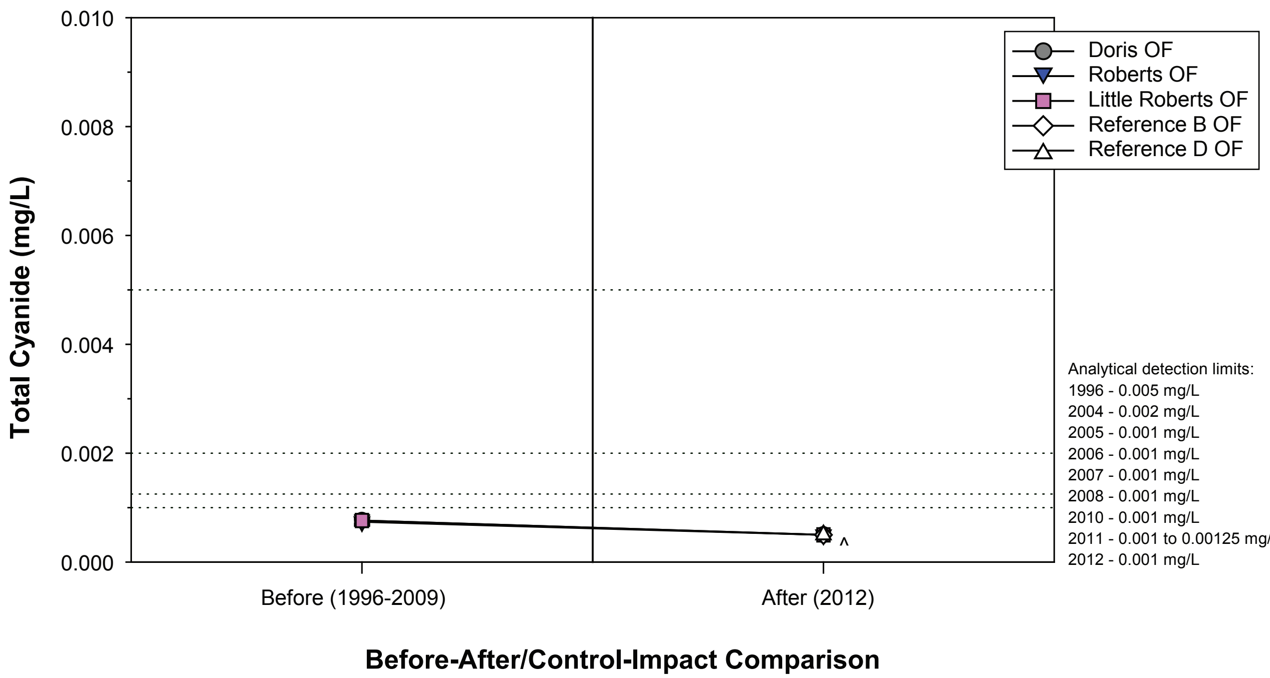
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In both exposure and reference streams, more than 90% of radium-226 concentrations measured during 2012 were below the analytical detection limits of 0.005 or 0.010 Bq/L. The remaining samples were slightly above this detection limit, except for one Reference B Outflow sample that was 0.060 Bq/L (Figure 3.3-8). Baseline concentrations were similarly near or below the detection limit of 0.005 Bq/L. The before-after plot suggests that Radium-226 concentrations increased in Roberts Outflow. However, the 2012 concentrations are within the range observed in the reference streams. Statistical analysis was not recommended for total radium-226, since greater than 70% of baseline and 2012 concentrations were below the analytical detection limits. Since radium-226 concentrations were either similar to those in the reference streams or below the detection limit, it is concluded that 2012 Project activities had no effect on radium-226 concentrations.

3.3.1.9 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 Roberts Outflow, mean 2012 total aluminum concentrations were higher than the pH-dependent CCME guideline of 0.1 mg/L. However, this guideline was frequently exceeded in all exposure streams during baseline years, particularly in Roberts and Little Roberts outflows where nearly all baseline mean concentrations were higher than this CCME guideline (Figure 3.3-9).

The before-after plot shows that mean 2012 total aluminum concentrations in all exposure streams were lower than baseline means (Figure 3.3-9). The before-after analysis confirmed that there was no significant difference in the baseline mean compared to the 2012 mean for any exposure stream ($p = 0.53$ for Doris Outflow, $p = 0.08$ for Roberts Outflow, and $p = 0.012$ for Little Roberts Outflow). This suggests that Project activities in 2012 did not affect total aluminum concentrations in exposure streams.





Analytical detection limits:
1996 - 0.005 mg/L
2004 - 0.002 mg/L
2005 - 0.001 mg/L
2006 - 0.001 mg/L
2007 - 0.001 mg/L
2008 - 0.001 mg/L
2010 - 0.001 mg/L
2011 - 0.001 to 0.00125 mg/L
2012 - 0.001 mg/L

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 cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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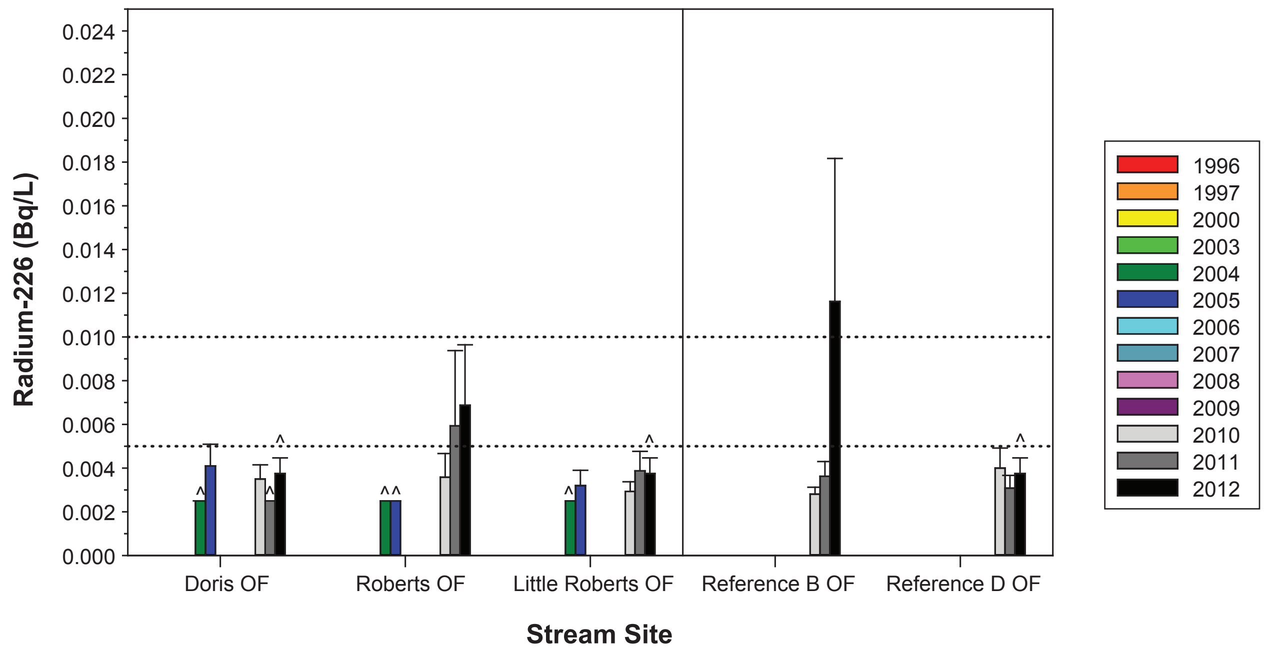
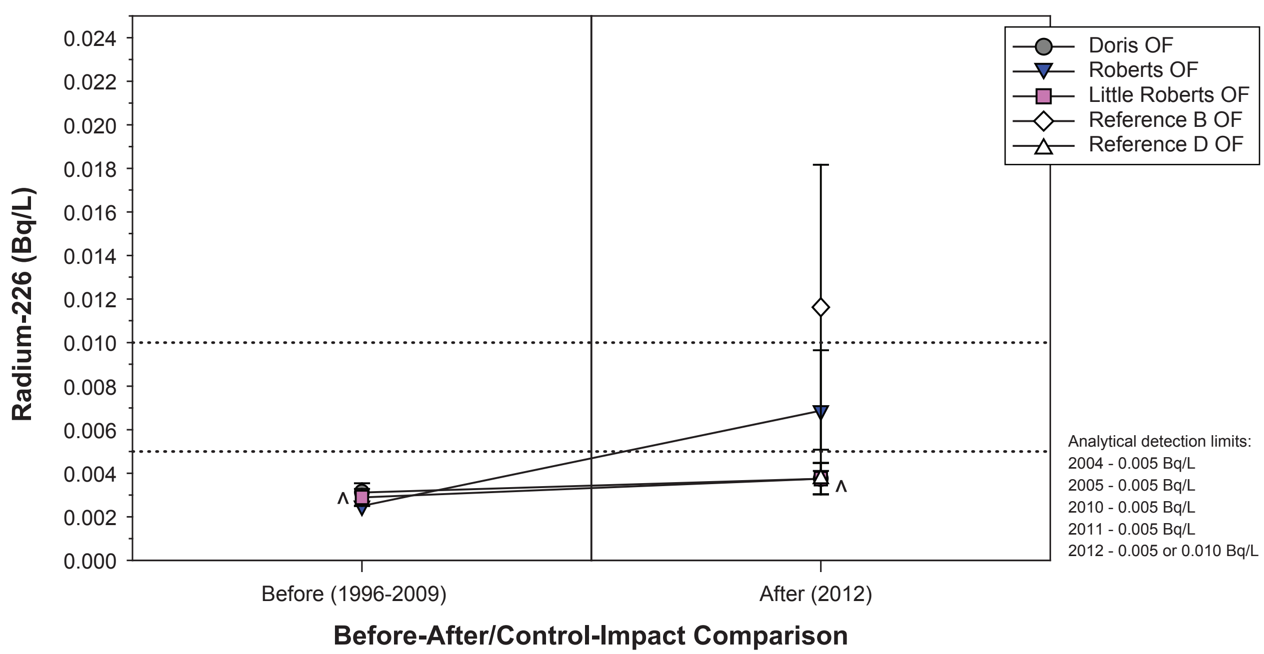
Total Cyanide Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-7

Rescan Engineers & Scientists





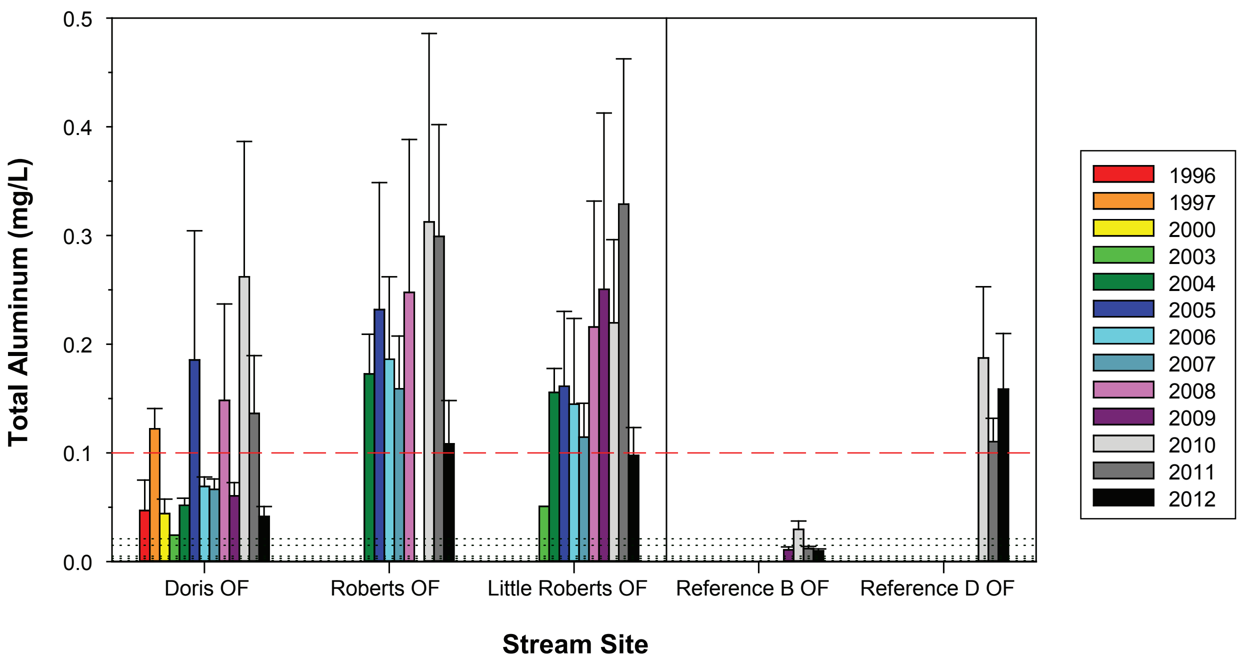
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated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

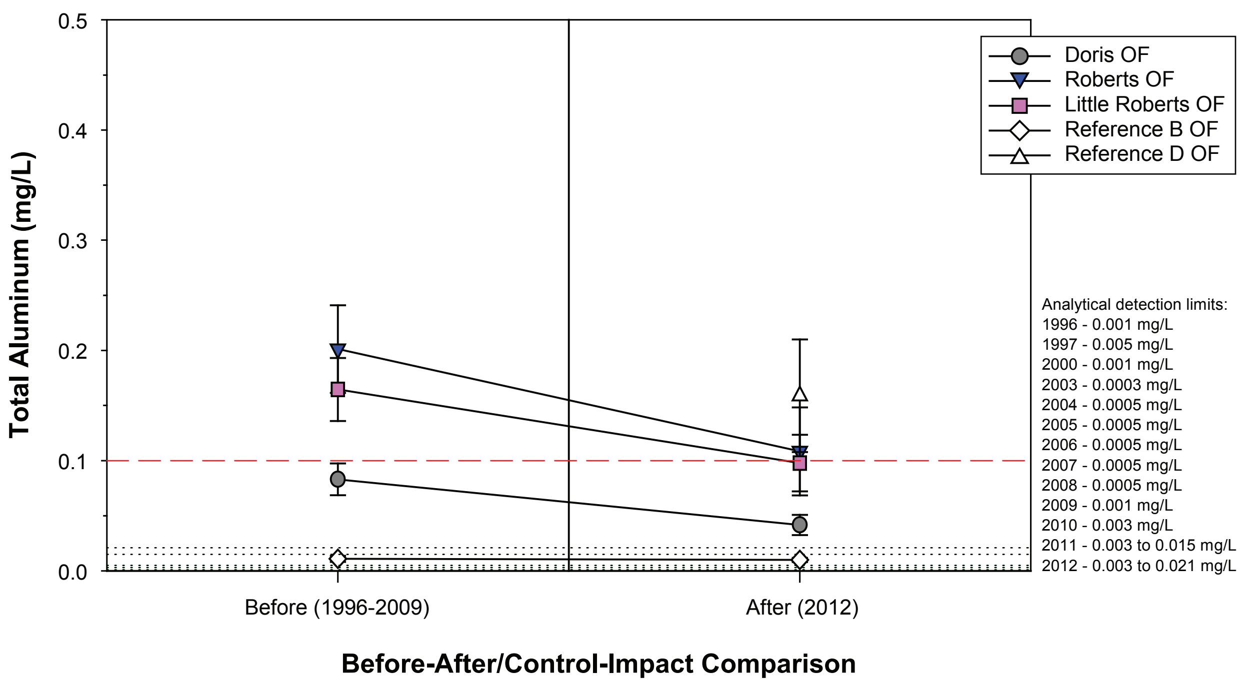
NEWMONT NORTH AMERICA

Radium-226 Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-8

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.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5).
Mean annual pH levels were greater than 6.5 in all exposure and reference streams.
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 Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-9

Rescan Engineers & Scientists

3.3.1.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2012, mean concentrations of total arsenic were similar among all streams (Figure 3.3-10), but were higher than concentrations measured in any previous years (except 1996 Doris Outflow). However, mean total arsenic concentrations in all stream samples were still substantially lower than the CCME guideline of 0.005 mg/L. The before-after comparison confirmed that there was a significant increase in arsenic concentrations in Roberts Outflow and Reference B Outflow ($p = 0.005$ for Roberts Outflow, $p < 0.0001$ for Reference B Outflow while $p = 0.30$ Doris Outflow and $p = 0.16$ Little Roberts Outflow). Consequently, a further BACI comparison found parallel changes in the concentration of total arsenic between Roberts Outflow and the reference streams ($p = 0.02$); as such there was no apparent Project related increase in arsenic concentrations.

3.3.1.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. With one exception, all total cadmium concentrations measured in streams during 2012 were below the analytical detection limit of 0.000005 mg/L. The total cadmium concentrations at all exposure streams were below the hardness-dependent CCME guideline for cadmium (Figure 3.3-11). There was therefore no evidence of a Project-related increase in cadmium concentrations between baseline years and 2012 since the only increase above baseline occurred in Reference B Outflow (Figure 3.3-11). Before-after results were not presented for cadmium because of the high proportion of concentrations that were below detection limits in the datasets for exposure streams rendering statistical results unreliable.

3.3.1.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In all exposure streams, mean 2012 copper concentrations were within the range of baseline means and below the hardness-dependent CCME guideline (Figure 3.3-12). The before-after analysis confirmed that there was no evidence of an increase in the mean copper concentration between baseline years and 2012 in any exposure stream site ($p = 0.98$ for Doris Outflow, $p = 0.77$ for Roberts Outflow, and $p = 0.73$ for Little Roberts Outflow). Therefore, there was no effect of 2012 Project activities on total copper concentrations.

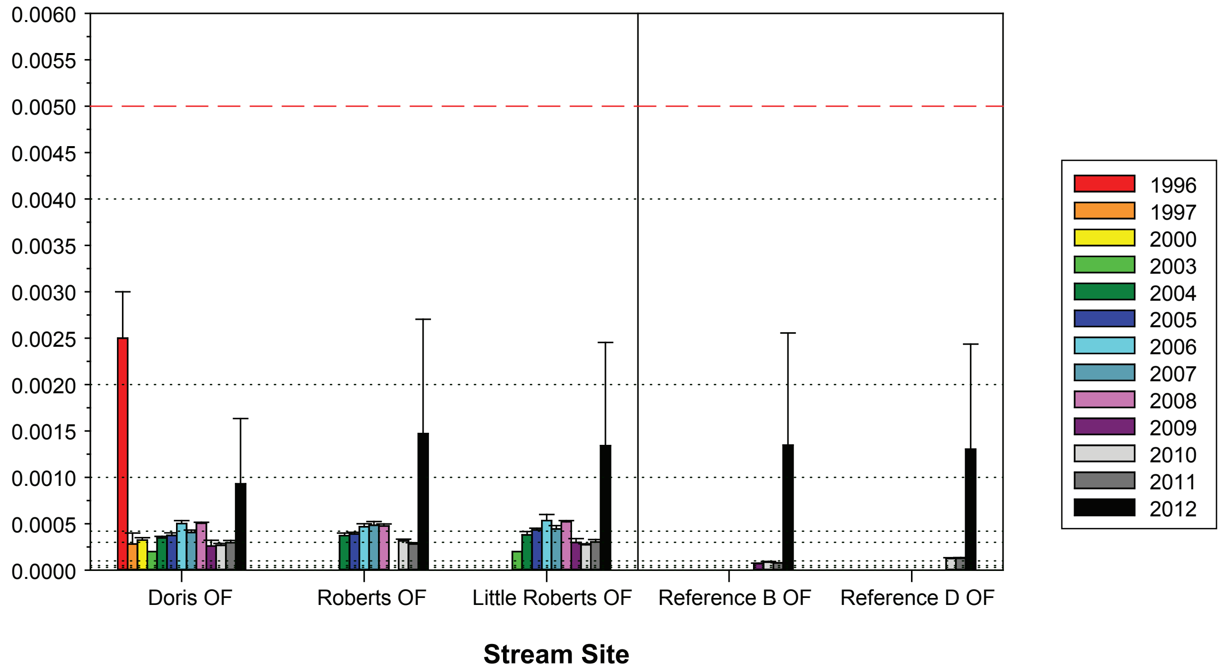
3.3.1.13 Total Iron

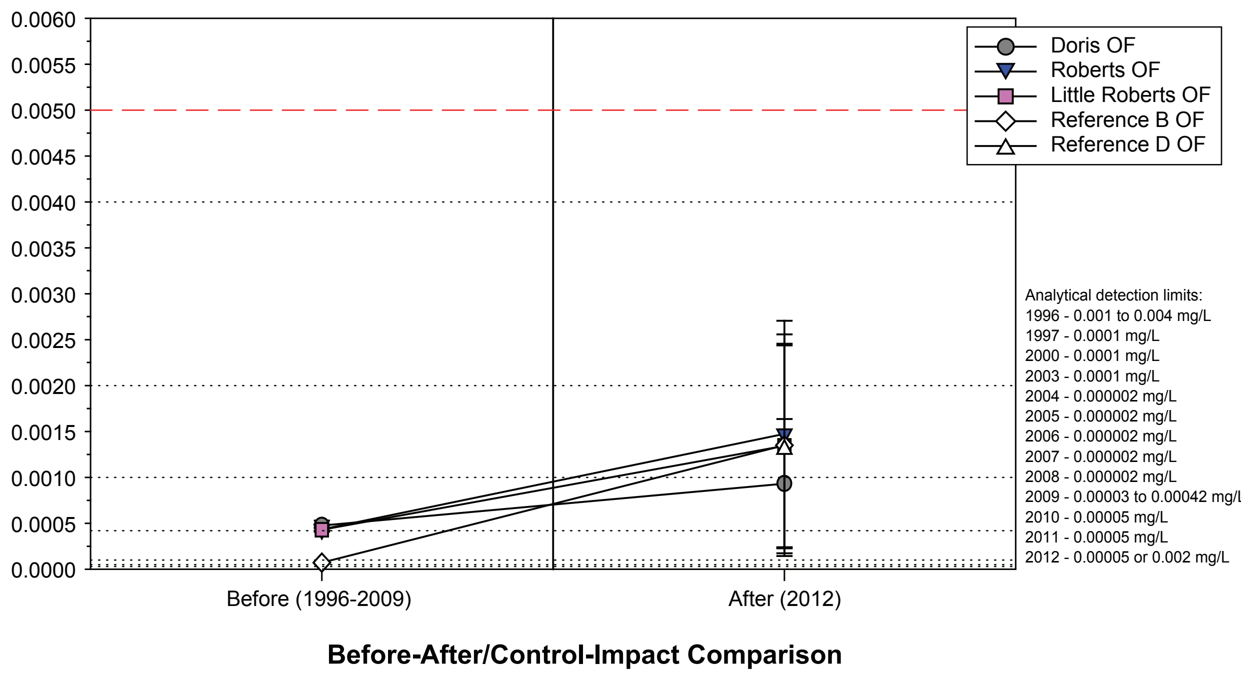
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total iron concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual variability (Figure 3.3-13). Mean 2012 total iron concentrations were within the range of baseline means and below the CCME guideline level of 0.3 mg/L (Figure 3.3-13).

The before-after analysis showed that there was no significant difference between baseline and 2012 means for any exposure stream ($p = 0.85$ for Doris Outflow, $p = 0.47$ for Roberts Outflow, and $p = 0.90$ for Little Roberts Outflow), suggesting that Project activities did not affect total iron concentrations in the exposure streams.

3.3.1.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. 2012 mean lead concentrations in exposure streams were similar to or less than baseline means, and were well below the hardness-dependent CCME guideline (Figure 3.3-14). The before-after comparison confirmed that there was no effect of 2012 Project activities on total lead concentrations in exposure streams ($p = 0.28$ for Doris Outflow, $p = 0.22$ for Roberts Outflow, and $p = 0.25$ 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.
Red dashed lines represent the CCME freshwater 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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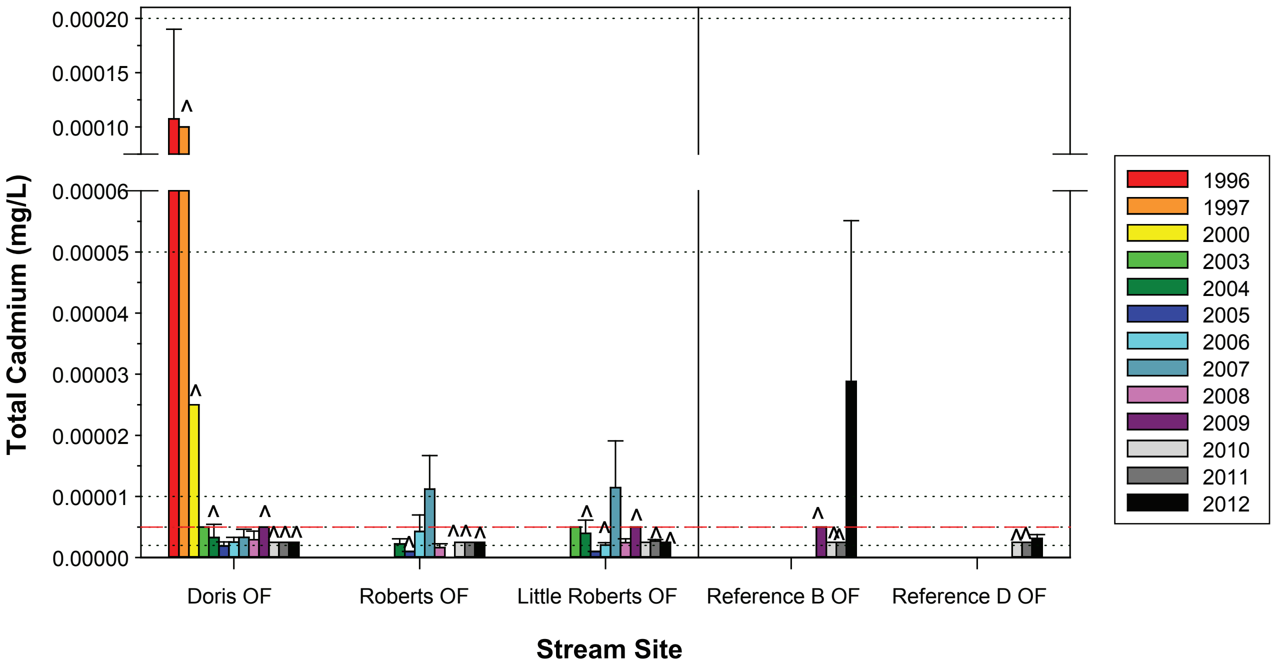
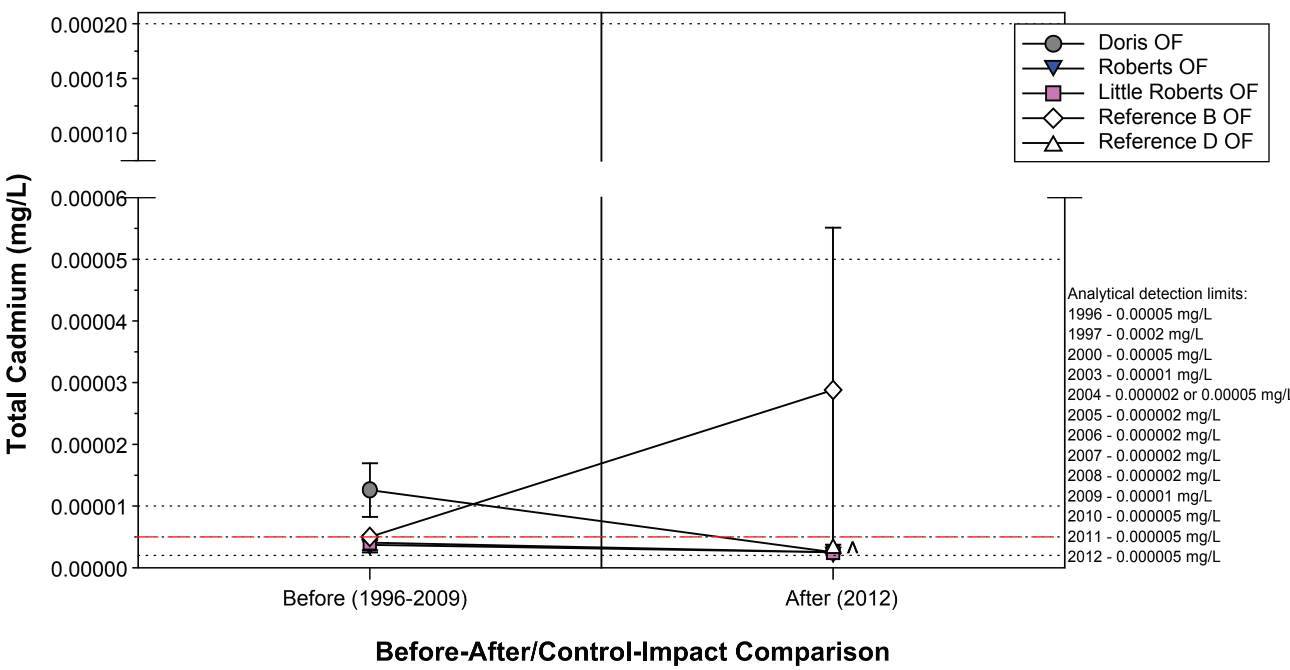
Total Arsenic Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-10

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 total cadmium concentrations were below the detection limit in all samples.
The CCME freshwater guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for cadmium based on the minimum hardness measured in exposure and reference streams between 1996 and 2012 (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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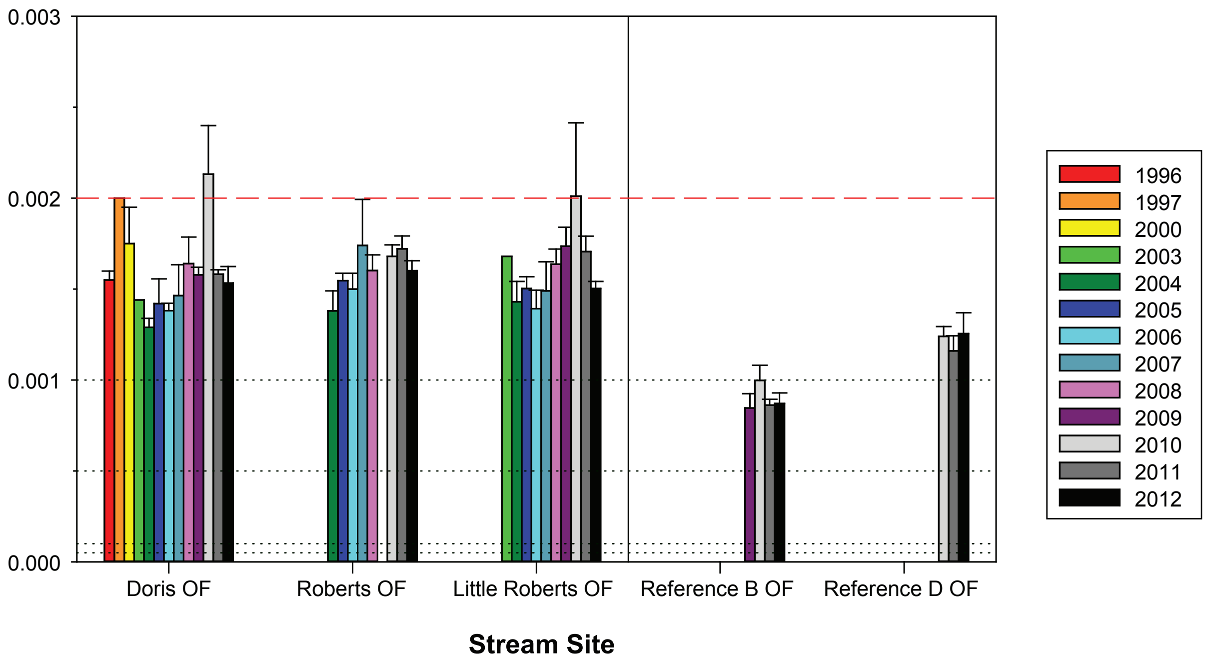
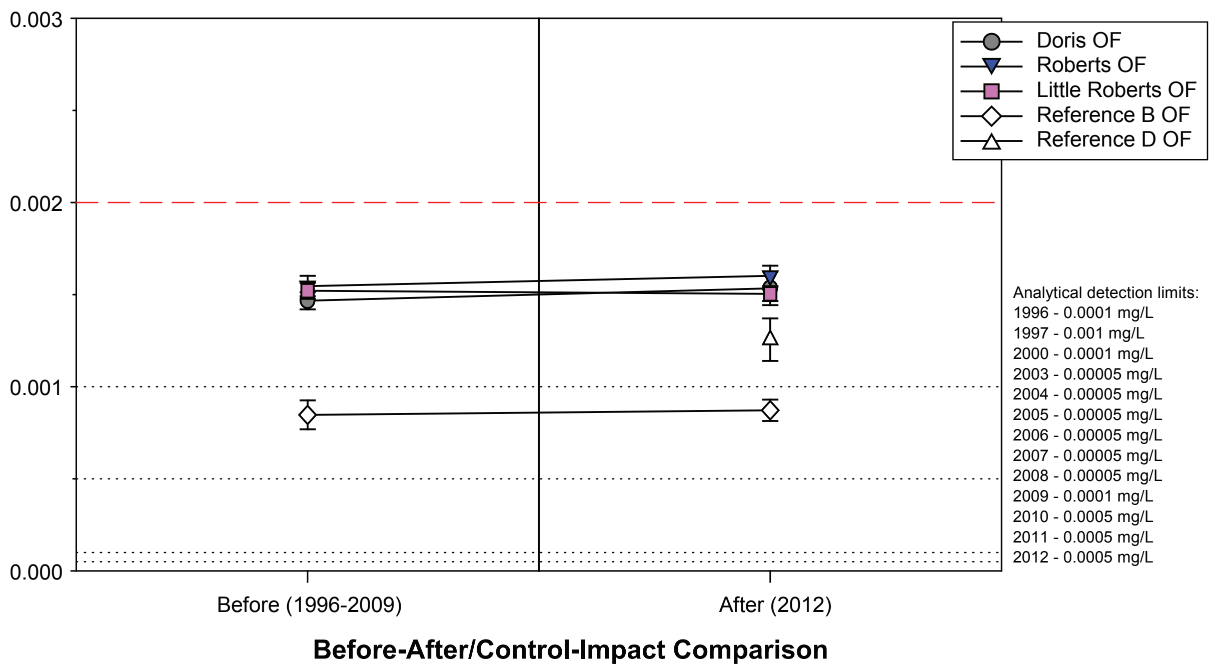
Total Cadmium Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-11

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.
The CCME freshwater guideline for copper is hardness dependent.
Red dashed lines represent the minimum CCME freshwater 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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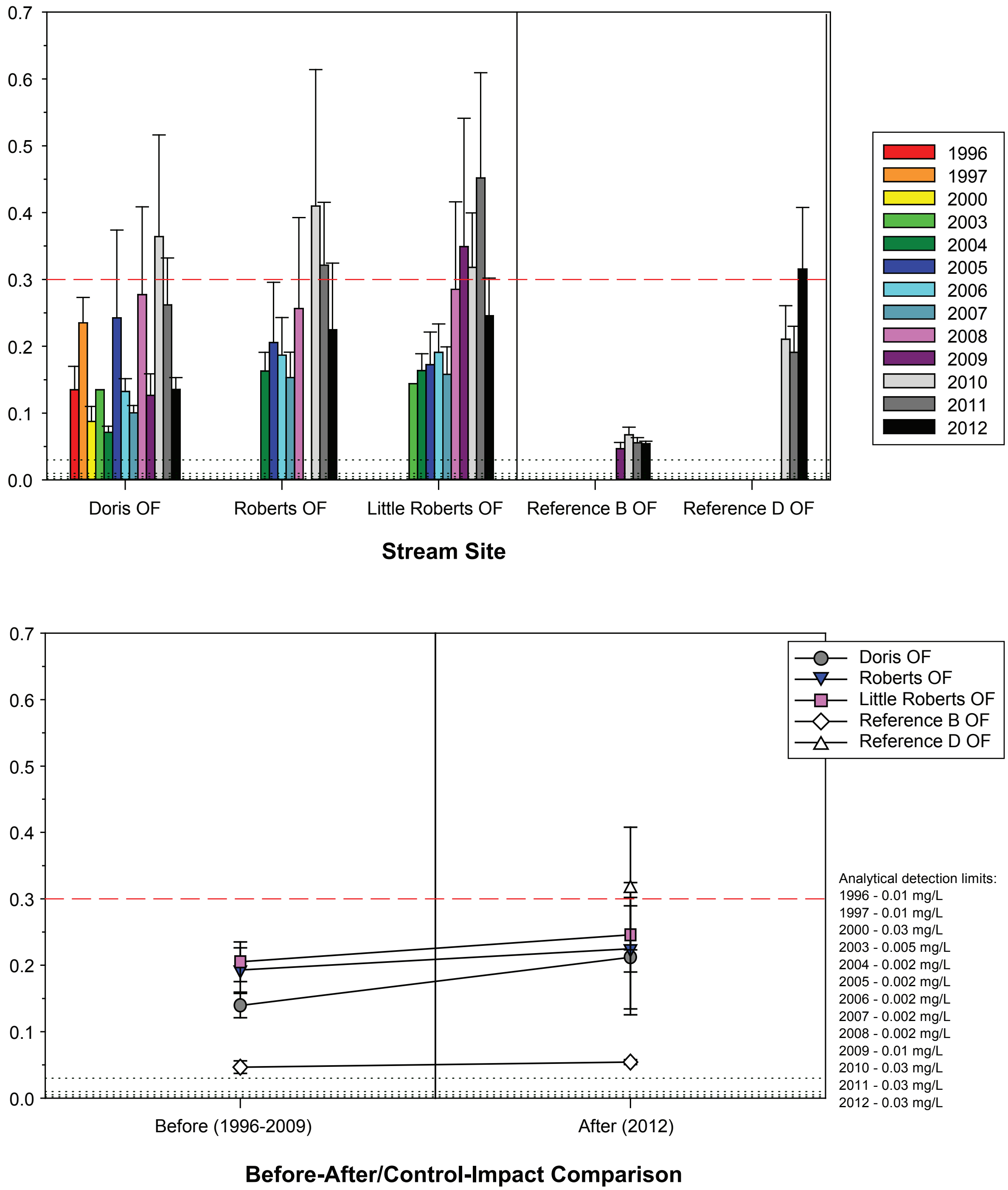
Total Copper Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-12

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.
Red dashed lines represent the CCME freshwater 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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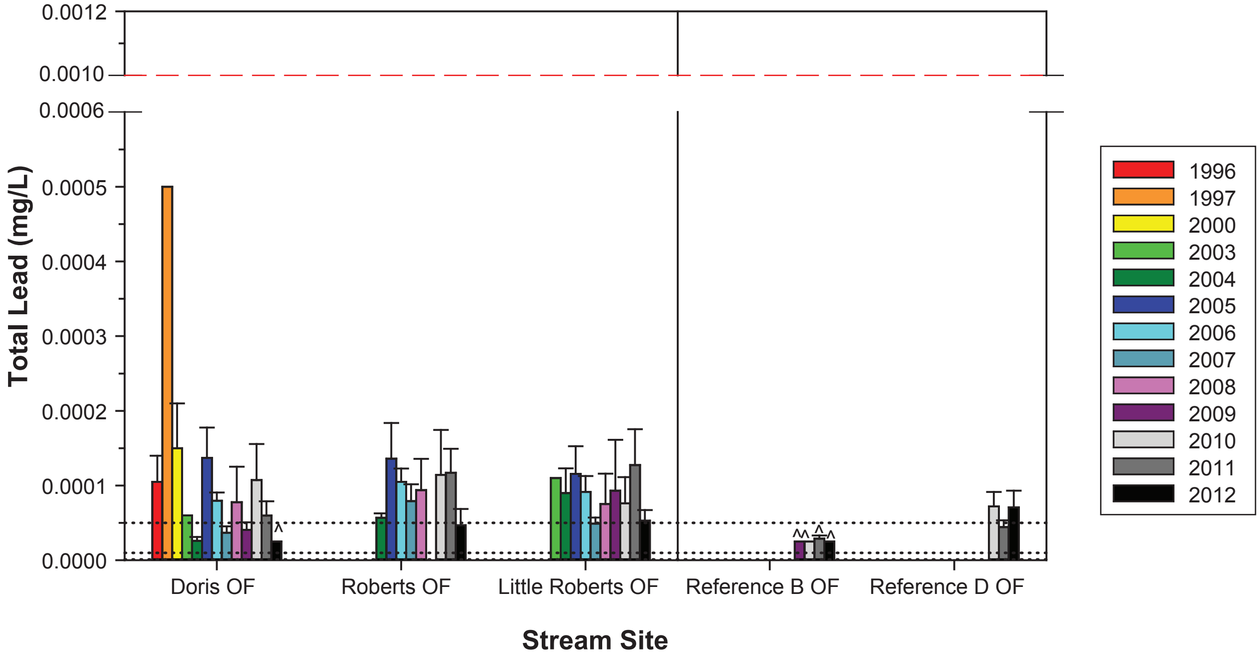
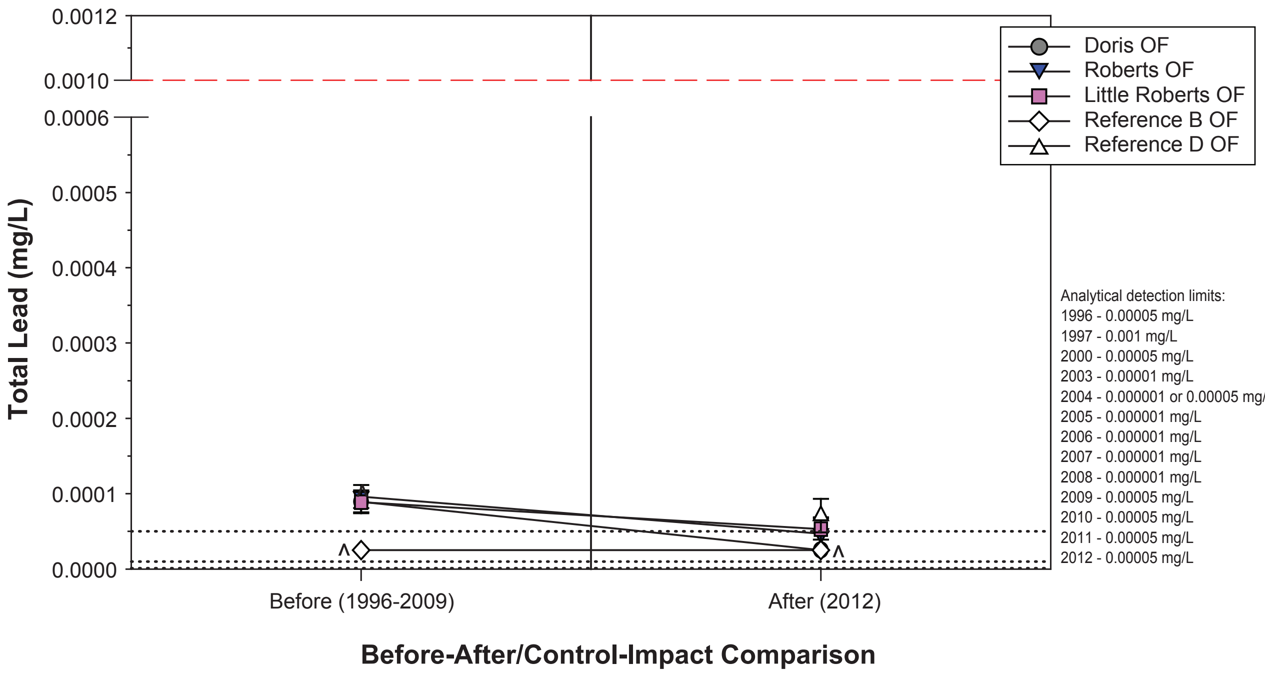
Total Iron Concentration in AEMP Streams Sites, Doris North Project, 1996 to 2012

Figure 3.3-13

Rescan Engineers & Scientists





Analytical detection limits:
1996 - 0.00005 mg/L
1997 - 0.001 mg/L
2000 - 0.00005 mg/L
2003 - 0.00001 mg/L
2004 - 0.000001 or 0.00005 mg/L
2005 - 0.000001 mg/L
2006 - 0.000001 mg/L
2007 - 0.000001 mg/L
2008 - 0.000001 mg/L
2009 - 0.00005 mg/L
2010 - 0.00005 mg/L
2011 - 0.00005 mg/L
2012 - 0.00005 mg/L

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 freshwater guideline for lead is hardness dependent.
Red dashed lines represent the minimum CCME freshwater 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.

Figure 3.3-14

Total Lead Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

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3.3.1.15 Total Mercury

Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. A high proportion of total mercury concentrations in the datasets for exposure streams were below detection limits (70% for Doris Outflow, 53% for Roberts Outflow, and 63% for Little Roberts Outflow). Mean total mercury concentrations measured in exposure streams in 2012 were always above the ultra-low detection limit (0.0000005 mg/L) and ranged from 0.00000025 to 0.0000017 mg/L. This was well below the CCME guideline for inorganic mercury of 0.000026 mg/L (Figure 3.3-15). The comparisons to pre-2010 data are problematic because of the high proportion of baseline data that were below detection limits, and the widely variable historical detection limits. The before-after analysis suggests that there was no difference in means between baseline years and 2012 ($p = 0.77$ for Doris Outflow, $p = 0.52$ for Roberts Outflow, and $p = 0.91$ for Little Roberts Outflow), but statistical results should be interpreted cautiously because of the high proportion of non-detectable concentrations in the baseline data. There was no evidence of an increase in mercury concentrations due to 2012 Project activities.

3.3.1.16 Total Molybdenum

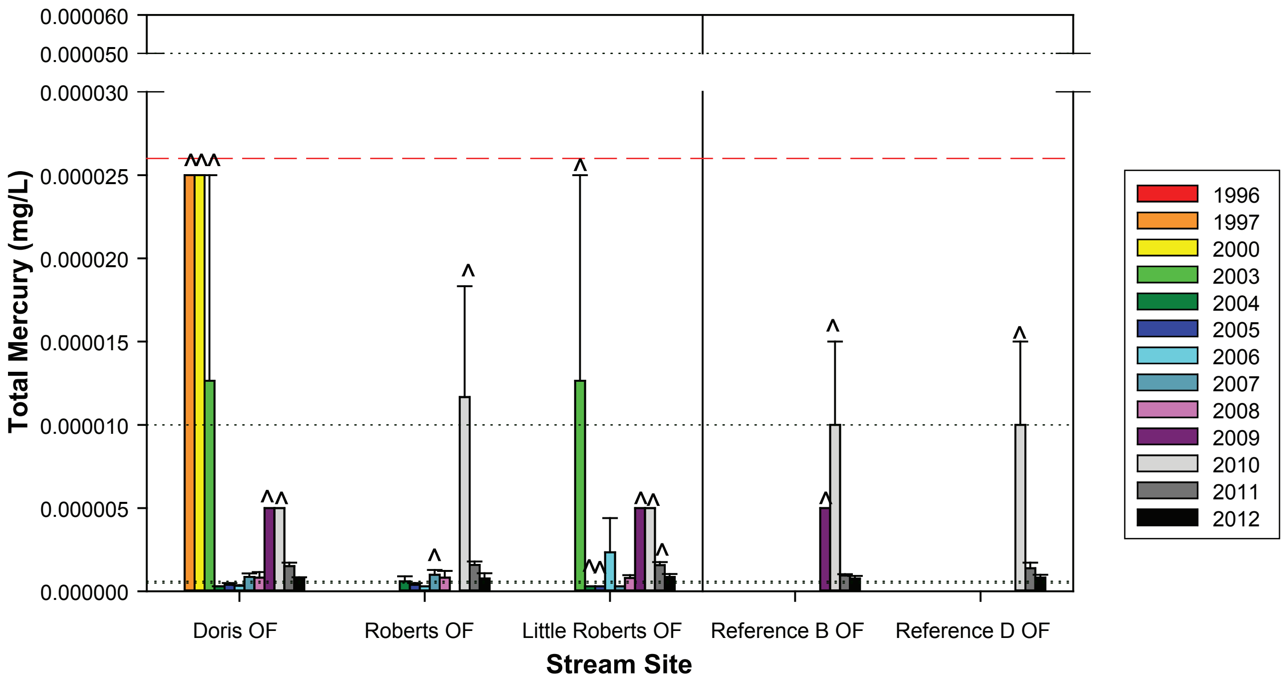
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean total molybdenum concentrations within each exposure stream were remarkably consistent from year to year (Figure 3.3-16). In both Roberts Outflow and Little Roberts Outflow, 2012 concentrations were similar to baseline concentrations, and the before-after comparison confirmed that there was no effect of 2012 Project activities on total molybdenum in these streams ($p = 0.48$ for Roberts Outflow and $p = 0.54$ for Little Roberts Outflow). In Doris Outflow, the 2012 mean concentration was slightly higher than the baseline mean, and the before-after analysis determined that this difference was statistically significant ($p = 0.0004$). However, the BACI analysis showed that this before-after trend paralleled the before-after trend for the reference sites ($p = 0.10$), indicating that the slight increase in molybdenum that occurred at Doris Outflow was not related to 2012 Project activities. Total molybdenum concentrations in all 2012 samples were more than two orders of magnitude lower than the interim CCME guideline of 0.073 mg/L (Figure 3.3-16).

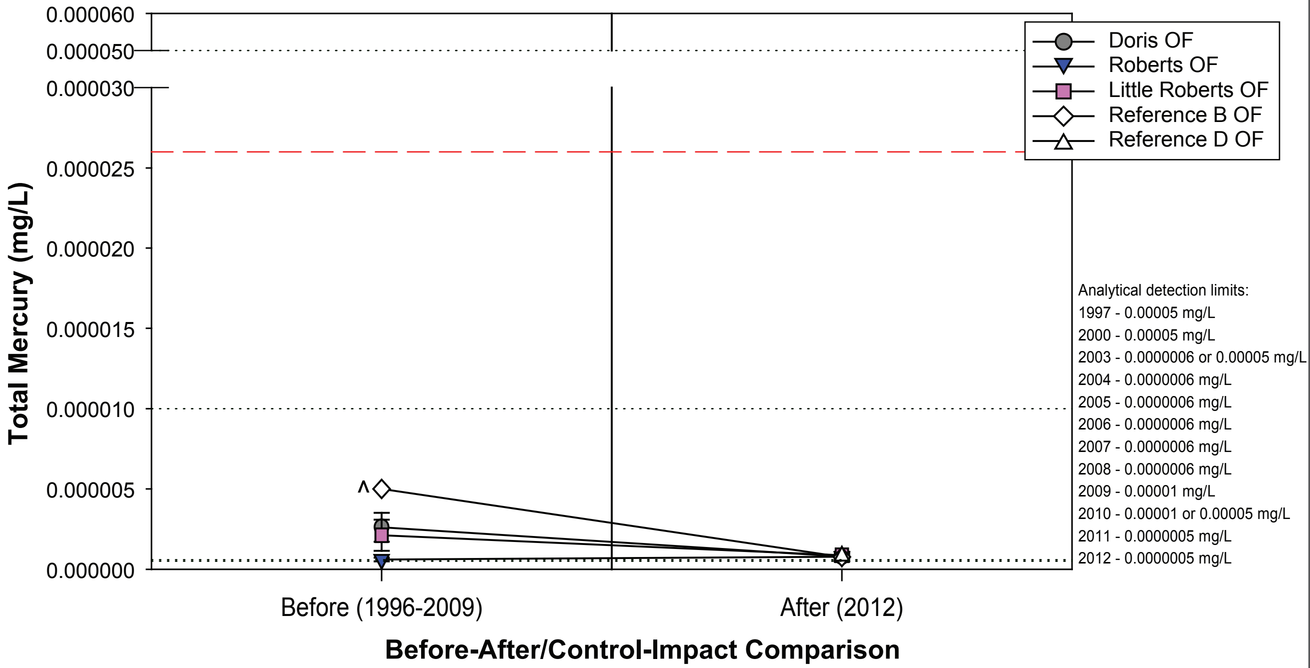
3.3.1.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2012 nickel concentrations in all streams were well below the hardness-dependent CCME guideline (Figure 3.3-17). In all three exposure streams, the before-after plot suggests that concentrations in 2012 were similar to baseline concentrations (Figure 3.3-17); the before-after analysis confirmed no significant difference between mean 2012 and pre-2010 nickel concentrations ($p = 0.72$ for Doris Outflow, $p = 0.23$ for Roberts Outflow, and $p = 0.67$ for Little Roberts Outflow). Therefore, there was no effect of 2012 Project activities on total nickel concentrations in streams.

3.3.1.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2012, total zinc concentrations were below the analytical detection limit of 0.003 mg/L in all samples collected from exposure streams between June and September, except two replicates collected at Roberts Outflow in August (which contained total zinc concentrations of 0.0039 and 0.0037 mg/L). All 2012 total zinc concentrations were well below the CCME guideline of 0.03 mg/L (Figure 3.3-18). The before-after analysis suggested that there was no difference in means between baseline years and 2012 ($p = 0.59$ for Doris Outflow, $p = 0.43$ for Roberts Outflow, and $p = 0.30$ for Little Roberts Outflow). This result, coupled with nearly all the 2012 values being below analytical detection limits, indicates that there was no apparent Project-related effect on total zinc concentrations in the exposure streams.





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 freshwater 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.

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Total Mercury Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-15

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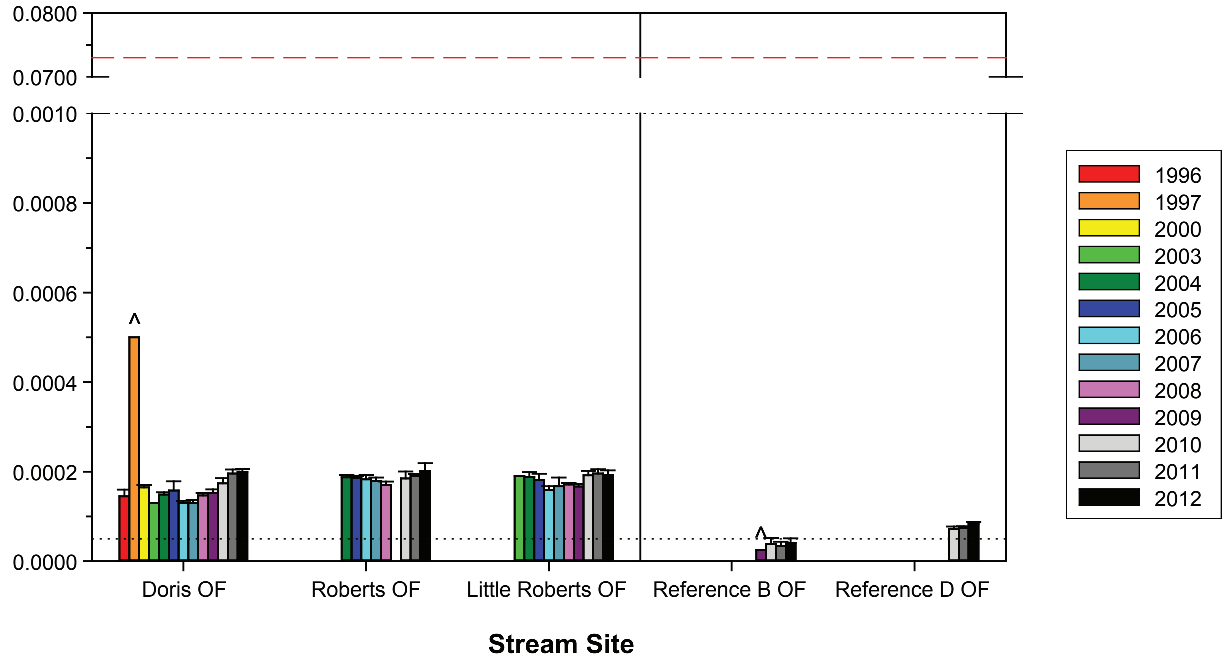

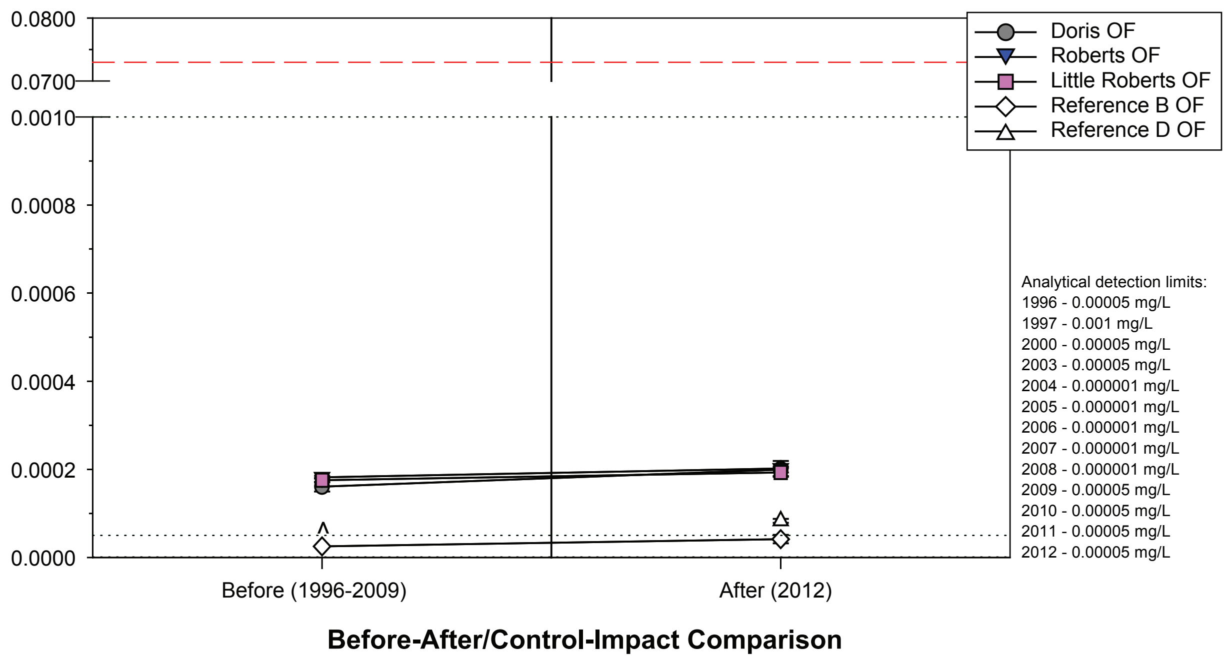

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME freshwater 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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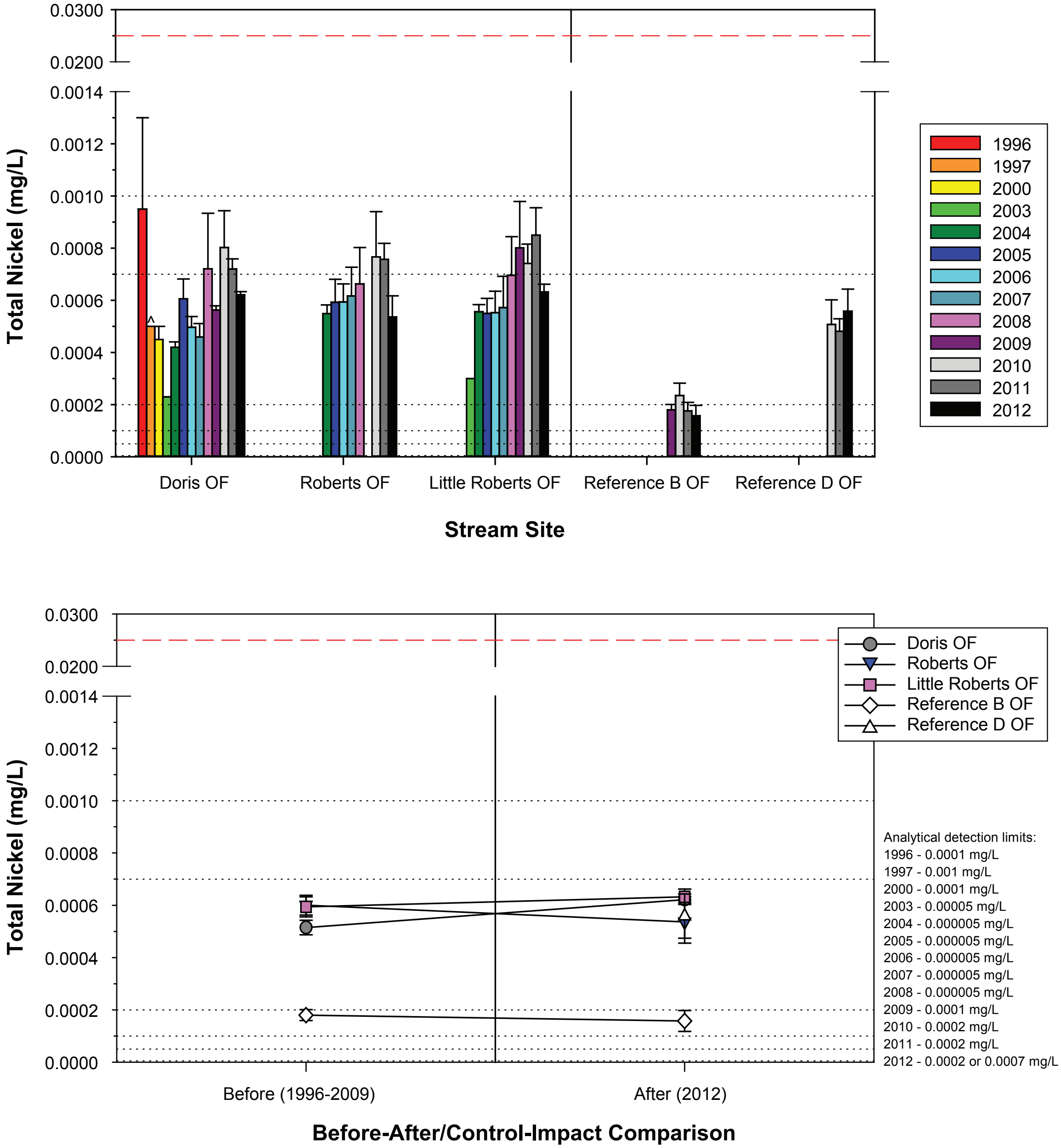
Total Molybdenum Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-16

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.
The CCME freshwater guideline for nickel is hardness dependent.
Red dashed lines represent the minimum CCME freshwater 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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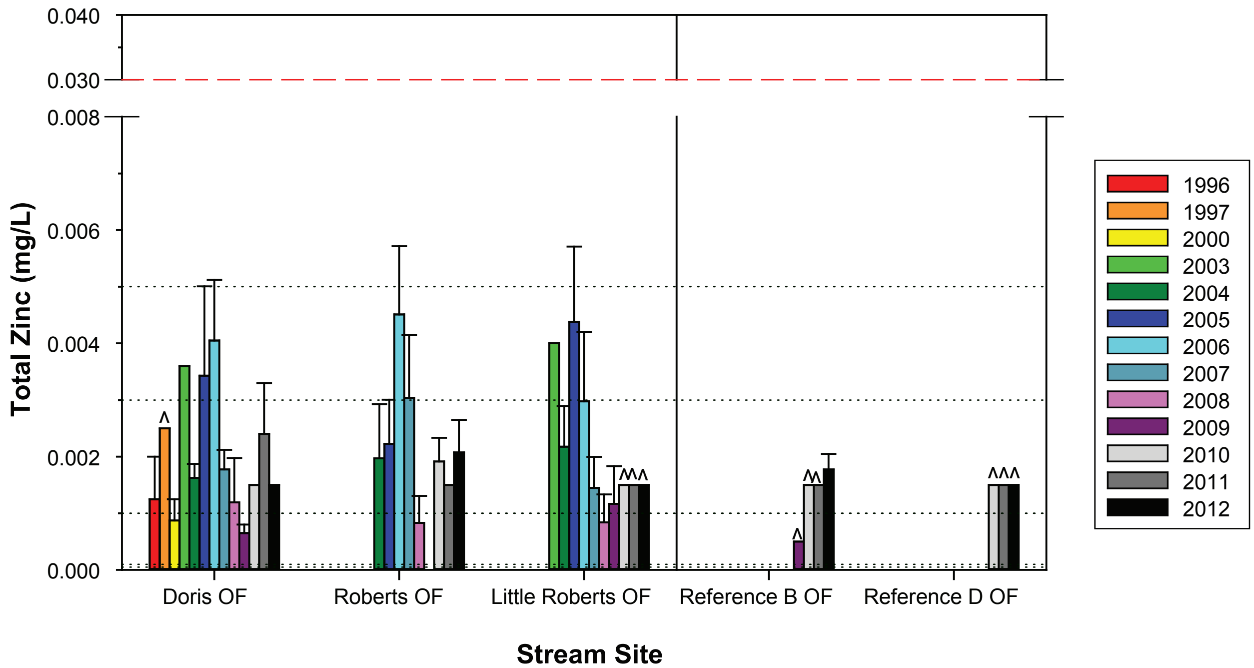
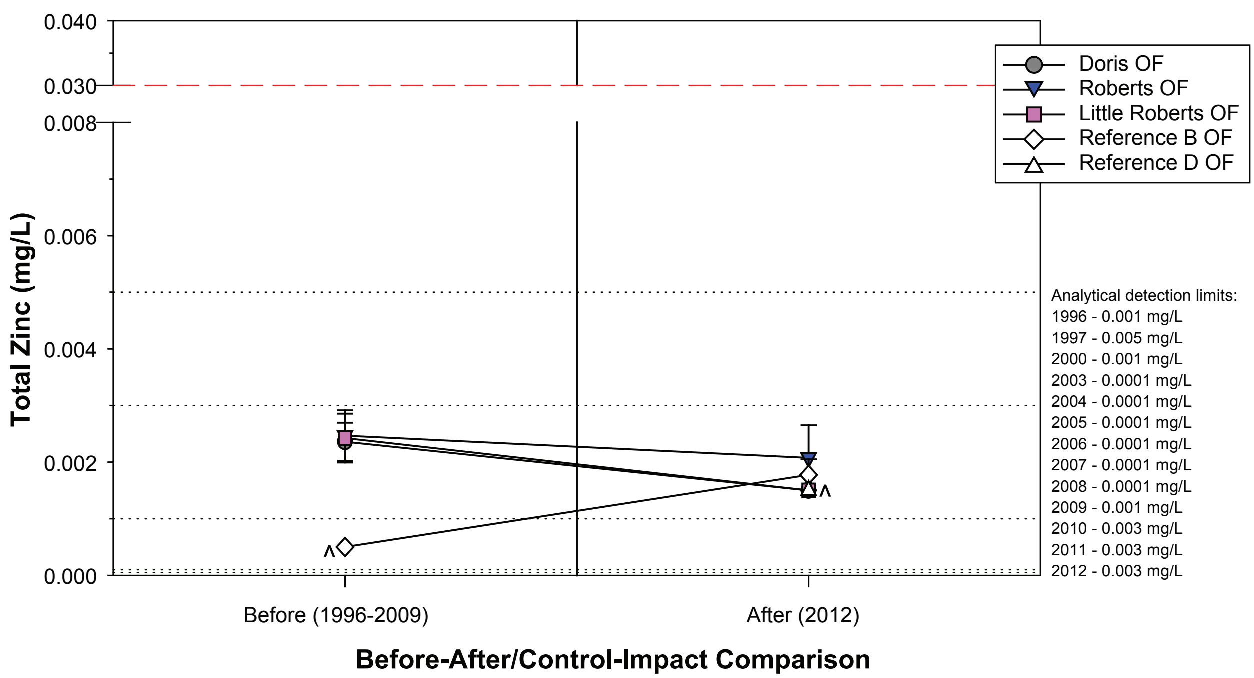
Total Nickel Concentration in AEMP Stream Sites, Doris North Project, 1996 to 2012

Figure 3.3-17

Rescan Engineers & Scientists





Analytical detection limits:
1996 - 0.001 mg/L
1997 - 0.005 mg/L
2000 - 0.001 mg/L
2003 - 0.0001 mg/L
2004 - 0.0001 mg/L
2005 - 0.0001 mg/L
2006 - 0.0001 mg/L
2007 - 0.0001 mg/L
2008 - 0.0001 mg/L
2009 - 0.001 mg/L
2010 - 0.003 mg/L
2011 - 0.003 mg/L
2012 - 0.003 mg/L

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 freshwater 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 to 2012

Figure 3.3-18

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3.3.2 Lakes

Water quality samples from lakes were collected from four exposure lake sites (Doris Lake South, Doris Lake North, Little Roberts Lake and Roberts Lake) and two reference lakes (Reference Lake B and Reference Lake D) in 2012. For the exposure lakes, relevant baseline data were available from 1995 to 1998, 2000, and 2003 to 2009 (though all lake sites were not sampled each year), but only for Doris Lake South, Doris Lake North and Little Roberts Lake. The only available baseline data for Reference Lake B were from 2009, and no pre-2010 baseline data were available for Reference Lake D.

Because of comparability in lake sizes, Reference Lake B was used as a reference site for the Doris Lake sites (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 < 1 km^2 in surface area). There was little evidence of vertical physico-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. As there was no previous data available for this section of Roberts Lake (westernmost extent), no before-after or BACI analyses were conducted for this lake. Furthermore, because no baseline data were available for Reference Lake D, no statistical analyses were possible for this lake, and no BACI analysis was possible for Little Roberts Lake. Graphs showing water quality trends in lakes over time are shown in Figures 3.3-19 to 3.3-36. All statistical results are presented in Appendix B.

3.3.2.1 pH

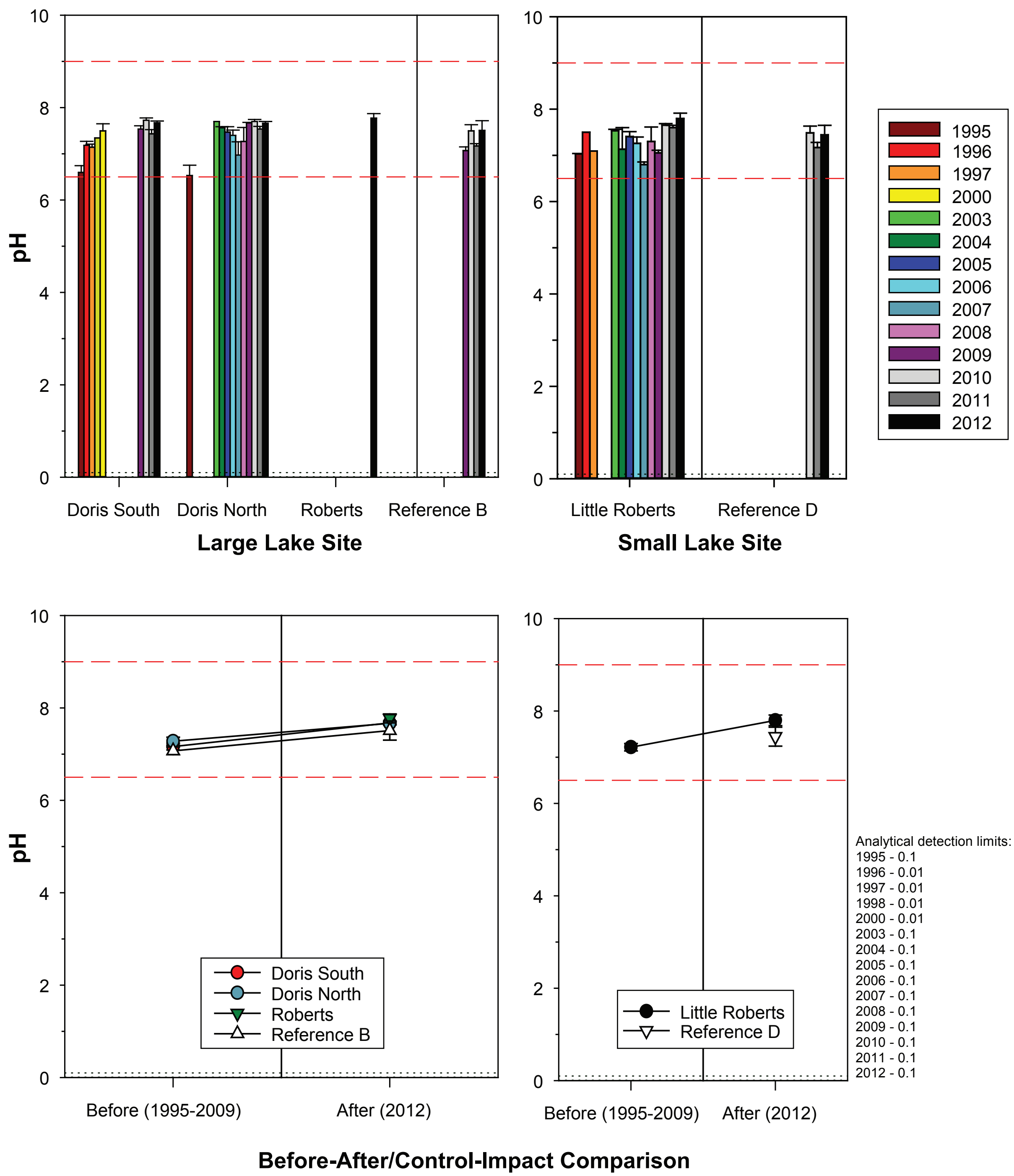
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. pH levels measured in 2012 in exposure lakes were always within the recommended CCME guideline range of 6.5 to 9.0. In the large lake sites (Doris Lake South and Doris Lake North), 2012 pH levels were similar to baseline pH levels (Figure 3.3-19). The before-after analysis confirmed that the mean baseline pH was not distinguishable from the mean 2012 pH in these exposure lake sites ($p = 0.26$ for Doris Lake South, $p = 0.27$ for Doris Lake North). In the smaller Little Roberts Lake, mean 2012 pH levels were slightly higher than baseline levels; a trend confirmed by the before-after analysis ($p = 0.005$). No BACI analysis was possible due to a lack of ‘before’ data in Reference Lake D. However, pH patterns in Little Roberts Lake are similar to those observed in Doris Lake North, suggesting that the observed increase was due to natural variability in the region and not Project activities. Therefore, there was no apparent effect of 2012 activities on pH in exposure lakes.

3.3.2.2 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 $CaCO_3$) levels measured in 2012 were always within the range of baseline alkalinity levels (Figure 3.3-20), and there was no evidence of any Project-related effects. The before-after analysis confirmed that there was no change in alkalinity in any exposure lake in 2012 ($p = 0.23$ for Doris Lake South, $p = 0.38$ for Doris Lake North, and $p = 0.93$ for Little Roberts Lake).

3.3.2.3 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. At the large lake exposure sites, 2012 mean hardness levels were slightly higher than the baseline means (Figure 3.3-21), but the before-after analysis indicated that this difference was not statistically significant ($p = 0.02$ for Doris Lake South and $p = 0.08$ for Doris Lake North). In Little Roberts Lake, 2012 hardness levels were within the range of baseline hardness levels, and the 2012 mean was not distinguishable from the baseline mean ($p = 0.78$). Therefore, 2012 activities did not affect hardness in exposure lakes.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Red dashed lines represent the CCME freshwater 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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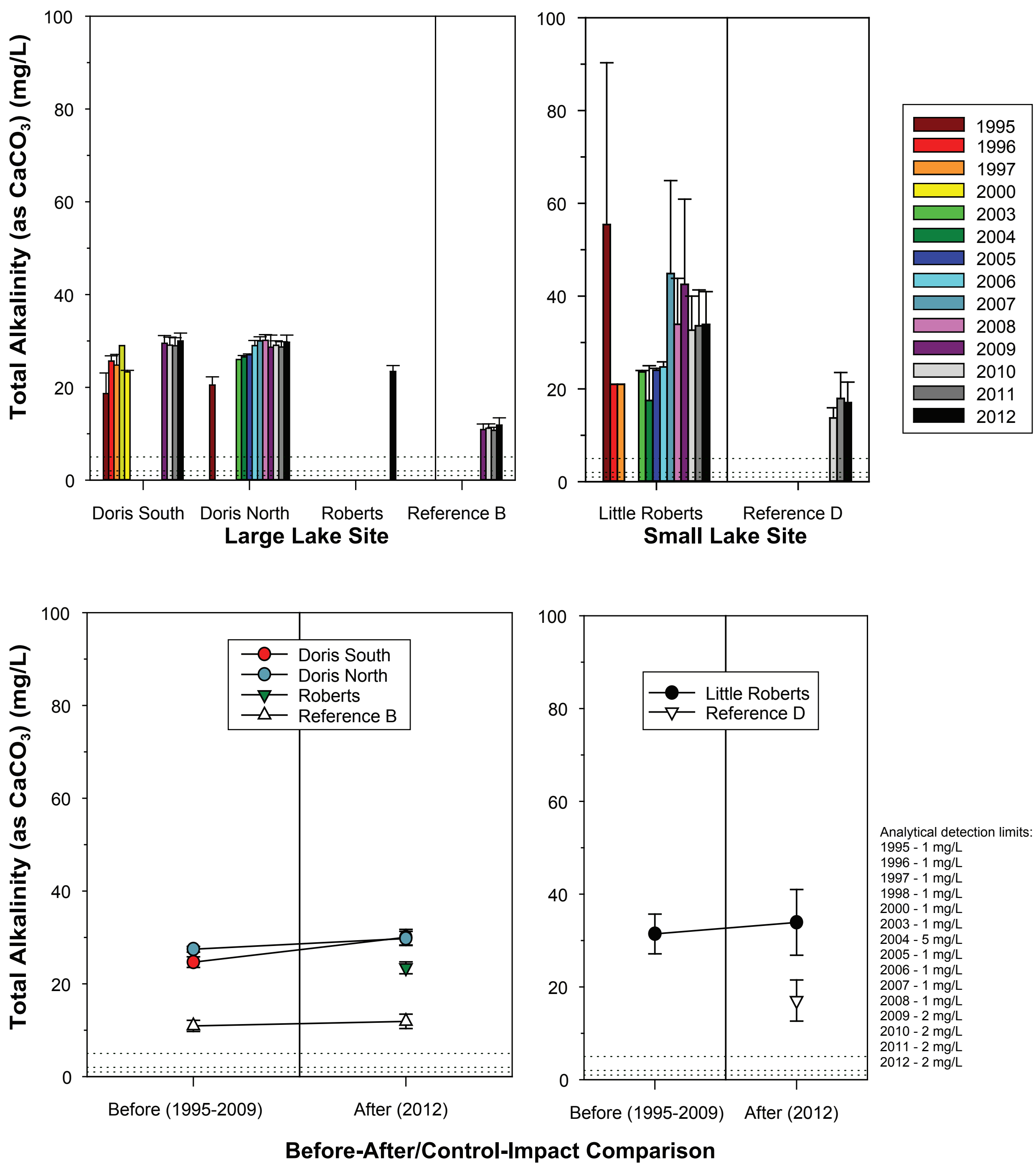
pH in AEMP Lake Sites, Doris North Project, Doris North Project, 1995 to 2012

Figure 3.3-19

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.
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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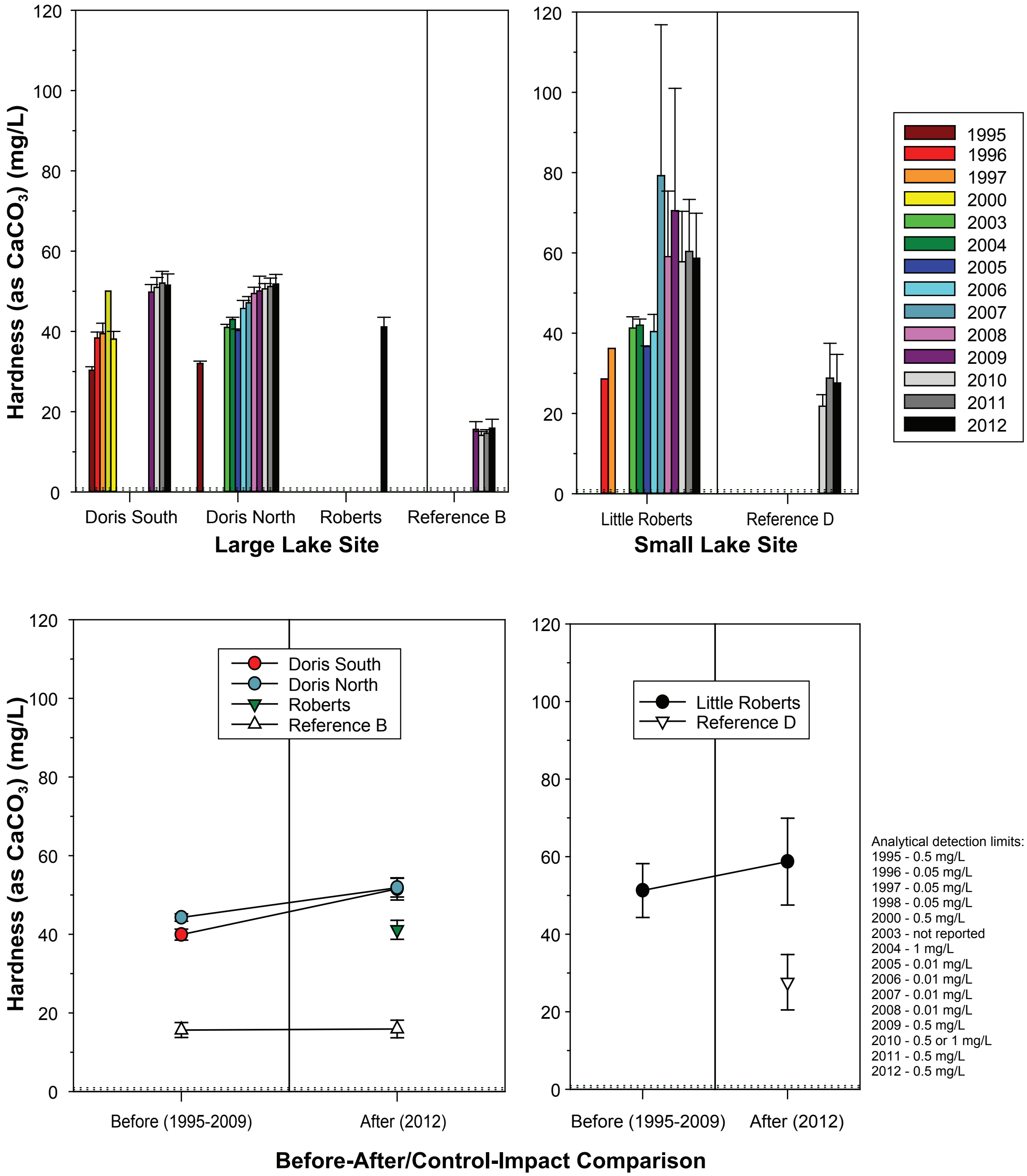
Total Alkalinity in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-20

Rescan Engineers & Scientists



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.

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Hardness in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-21

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3.3.2.4 Total Suspended Solids

TSS is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean TSS concentrations were inter-annually variable, particularly in Little Roberts Lake (Figure 3.3-22). 2012 TSS concentrations measured in the exposure lakes were within the range of baseline concentrations, and the before-after analysis showed that 2012 means were not statistically different from baseline means in any of the exposure lakes ($p = 0.92$ for Doris Lake South, $p = 0.96$ for Doris Lake North, and $p = 0.18$ for Little Roberts Lake). Therefore, there was no apparent effect of 2012 activities on TSS levels in these lakes.

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 2012b). Because there was no increase in TSS concentrations from background levels, 2012 TSS concentrations in exposure lakes were below the CCME guideline.

3.3.2.5 Total Ammonia

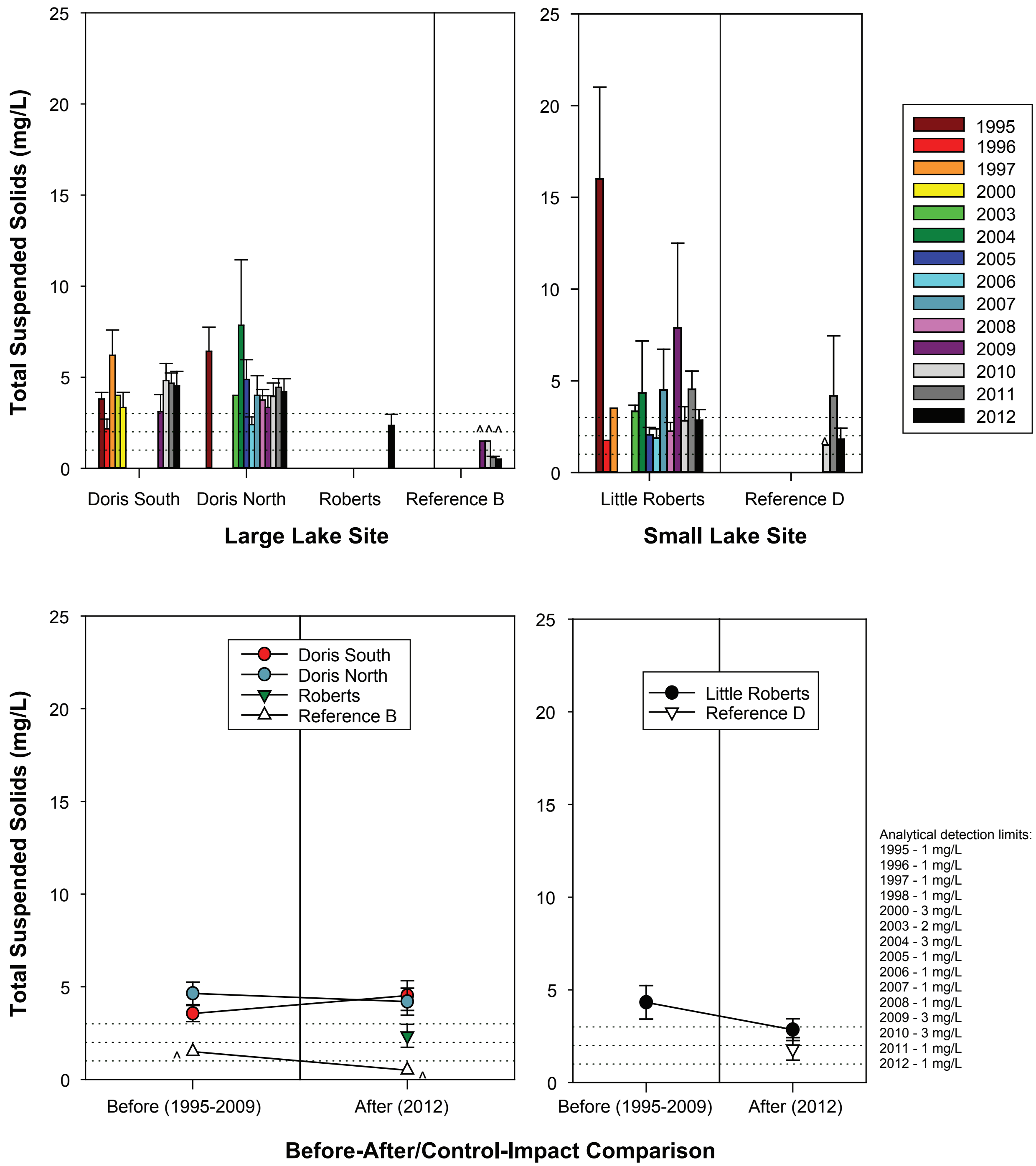
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean ammonia concentrations for most years were near or below analytical detection limits. However, there were some sporadically elevated mean concentrations in the baseline dataset (e.g., Little Roberts Lake in 1995 and 2007; Figure 3.3-23). Historical and 2012 concentrations of total ammonia in exposure and reference lakes were always well below the pH- and temperature-dependent CCME guideline (Figure 3.3-23). Total ammonia concentrations measured in 2012 in exposure lakes were within baseline ranges, even the high concentrations observed in Little Roberts Lake, suggesting that 2012 Project activities did not cause an increase in ammonia levels (Figure 3.3-23). This was confirmed by the before-after analysis, which determined that there were no significant differences between baseline and 2012 means for any exposure lake ($p = 0.74$ for Doris Lake South, $p = 0.05$ for Doris Lake North, and $p = 0.55$ for Little Roberts Lake).

3.3.2.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Nitrate concentrations measured in exposure lakes in 2012 were within range of baseline concentrations and were well below the interim CCME guideline of 2.935 mg nitrate-N/L (Figure 3.3-24). The before-after analysis showed that 2012 mean nitrate concentrations were not distinguishable from baseline means for any exposure lake ($p = 0.55$ for Doris Lake South, $p = 0.93$ for Doris Lake North, and $p = 0.47$ for Little Roberts Lake). 2012 results indicate that there were no effects of Project activities on nitrate concentrations in exposure lakes, and on-site management of surface waters and quarry rock were successful in keeping ammonium nitrate salt and residues out of surface waters.

3.3.2.7 Total Cyanide

Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. 97.9% (46/47) of the samples collected from both the exposure and reference lakes in 2012 had cyanide concentrations below the analytical detection limit of 0.001 mg/L (Figure 3.3-25). Baseline concentrations in the exposed lakes were also at or below detection limits. Therefore, there was no evidence of an increase in cyanide concentrations due to 2012 Project activities. A before-after statistical analysis is not possible for cyanide because of the high proportion of data that were below detection limits in the datasets.



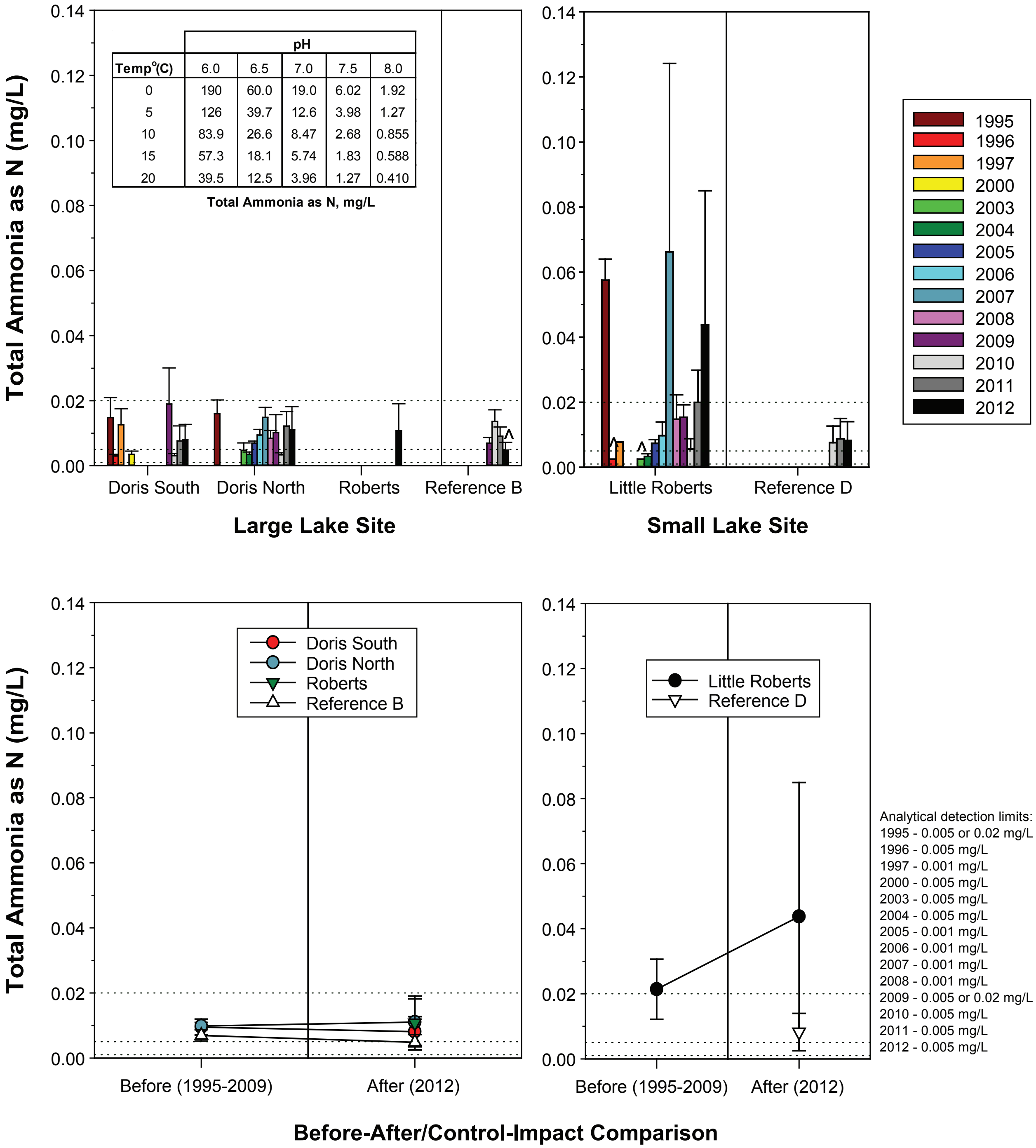
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline 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 Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-22

Rescan Engineers & Scientists



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

Total Ammonia as N, mg/L

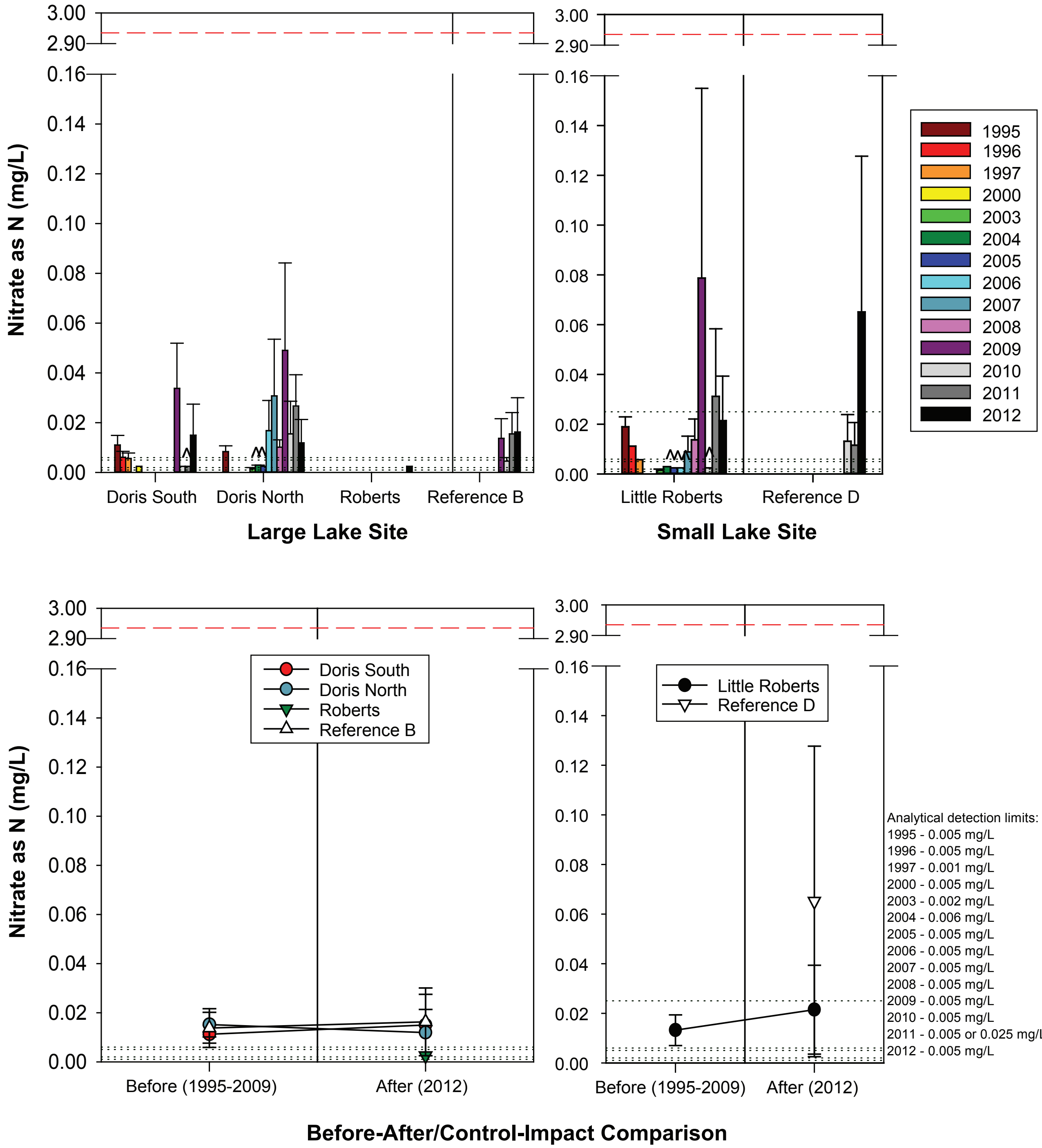
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Inset table shows the pH- and temperature-dependent CCME freshwater 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 Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-23

Rescan Engineers & Scientists



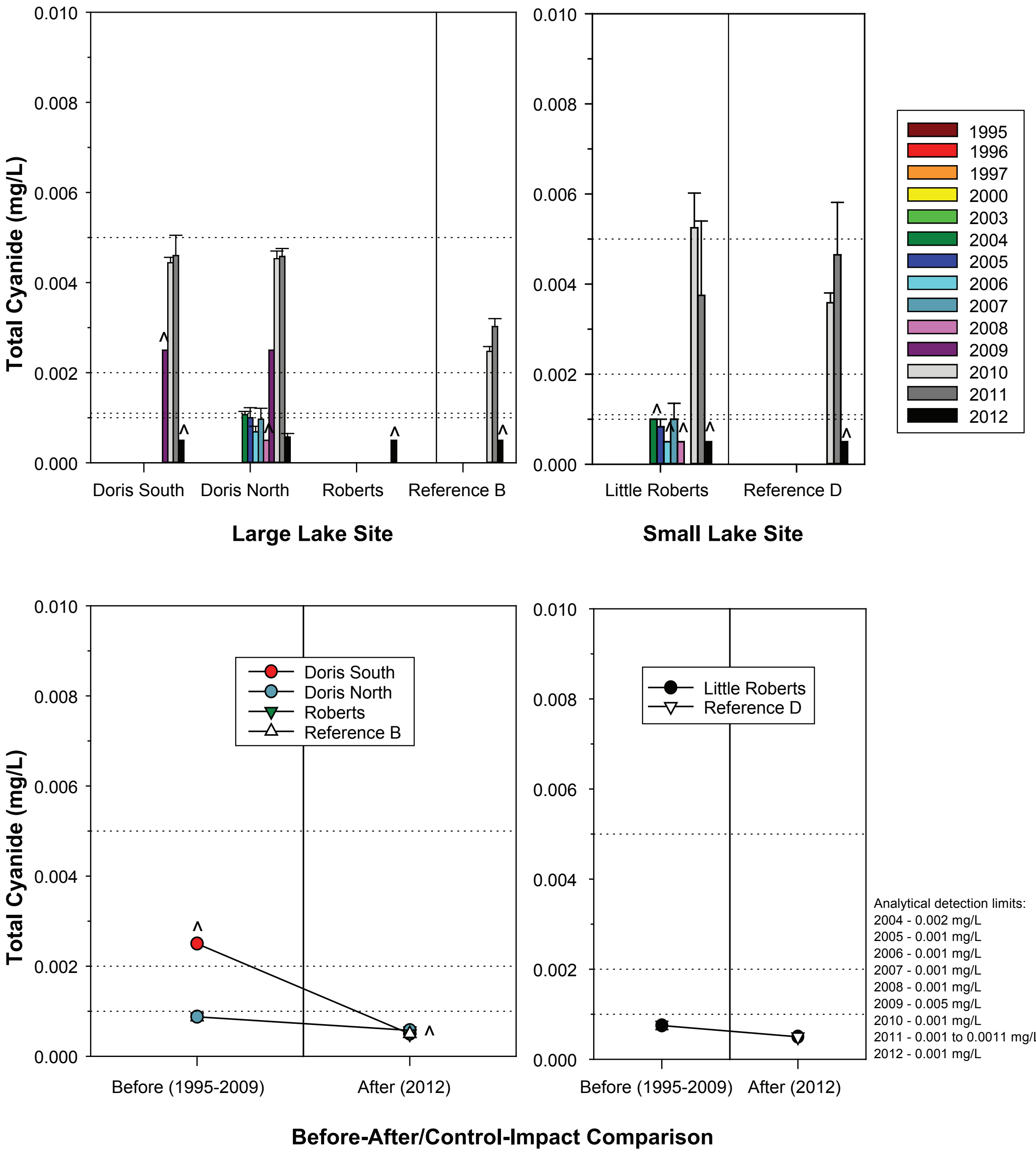
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME freshwater guideline for nitrate as N (2.935 mg/L).
The anomalously high nitrate concentrations of 4.51 mg/L reported for Doris South in August 1996 and 5.3 mg/L reported for Little Roberts Lake in September 2004 were considered outliers and was excluded from plots.
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 Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-24

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.
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 to 2012

Figure 3.3-25

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Free cyanide concentrations (cyanide existing in the form of HCN and CN-) in lake samples were measured in 2012 to allow for direct comparisons with the CCME guideline for cyanide (0.005 mg/L as free cyanide). Concentrations of free cyanide in lakes samples were almost always below the detection limits of 0.001 mg/L (Appendix A). The only detectable concentrations of free cyanide were in the April samples collected from Doris Lake South (0.0011 mg/L), Doris Lake North (0.0013 mg/L), and Little Roberts Lake (0.0012 mg/L; Appendix A). Without exception, all free cyanide concentrations measured in lakes in 2012 were below the CCME guideline for free cyanide of 0.005 mg/L. Therefore, the cyanide in exposure lakes in 2012 would not be expected to pose a threat to freshwater aquatic life.

3.3.2.8 Radium-226

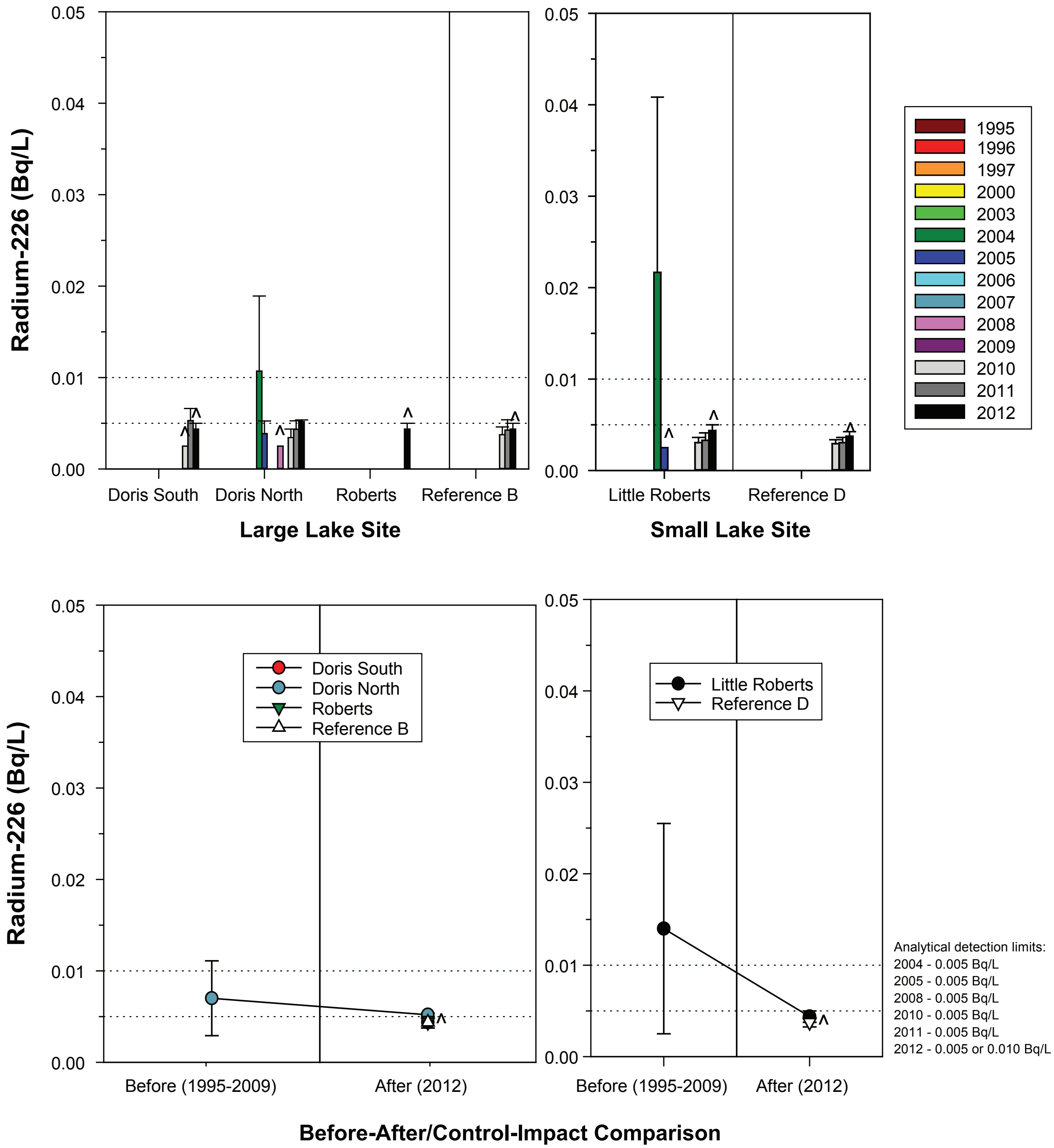
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Concentrations of radium-226 measured in 2012 at all lake sites were near or below the analytical detection limit of 0.005 Bq/L (Figure 3.3-26). Baseline concentrations in exposure lakes were similarly near or below the detection limit of 0.005 Bq/L. Therefore, there was no evidence of an increase in radium-226 concentrations in exposure lakes in 2012. Statistical analysis results are not presented for radium-226 because > 80% of concentrations in the datasets for Doris Lake North and Little Roberts Lake were below analytical detection limits and there is no baseline radium-226 data available for Doris Lake South.

3.3.2.9 Total Aluminum

Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In both Little Roberts Lake and Reference Lake D, mean 2012 total aluminum concentrations exceeded the pH-dependent CCME guideline of 0.1 mg/L. However, this guideline was commonly exceeded in Little Roberts Lake between 1996 and 2009 (Figure 3.3-27). In the large lake sites, all 2012 and most baseline concentrations were below the CCME guideline. Concentrations of total aluminum measured in exposure lakes in 2012 were within the range of baseline concentrations (Figure 3.3-27), except in Doris Lake North were 2012 concentrations were higher than those in the baseline. The before-after analysis confirmed that the mean 2012 concentration was not distinguishable from the baseline mean for Doris Lake South and Little Roberts Lake ($p = 0.91$ and, $p = 0.89$ respectively), however, mean 2012 concentrations at Doris Lake North were significantly higher than the baseline concentrations ($p < 0.0001$). A further BACI comparison found parallel changes in total aluminum concentrations in Doris Lake North and Reference lake B ($p = 0.10$); therefore, there was no apparent effect of 2012 Project activities on total aluminum concentrations.

3.3.2.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2012 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 baseline means (Figure 3.3-28); thus, 2012 activities did not cause an increase in arsenic concentrations in lakes. For all exposed lake sites, the before-after comparison indicated that there was no difference between 2012 mean arsenic concentrations and baseline means ($p = 0.86$ for Doris Lake South, $p = 0.13$ for Doris Lake North and $p = 0.55$ for Little Roberts Lake). Therefore, there was no adverse effect of 2012 Project activities on arsenic concentrations in the exposure lakes.



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 to 2012

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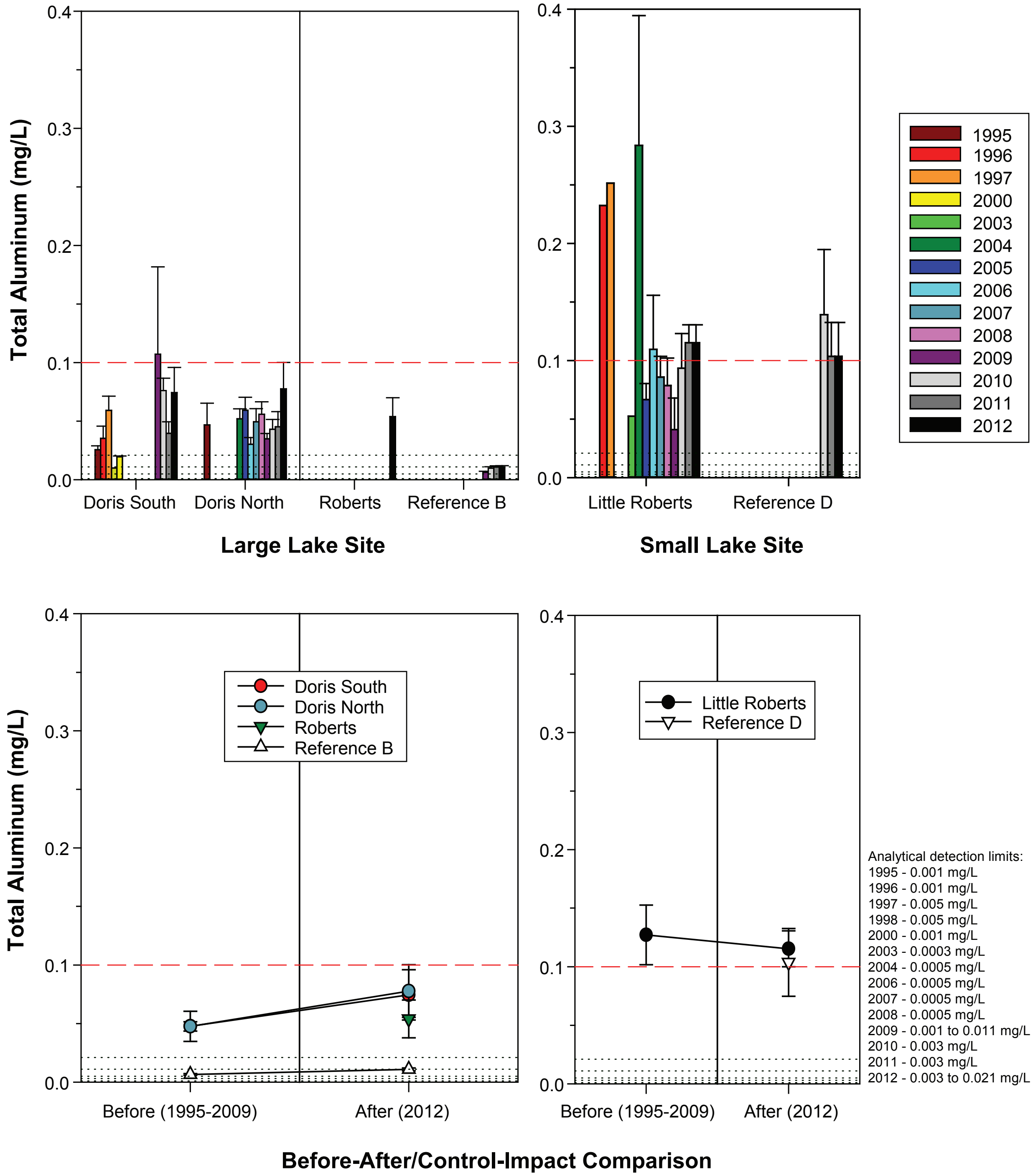

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH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

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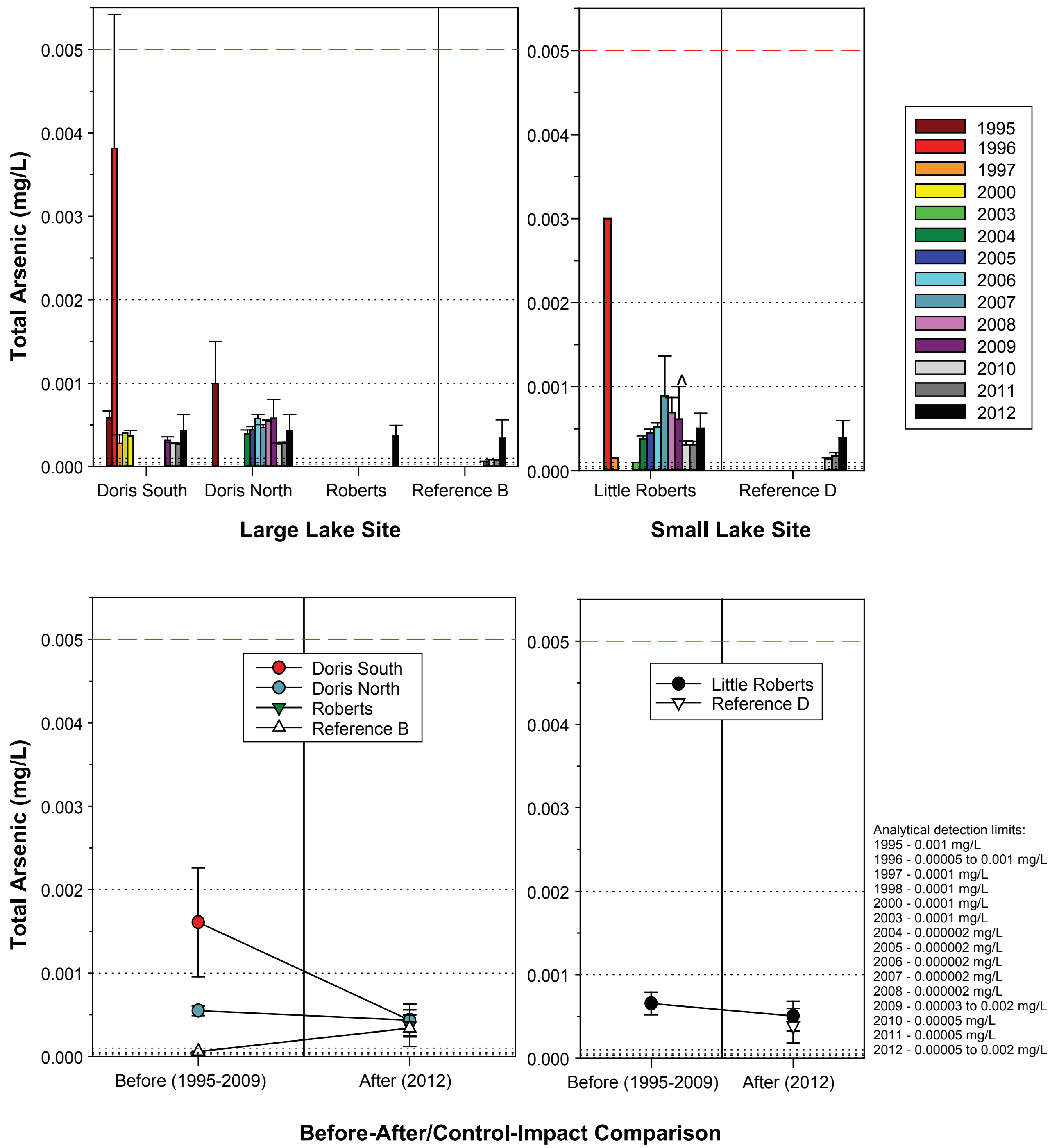
Total Aluminum Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-27

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 freshwater guideline for arsenic (0.005 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 Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-28

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3.3.2.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In the both the large and small lake sites, mean 2012 cadmium concentrations were similar to or lower than baseline means, indicating that Project activities did not cause an increase in cadmium concentrations (Figure 3.3-29). Statistical results are not presented for Doris Lake North, Doris Lake South or Little Roberts Lake because more than 70% of cadmium concentrations in the baseline and 2012 dataset were below the analytical detection limits. Since 97.9% of the 2012 total cadmium concentrations were below analytical detection limits, it can be concluded that there was no adverse effect of 2012 Project activities on total cadmium concentrations.

3.3.2.12 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 2012 copper concentrations were within the range of baseline annual means (Figure 3.3-30). Although five samples were above the hardness-dependent CCME guideline, the before-after analysis found that 2012 mean copper concentrations were not distinguishable from baseline means in the exposure lakes ($p = 0.41$ for Doris Lake South, $p = 0.70$ for Doris Lake North, and $p = 0.75$ for Little Roberts Lake). Therefore, there was no apparent effect of 2012 Project activities on total copper levels in any exposure lake.

3.3.2.13 Total Iron

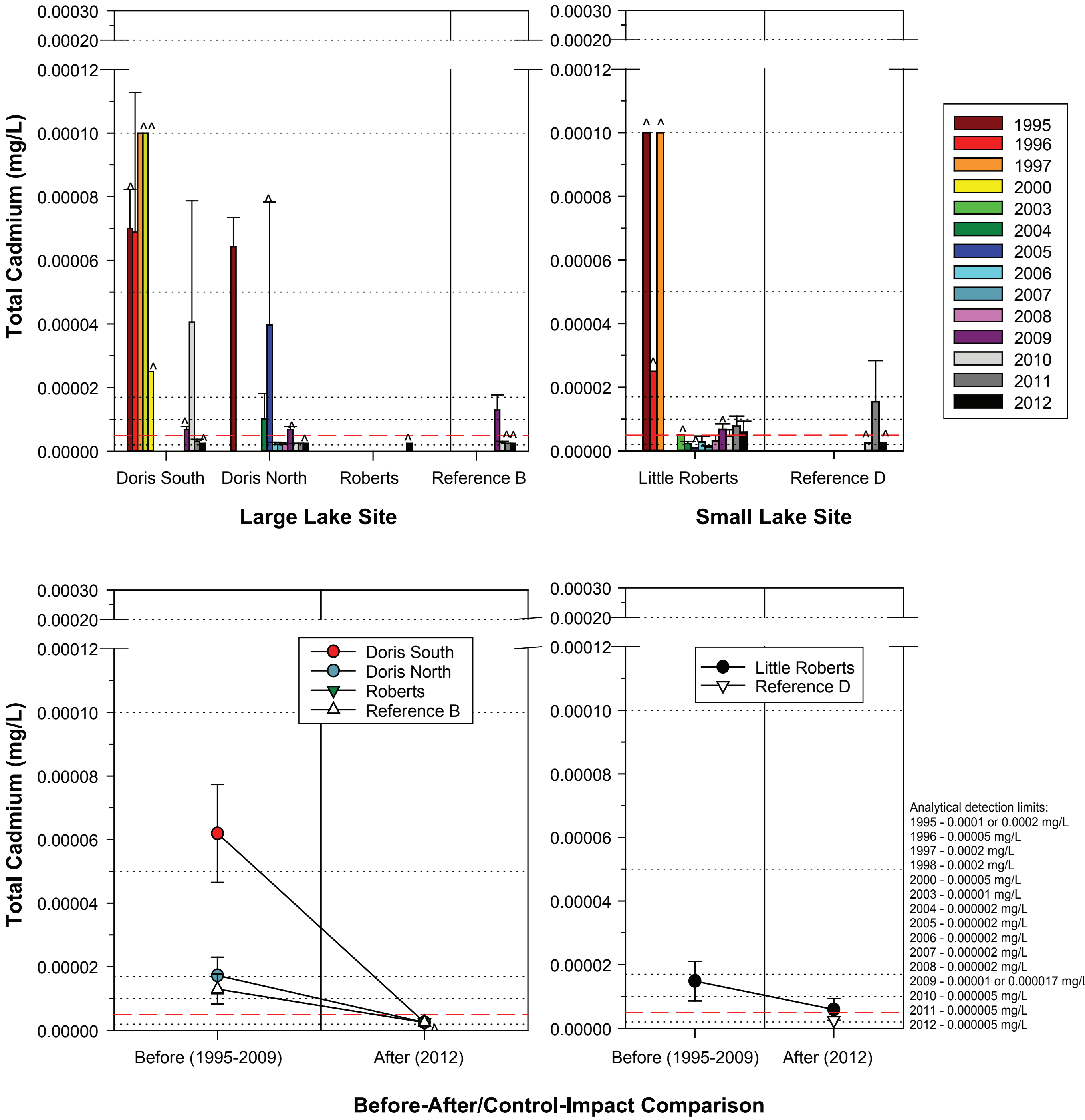
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Although four samples were above the hardness-dependent CCME guideline, mean 2012 total iron concentrations were within the range of baseline means at all exposure sites, suggesting that 2012 Project activities had no effect on iron concentrations (Figure 3.3-31). The before-after comparison confirmed that there was no change in iron concentrations in the exposure lakes in 2012 compared to baseline concentrations ($p = 0.74$ for Doris Lake South, $p = 0.90$ for Doris Lake North, and $p = 0.55$ for Little Roberts Lake).

3.3.2.14 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 inter-annually variable in all lakes, making it difficult to distinguish potential Project-related effects from natural variability (Figure 3.3-32). Two samples were above the hardness-dependent CCME guideline for lead. However, for all exposure lakes, the before-after analysis showed that mean 2012 total lead concentrations were not distinguishable from baseline means ($p = 0.48$ for Doris Lake South, $p = 0.42$ for Doris Lake North, and $p = 0.73$ for Little Roberts Lake), suggesting that 2012 Project activities had no effect on lead concentrations.

3.3.2.15 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 2012 were below the analytical detection limit of 0.0000005 mg/L (Appendix A) that is well below the CCME guideline for inorganic mercury of 0.000026 mg/L (Figure 3.3-33; Appendix A). Comparisons to pre-2010 data are problematic because of the high proportion of data that were below detection limits, and the widely variable historical detection limits. However, the before-after analysis showed that there was no difference in means between baseline years and 2012 for Doris Lake North ($p = 0.34$) and Little Roberts Lake ($p = 0.35$), suggesting that Project activities did not affect total mercury concentrations in these exposure lake sites. At Doris Lake South, there was a significant difference between mean baseline and 2012 mercury concentrations ($p < 0.0001$). In this case, 2012 concentrations were significantly lower than historical levels and these decreases are of no concern. Therefore, 2012 Project activities had no effect on mercury 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.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for cadmium based on the minimum hardness measured in exposure and reference lakes between 1996 and 2012 (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 to 2012

Figure 3.3-29

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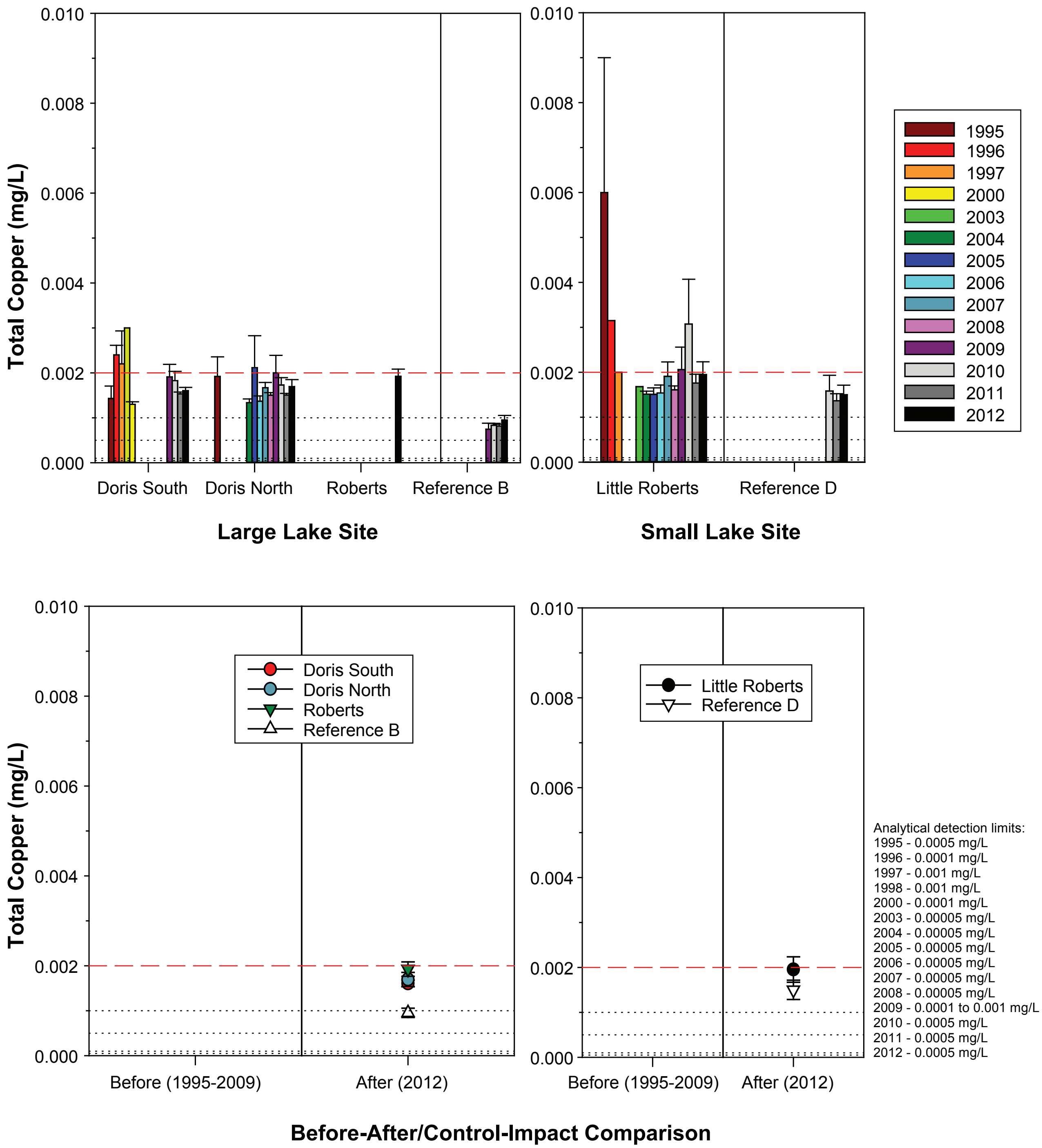

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The CCME freshwater guideline for copper is hardness dependent.
Red dashed lines represent the minimum CCME freshwater 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.

Figure 3.3-30

Total Copper Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

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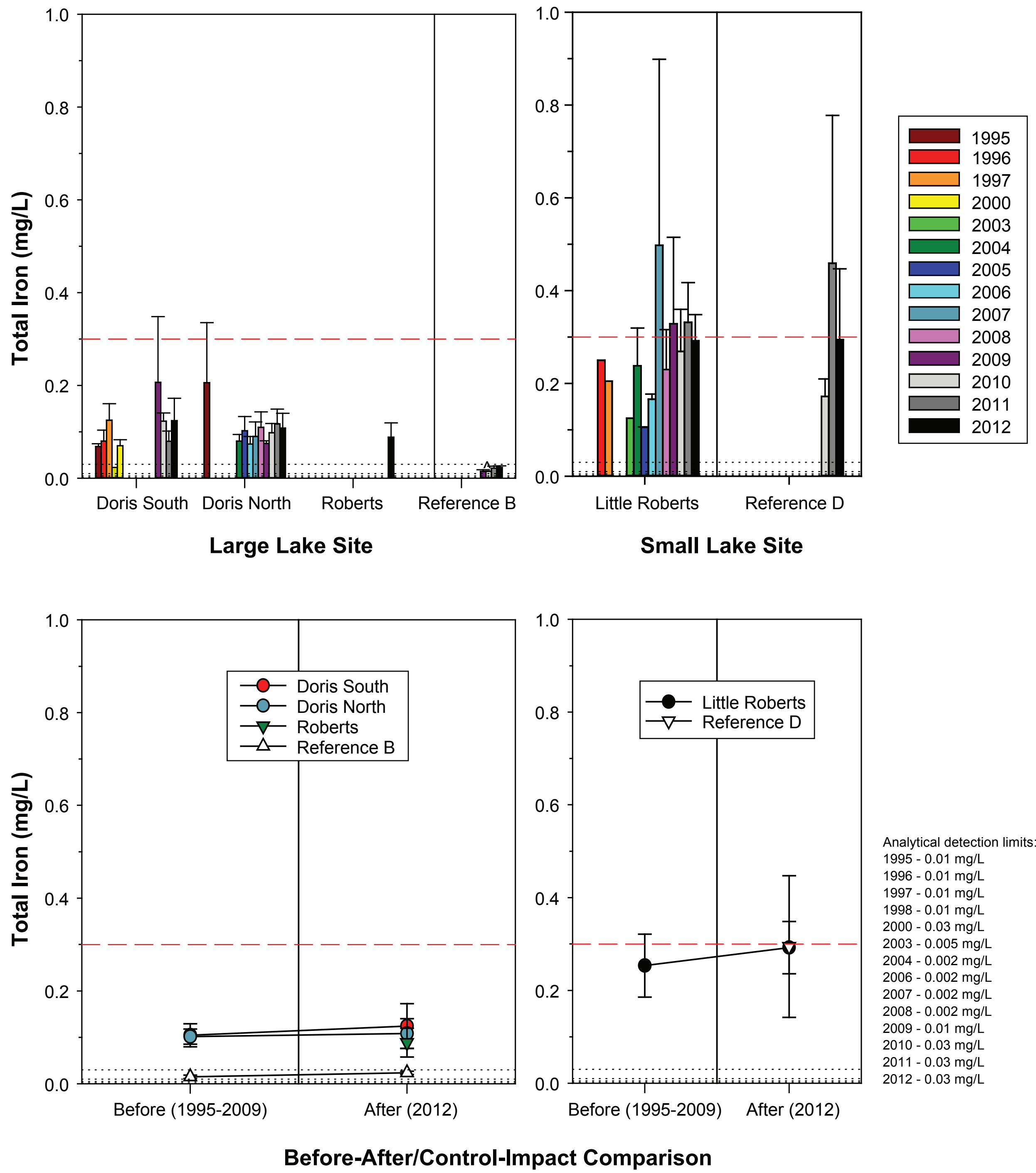

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater 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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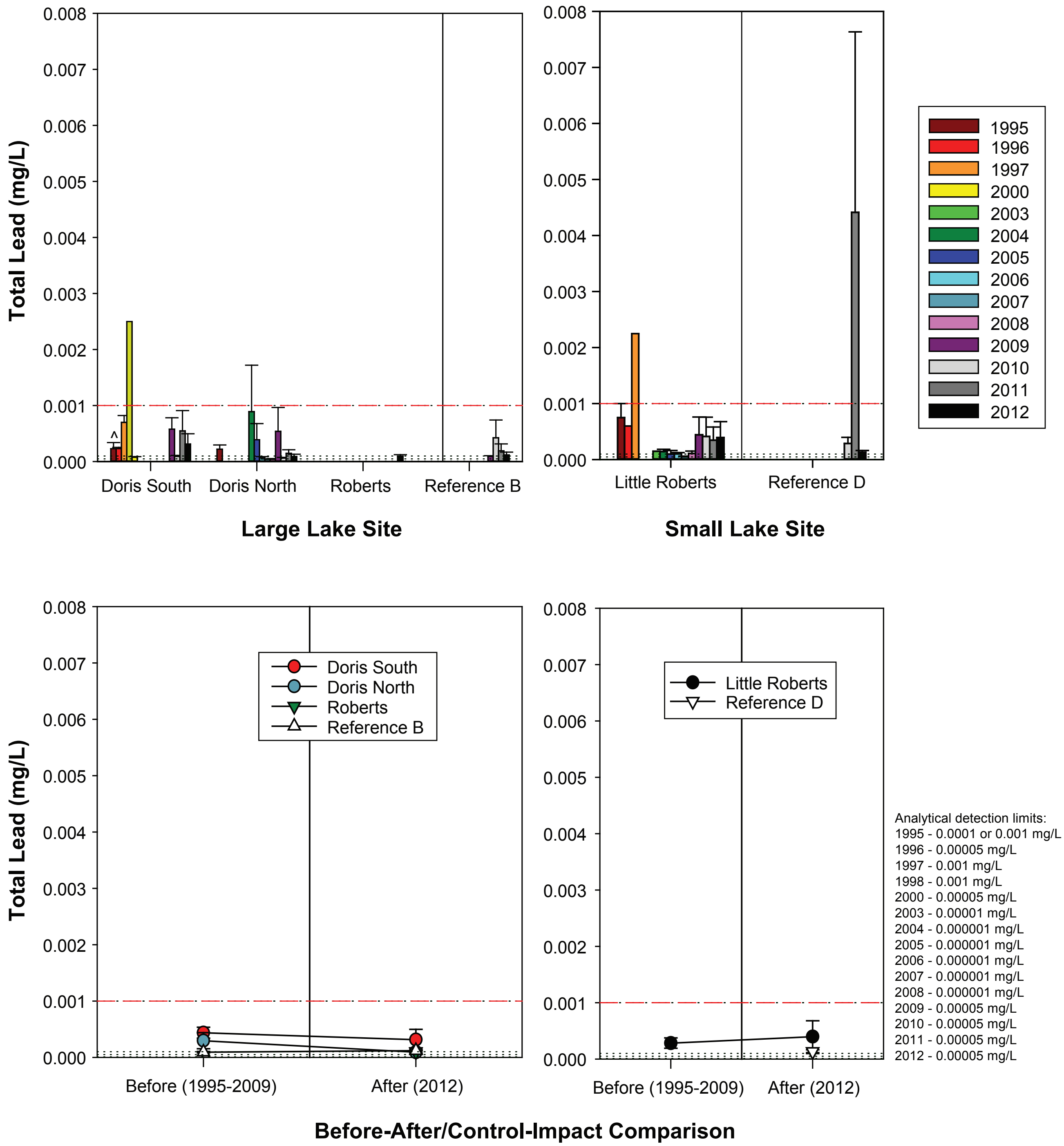
Total Iron Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-31

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.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the minimum CCME freshwater 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.

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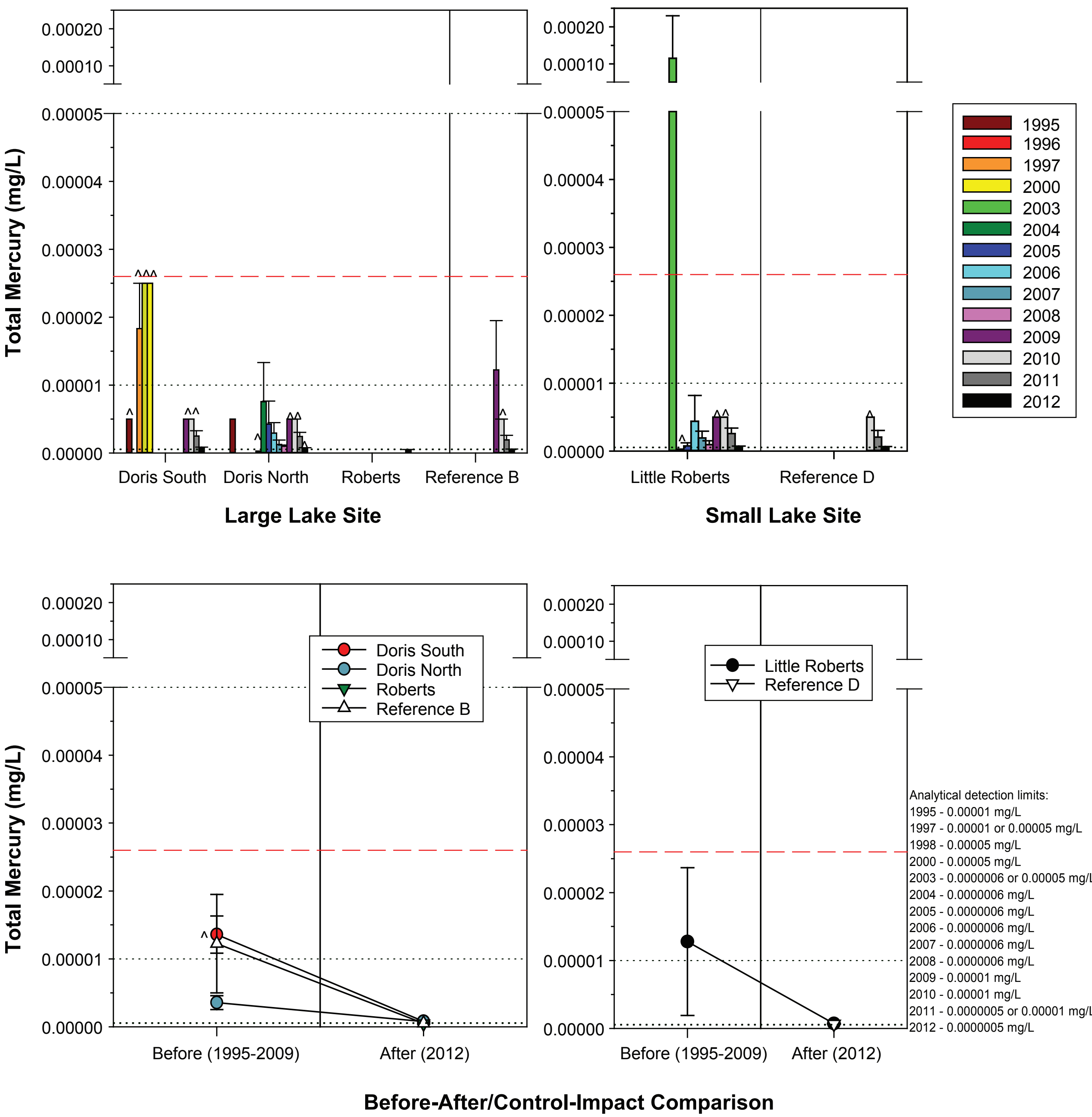
Total Lead Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-32

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 freshwater 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 to 2012

Figure 3.3-33

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3.3.2.16 Total Molybdenum

Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Although total molybdenum concentrations were generally similar over time within each lake, there were slight increases in concentrations in both Doris Lake North and Little Roberts Lake (Figure 3.3-34). The before-after comparison confirmed these trends; mean 2012 molybdenum concentrations were significantly different from baseline means in Doris Lake North and Little Roberts Lake, but not Doris Lake South ($p < 0.00001$ for Doris Lake North, $p = 0.00001$ for Little Roberts Lake and $p = 0.90$ for Doris Lake South). A further BACI comparison found parallel changes in the concentration of molybdenum between Doris Lake North and Reference Lake B ($p = 0.04$). No BACI comparison was possible for Little Roberts Lake. However, the pattern of molybdenum concentrations in Little Roberts Lake were similar to those observed in Doris Lake North, suggesting that the observed increase was due to natural variability in the region and not Project activities. For all three exposure lakes, mean 2012 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 3.3-34).

3.3.2.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Total nickel concentrations measured in exposure lake sites in 2012 were well below the hardness-dependent CCME guideline for nickel and generally similar to baseline concentrations (Figure 3.3-35). This suggests that 2012 Project activities did not cause an increase in total nickel concentrations in exposure lakes. The before-after comparison confirmed that mean nickel concentrations did not change significantly in any exposure lake in 2012 compared to baseline years ($p = 0.44$ for Doris Lake South, $p = 0.60$ for Doris Lake North, and $p = 0.95$ for Little Roberts Lake).

3.3.2.18 Total Zinc

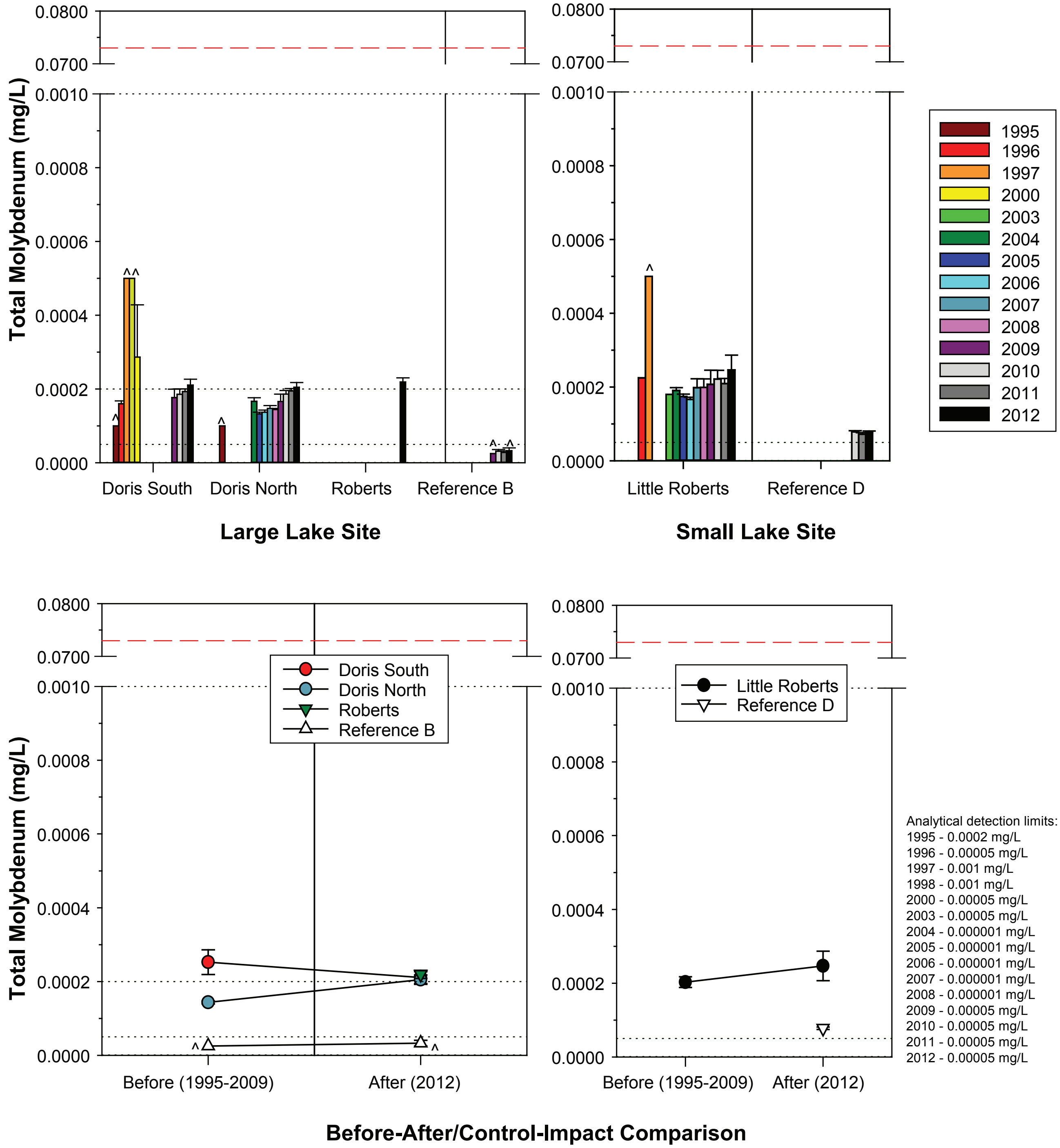
Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2012, 91% of total zinc concentrations measured in exposure lakes were below the analytical detection limit of 0.003 mg/L and all concentrations were below the CCME guideline of 0.03 mg/L (Figure 3.3-36). Before-after statistical results indicate that there was no difference between mean 2012 and baseline zinc concentrations ($p = 0.45$ for Doris Lake South, $p = 0.52$ for Doris Lake North and $p = 0.40$ for Little Roberts Lake). Therefore, there was no evidence of an increase in zinc in exposure lakes as a result of 2012 activities.

3.3.3 Marine

Water quality samples from marine areas were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Ida Bay (REF-Marine 1) in 2012. Baseline data from 2009 are available for all sites, and additional baseline data from 1996 and 2004 to 2008 are available for site RBE. All 2012 samples were collected at the surface (0.5 to 1 m depth), so any baseline data collected from near the water-sediment interface were excluded from the baseline dataset used for the effects analyses. Graphs showing water quality trends in marine sites over time are shown in Figures 3.3-37 to 3.3-54, and all statistical results are presented in Appendix B.

3.3.3.1 pH

pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. Mean 2012 pH levels in marine exposure and reference sites were always within the recommended marine CCME guideline range of 7.0 to 8.7 (Figure 3.3-37). pH levels measured at RBW and RBE in 2012 were similar to levels measured at REF-Marine 1 and to baseline pH levels (Figure 3.3-37). Marine environments have a high buffering capacity compared to freshwater systems, so pH levels are relatively insensitive to change. The before-after comparison confirmed that there was no change in marine pH at the exposure sites in 2012 compared to baseline years ($p = 0.03$ for RBW and $p = 0.60$ for RBE). Therefore, there was no apparent effect of 2012 Project activities on marine pH.



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 freshwater 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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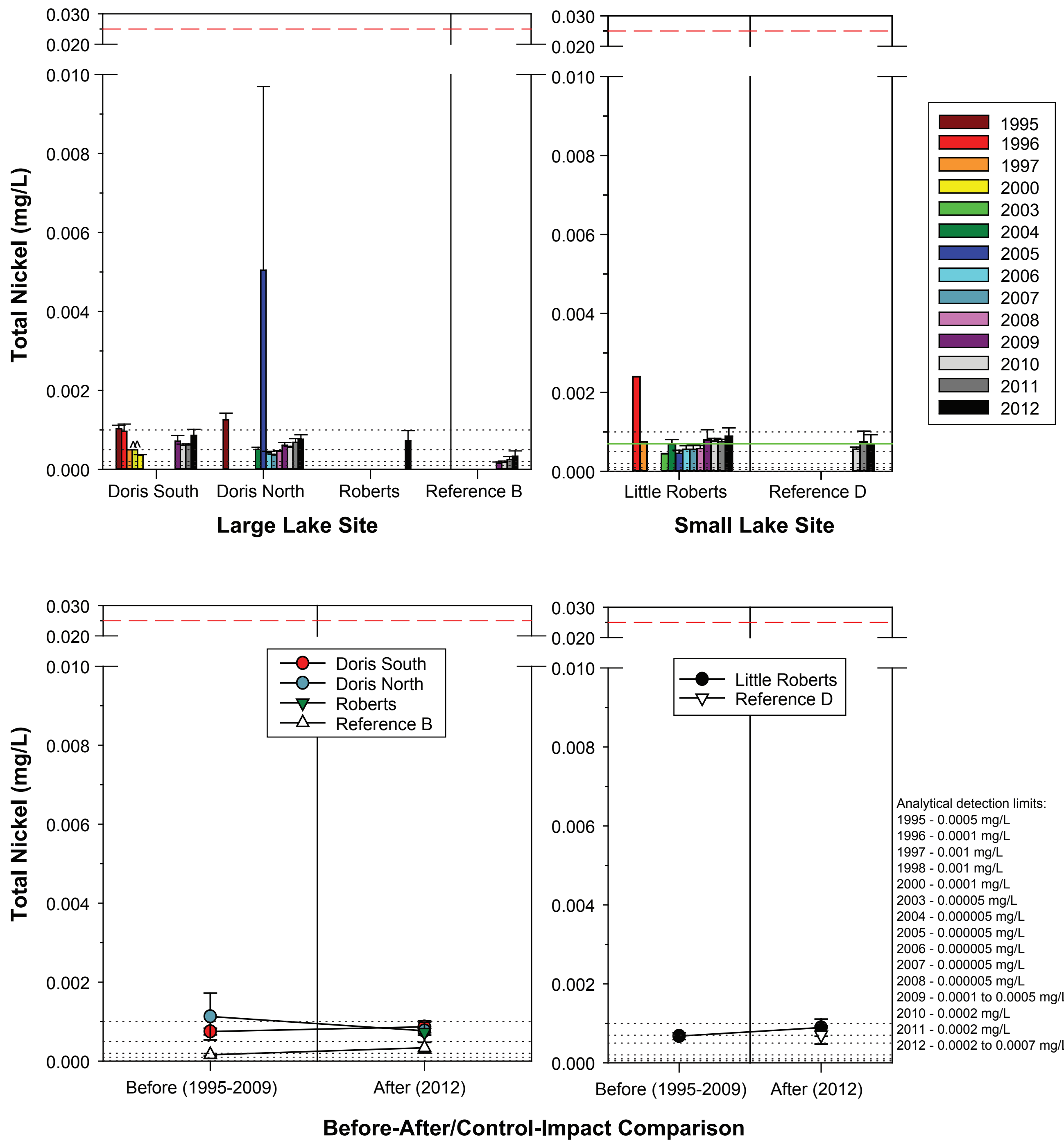
Total Molybdenum Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-34

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.
The CCME freshwater guideline for nickel is hardness dependent.
Red dashed lines represent the minimum CCME freshwater 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.

Figure 3.3-35

Total Nickel Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

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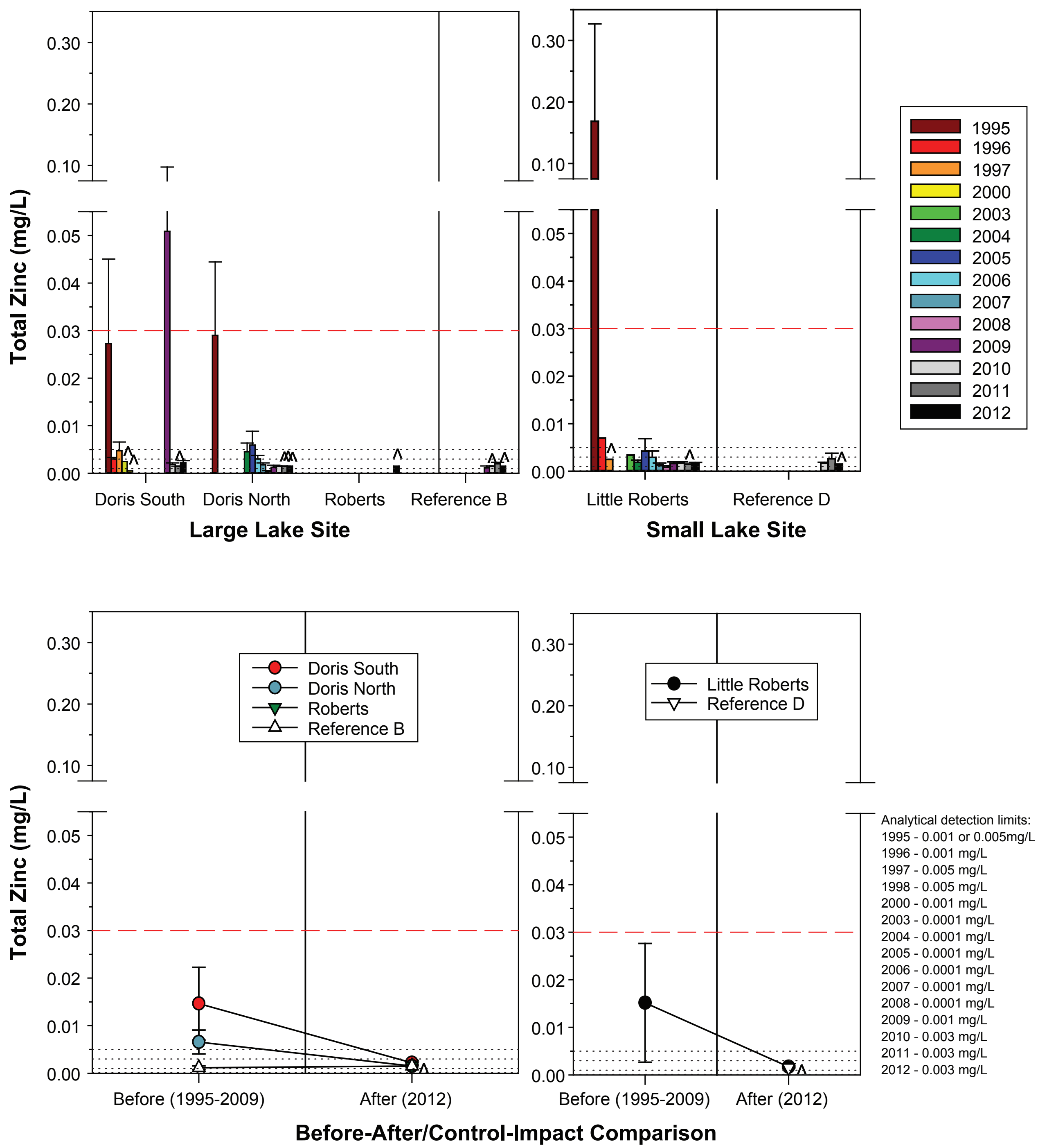

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater 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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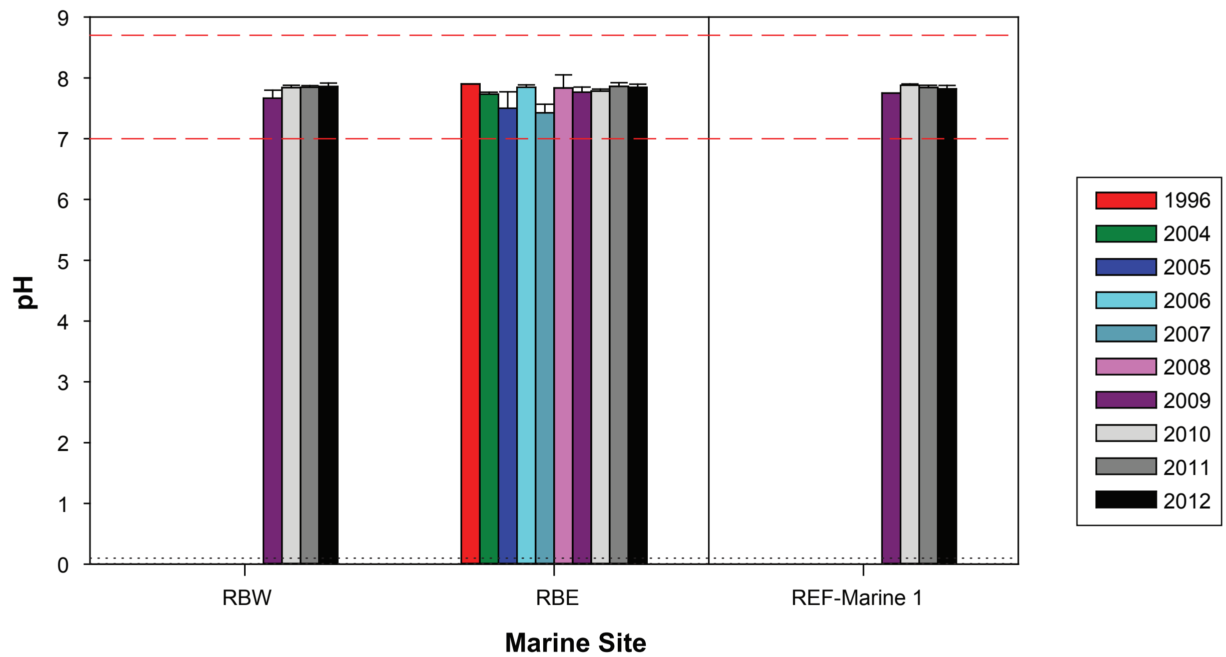
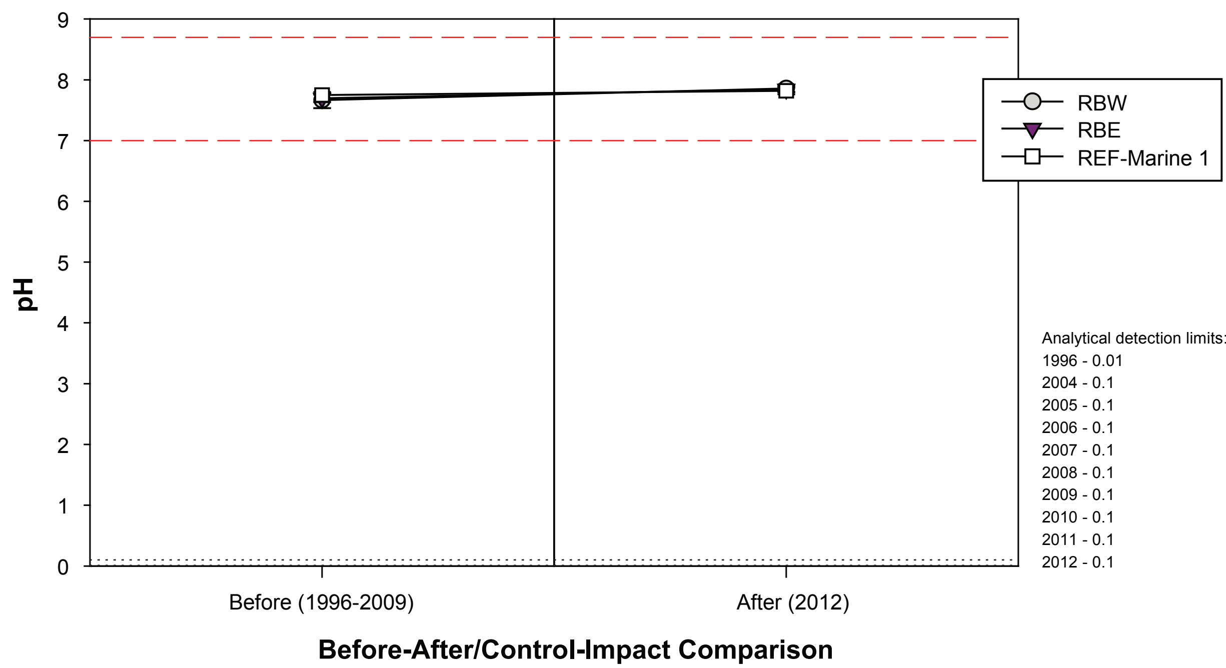
Total Zinc Concentration in AEMP Lake Sites, Doris North Project, 1995 to 2012

Figure 3.3-36

Rescan Engineers & Scientists





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Red dashed lines represent the CCME marine and estuarine 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.

Figure 3.3-37

pH in AEMP Marine Sites, Doris North Project, 1996 to 2012

3.3.3.2 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 baseline total alkalinity data are available. At this site, the mean 2012 alkalinity was slightly higher than the baseline mean, but there was overlap in alkalinity values because of high within-year variability (Figure 3.3-38). The before-after comparison indicated that there was no statistically significant change in alkalinity in 2012 at RBE compared to baseline levels ($p = 0.14$). Therefore, there was no evidence of an effect of Project activities on alkalinity at this site. Although no statistical analysis was possible for site RBW, 2012 alkalinity levels were generally comparable among the three sites monitored (RBE, RBW, and REF-Marine 1; Figure 3.3-38). Freshwater inputs can affect marine alkalinity because, as observed in lakes and streams sampled as part of the AEMP, 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.

3.3.3.3 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 measured in 2012 in Roberts Bay sites were generally similar to baseline hardness levels, and were also similar to the hardness levels measured in Ida Bay (REF-Marine-1; Figure 3.3-39). The before-after comparison confirmed that 2012 hardness levels at RBW and RBE were not distinguishable from baseline levels ($p = 0.62$ for RBW and $p = 0.63$ for RBE), suggesting that there was no effect of 2012 Project activities on the hardness of marine waters.

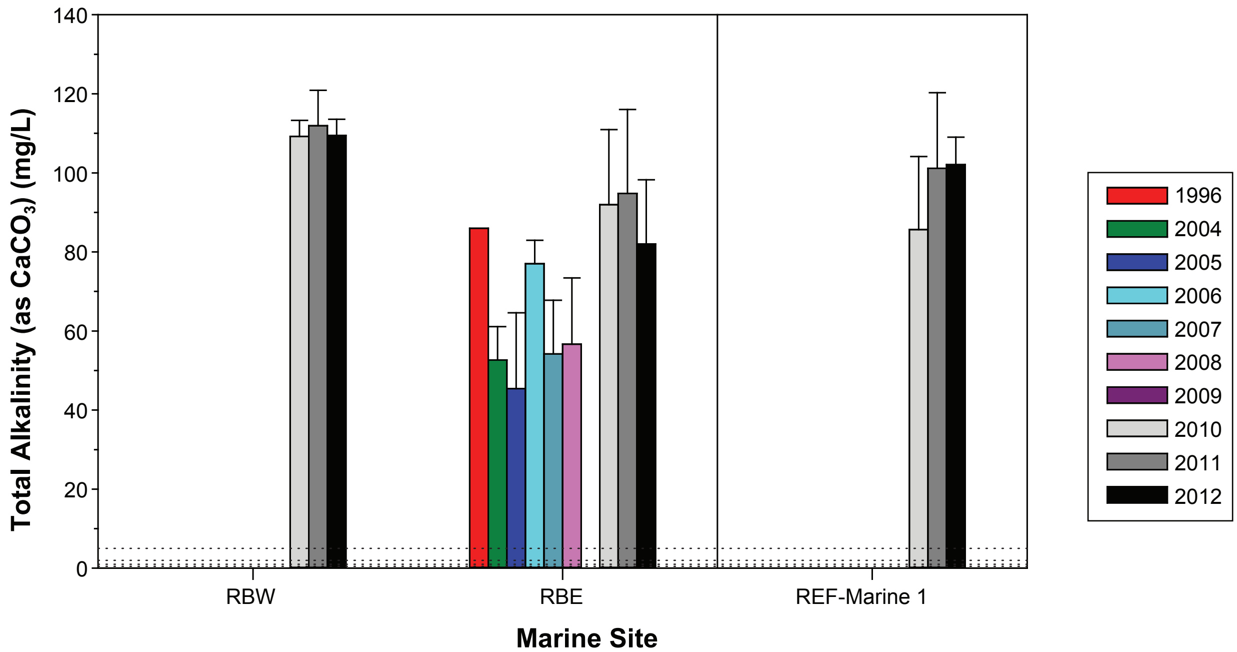
3.3.3.4 Total Suspended Solids

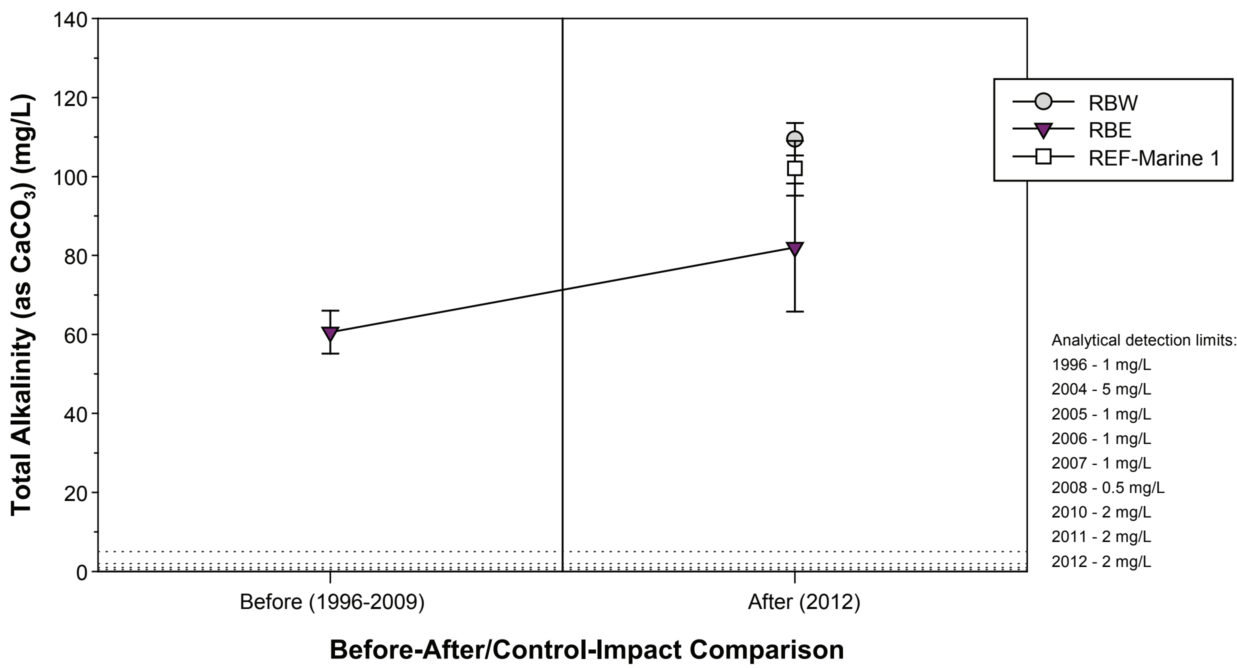
TSS are regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2012 TSS concentrations at RBW and RBE were lower than baseline means (Figure 3.3-40). For site RBE, the before-after comparison indicated that the 2012 mean was not statistically distinguishable from the baseline mean ($p = 0.11$). However, the same before-after statistical analysis indicated that mean 2012 concentrations at RBW were significantly different from mean baseline concentrations ($p = 0.004$). In this case, 2012 TSS was significantly lower than historical levels and decreasing TSS concentrations are not of concern. Therefore, there were no apparent adverse effect of 2012 Project activities on marine TSS concentrations.

The marine 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 2012b). Because there was no increase in TSS concentrations from background levels at either RBW or RBE, 2012 TSS concentrations in marine exposure sites continued to remain below the CCME guideline.

3.3.3.5 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 2012 samples from Roberts Bay were near or below the analytical detection limit of 0.005 mg ammonia-N/L (Figure 3.3-41). At site RBE, baseline ammonia concentrations were widely variable and were frequently higher than 2012 concentrations (Figure 3.2-41). The before-after comparison indicated that the 2012 mean total ammonia concentration at RBE and RBW was not significantly different from the baseline mean ($p = 0.27$ and $p = 0.78$, respectively). There was no evidence of an effect of 2012 Project activities on total ammonia concentrations in the marine environment.

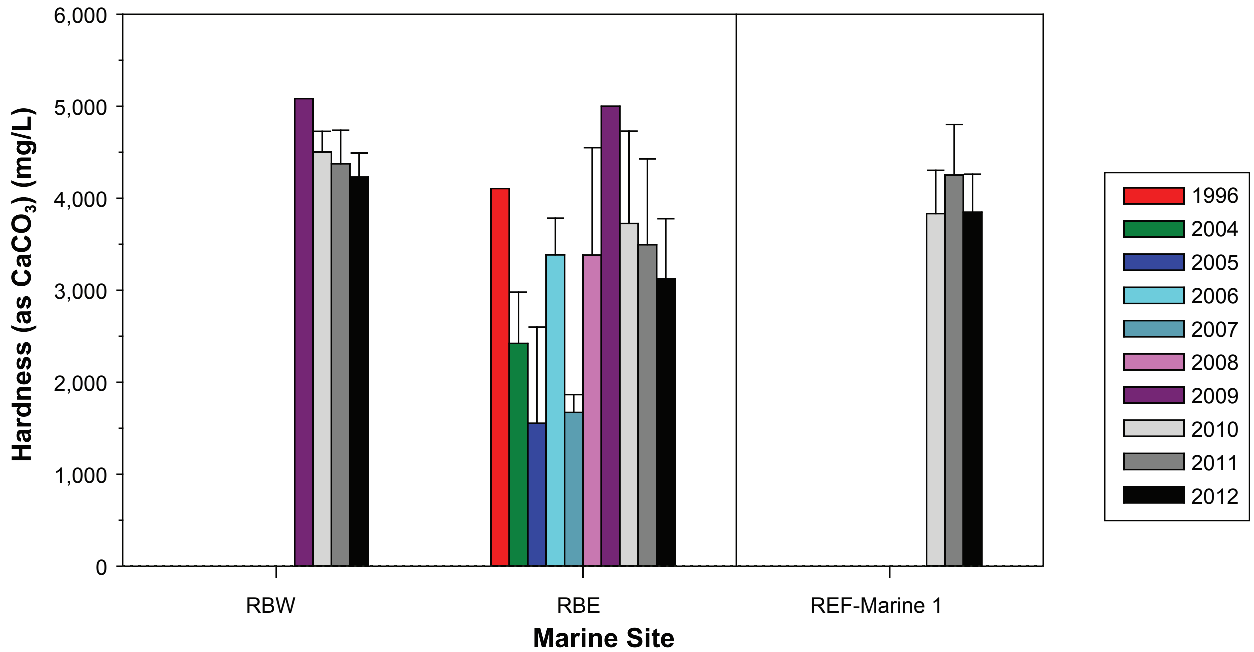


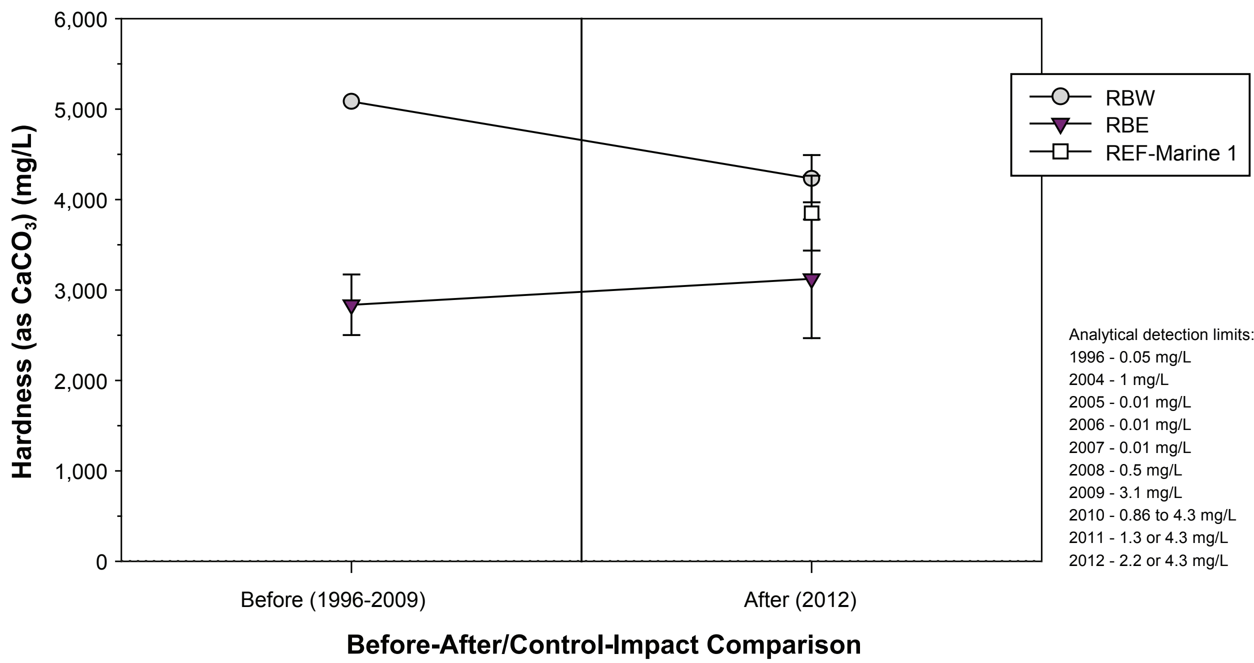


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as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

Figure 3.3-38

Total Alkalinity in AEMP Marine Sites, Doris North Project, 1996 to 2012





Analytical detection limits:
1996 - 0.05 mg/L
2004 - 1 mg/L
2005 - 0.01 mg/L
2006 - 0.01 mg/L
2007 - 0.01 mg/L
2008 - 0.5 mg/L
2009 - 3.1 mg/L
2010 - 0.86 to 4.3 mg/L
2011 - 1.3 or 4.3 mg/L
2012 - 2.2 or 4.3 mg/L

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.

Figure 3.3-39

Hardness in AEMP Marine Sites, Doris North Project, 1996 to 2012

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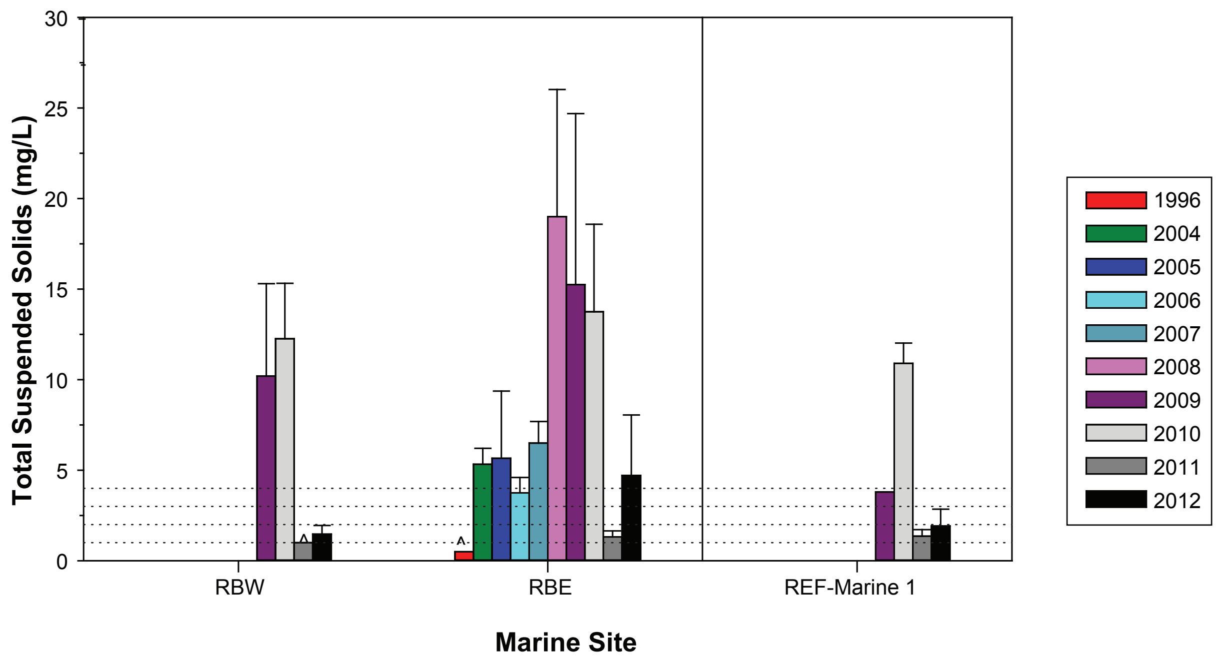

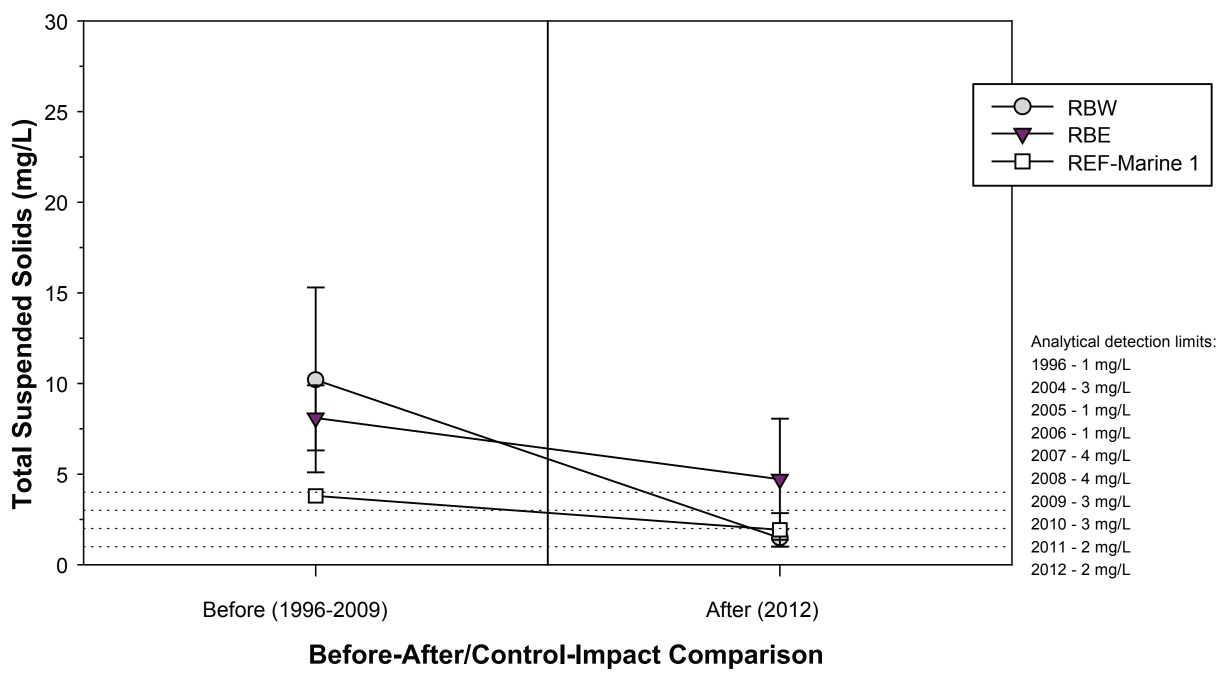

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME marine guideline 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 Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

Figure 3.3-40

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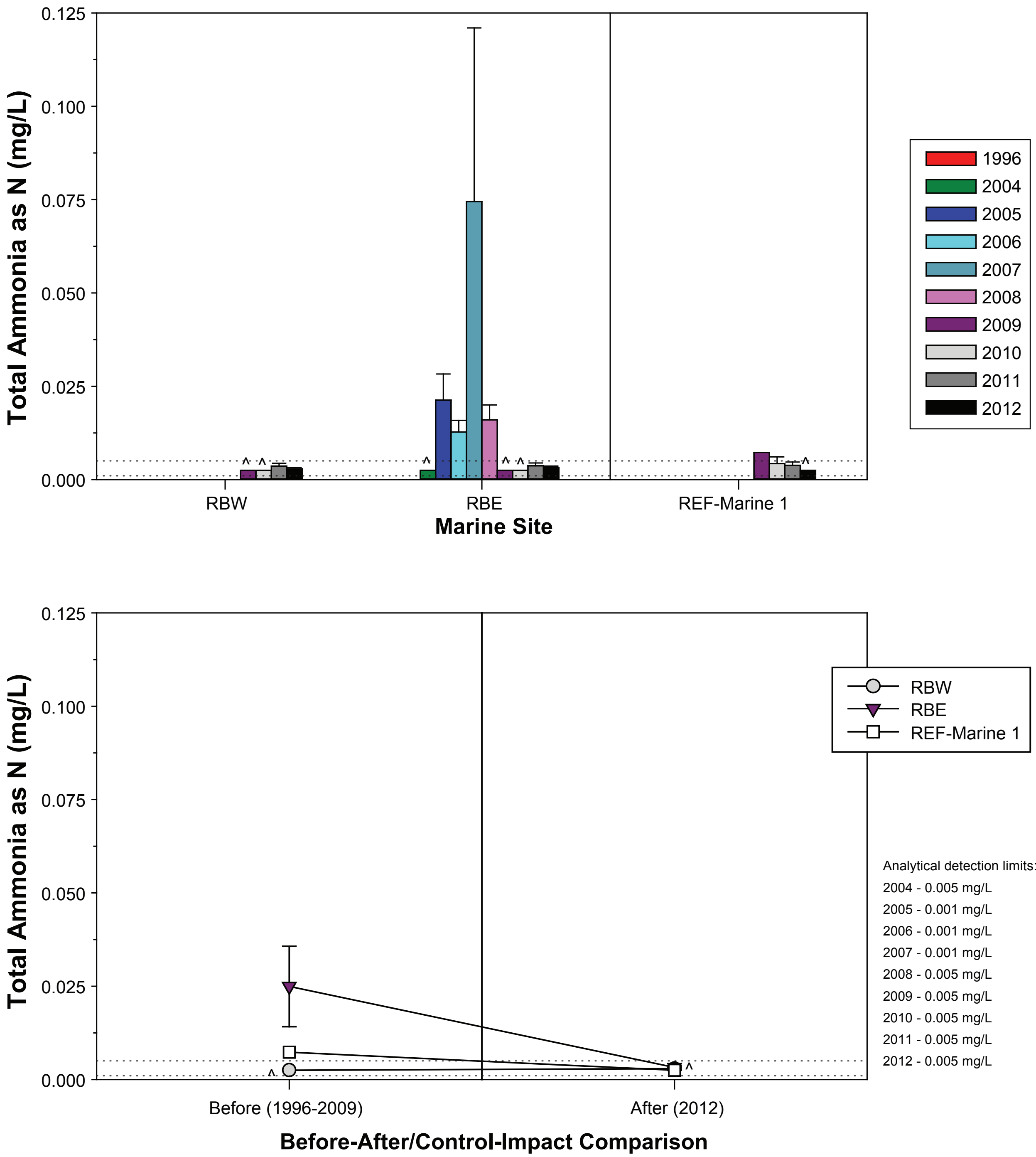

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Sample concentrations that were below the very high detection limit of 5 mg/L were excluded from plots.
^ 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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Figure 3.3-41

Total Ammonia Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

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3.3.3.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All 2012 and baseline nitrate concentrations measured in marine reference and exposure sites were well below the marine CCME guideline of 3.612 mg nitrate-N/L (Figure 3.3-42). The mean 2012 nitrate concentration at RBW and RBE were within the range of baseline means (Figure 3.3-42). The before-after analysis confirmed that the 2012 and baseline means were not statistically distinguishable (p = 0.02 for RBW and p = 0.74 for RWE). There was no apparent effect of 2012 Project activities on nitrate concentrations in the marine exposure sites

3.3.3.7 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 baseline cyanide data are available, baseline and 2012 total cyanide concentrations were usually near or below the detection limit, except some relatively high concentrations measured in 2005 (Figure 3.3-43). The mean 2012 cyanide concentration at site RBE was within the range of baseline concentrations and the before-after analysis showed that the 2012 mean was not distinguishable from the baseline mean (p = 0.62). Although statistical analysis was not possible for RBW because there was no baseline data for this site, mean 2012 cyanide concentrations were similarly low among all marine exposure and reference sites (Figure 3.3-43). Cyanide was not brought to the Project site in 2012, so there is no reason to expect that cyanide concentrations would increase in either of the marine exposure sites due to Project activity.

3.3.3.8 Radium-226

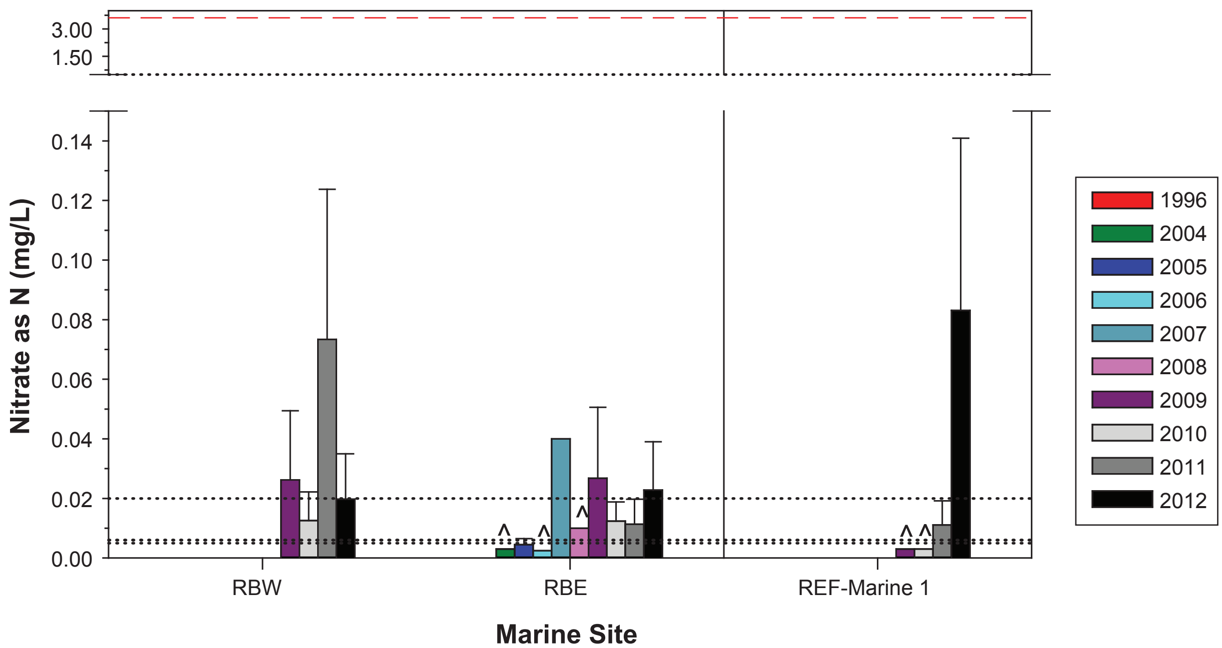
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. All radium-226 concentrations measured at the exposure marine sites in 2012 were below the analytical detection limits of 0.005 or 0.01 Bq/L (Figure 3.3-44). Although statistical analysis were not possible from RBE or RBW because of a high proportion (>70%) of below detection limited values in the dataset, the before-after plot not only suggests that 2012 concentrations were within the range of baseline concentrations, but that concentrations are decreasing (Figure 3.3-43). Therefore, there was no evidence of an increase in radium-226 concentrations in the marine exposure sites as a result of 2012 activities.

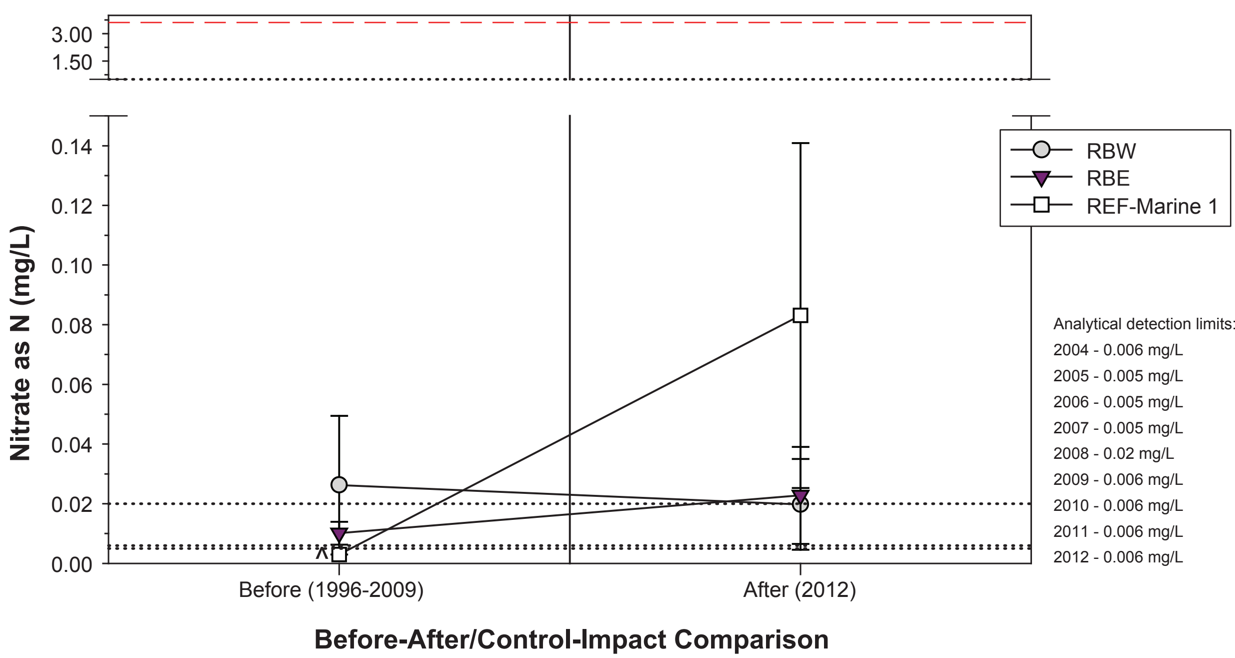
3.3.3.9 Total Aluminum

Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, the mean 2012 total aluminum concentration was within the range of baseline means (Figure 3.3-45). At site RBW, the 2012 mean was slightly higher than the 2009 mean (Figure 3.3-45). The before-after comparison for both marine exposure sites indicated that the 2012 means were not statistically different from the baseline means (p =0.69 for RBW and p = 0.84 for RBE). This suggests that there was no effect of Project activities on total aluminum concentrations at the Roberts Bay exposure sites.

3.3.3.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. All total arsenic concentrations measured at marine exposure and reference sites in 2012 were well below the marine CCME guideline of 0.0125 mg/L (Figure 3.3-46). Arsenic concentrations measured at exposure sites in 2012 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 typically more than an order of magnitude higher than 2012 concentrations (Figure 3.3-46). These unusually high arsenic concentrations were treated as outliers and removed from the dataset for the statistical analyses to increase the ability of statistical tests to detect differences. The before-after comparisons revealed that the 2012 mean arsenic concentrations at RBW and RBE were not distinguishable from baseline means (p = 0.14 for RBW and p = 0.69 for RBE). Therefore, 2012 Project activities did not affect total arsenic concentrations at 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.
Sample concentrations that were below the very high detection limits of 0.1, 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 Marine 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.

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Nitrate Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

Figure 3.3-42

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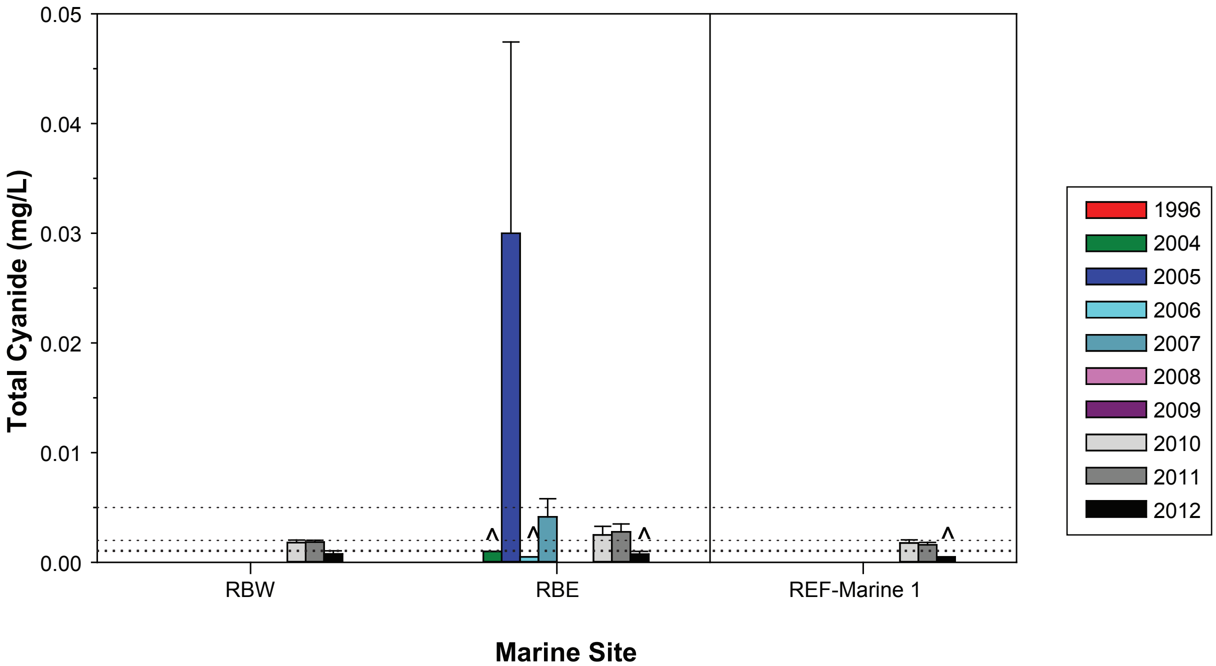

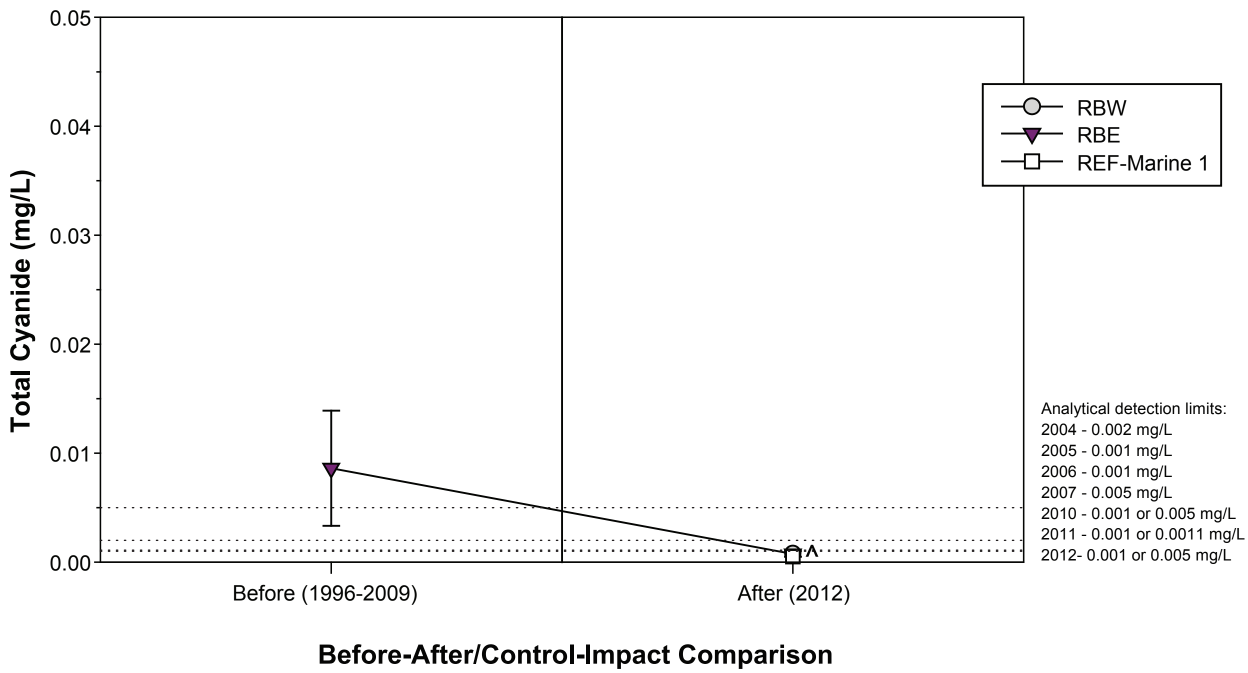

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Samples concentrations that were below the very high detection limits of 0.5 or 5 mg/L were excluded from plots.
^ 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.

Figure 3.3-43

Total Cyanide Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

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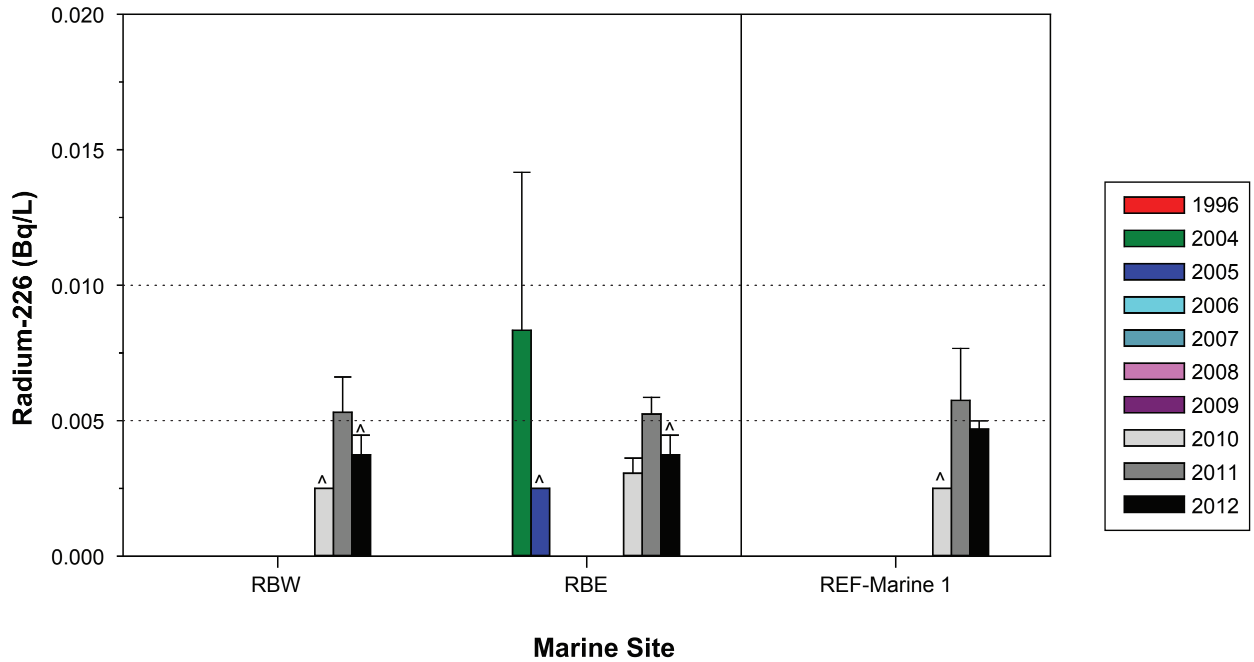
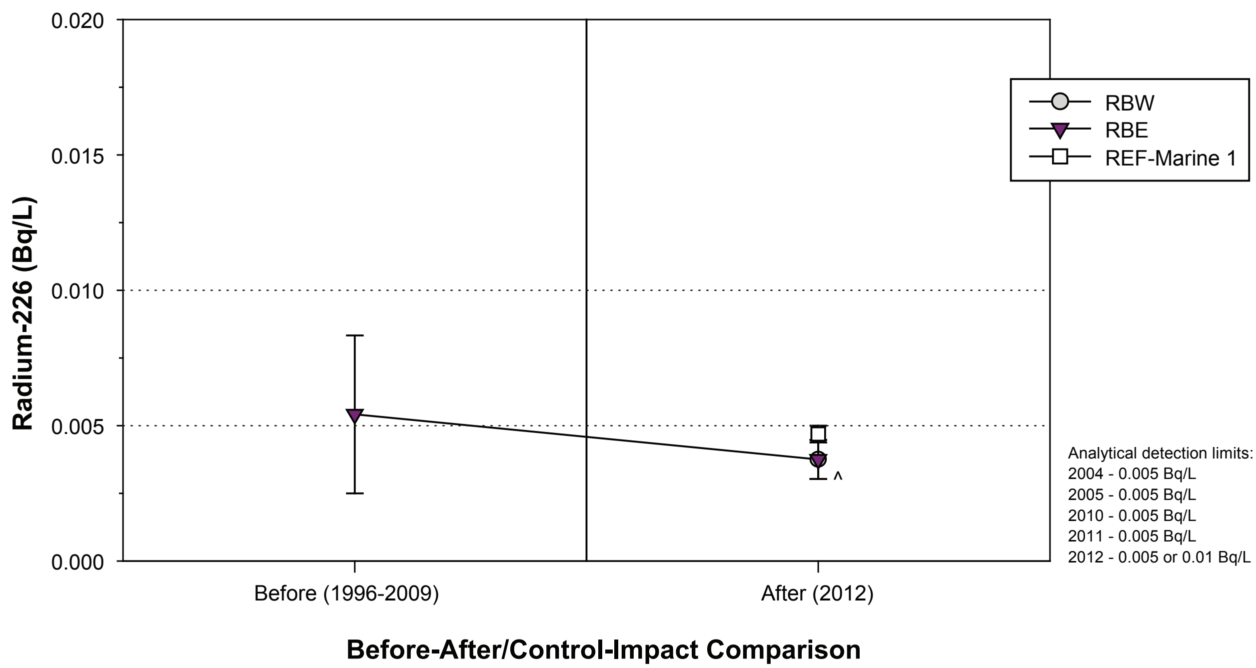
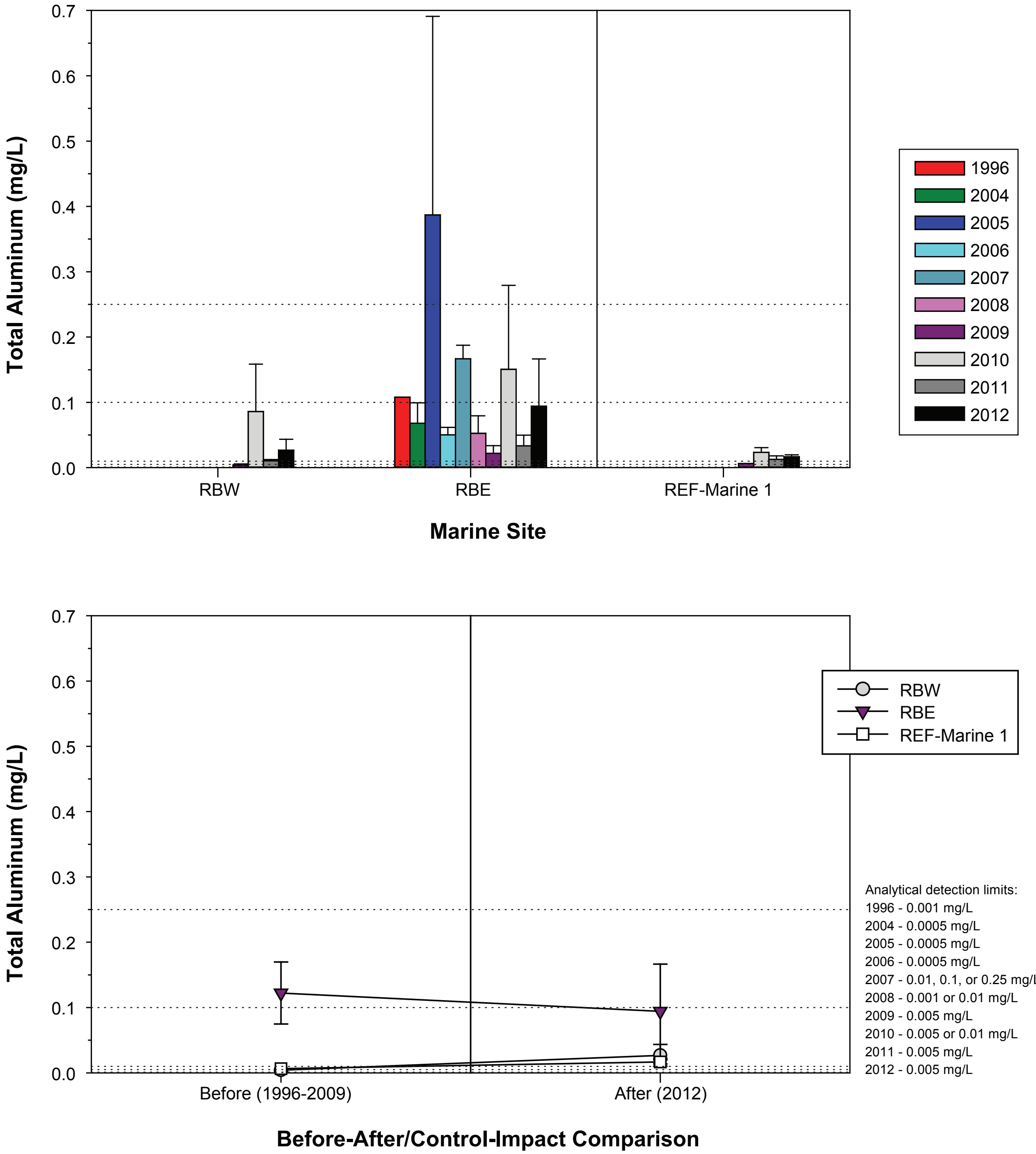




Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated as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

Radium-226 Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

Figure 3.3-44



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.

Figure 3.3-45

Total Aluminum Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

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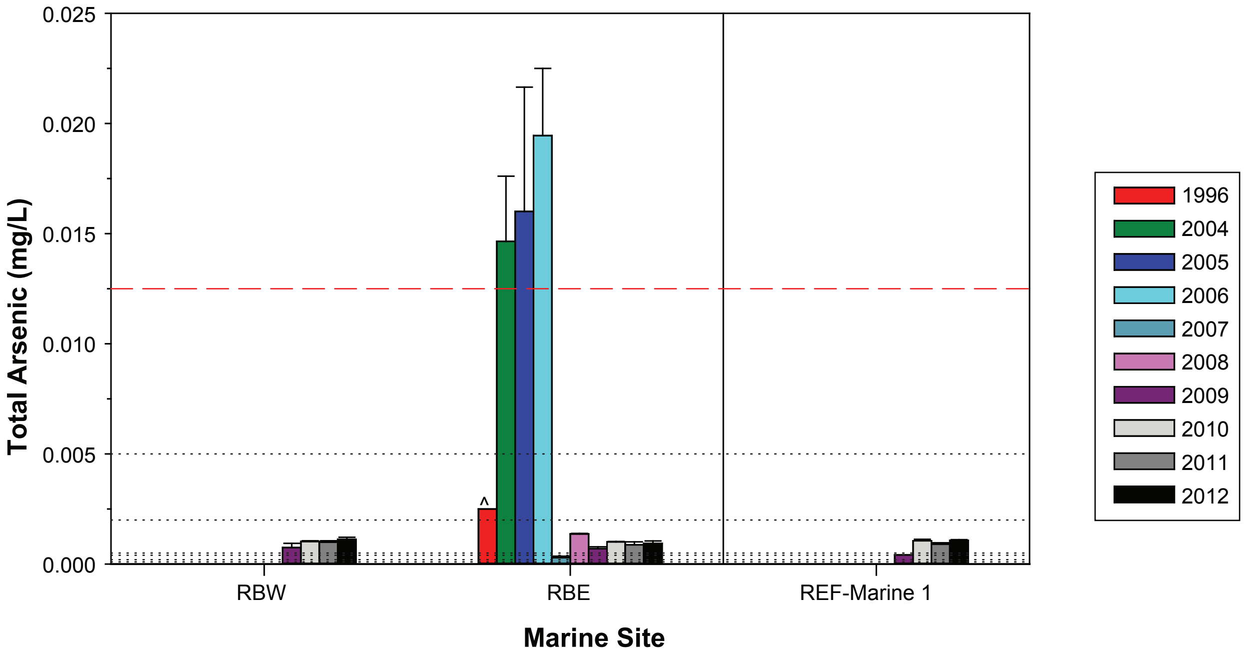

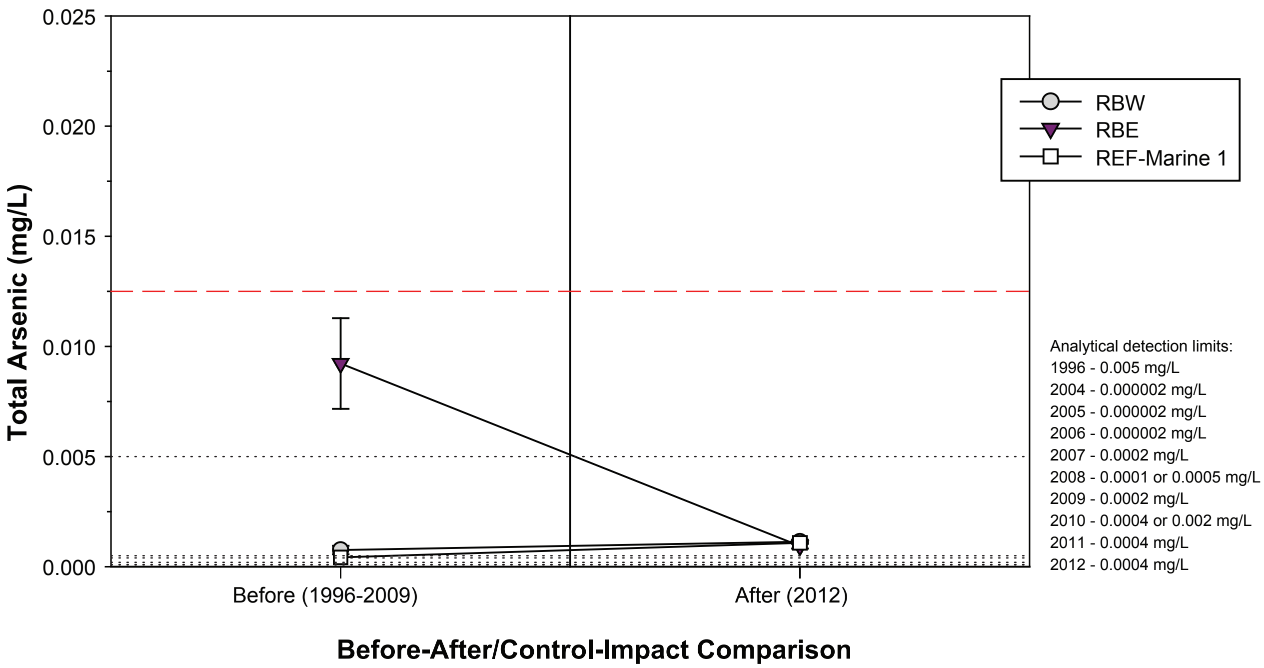

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME marine guideline for arsenic (0.0125 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 Marine Sites, Doris North Project, 1996 to 2012

Figure 3.3-46

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3.3.3.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In 2012, all total cadmium concentrations in samples collected from RBW, RBE, and REF-Marine 1 were below the marine CCME guideline of 0.00012 mg/L (Figure 3.3-47). The before-after plot shows that 2012 mean cadmium concentrations decreased slightly in both of the exposure sites compared to baseline means (Figure 3.3-47). However, the before-after statistical comparison indicated that these differences were not statistically significant ($p = 0.19$ for RBW and $p = 0.73$ for RBE). Therefore, there was no apparent effect of 2012 activities on total cadmium concentrations at the marine exposure sites.

3.3.3.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Between 1996 and 2009, total copper concentrations at RBE were inter-annually variable. The 2012 mean concentration at RBE was within the range of these historical levels (Figure 3.3-48). At RBW, 2012 total copper concentrations were similar to the 2009 concentrations (Figure 3.3-48). The before-after comparison showed that for both RBW and RBE, there was no difference between baseline and 2012 mean copper concentrations ($p = 0.75$ for RBW and $p = 0.59$ for RBE). Therefore, there was no effect of 2012 Project activities on total copper concentrations at sites RBW and RBE in Roberts Bay.

3.3.3.13 Total Iron

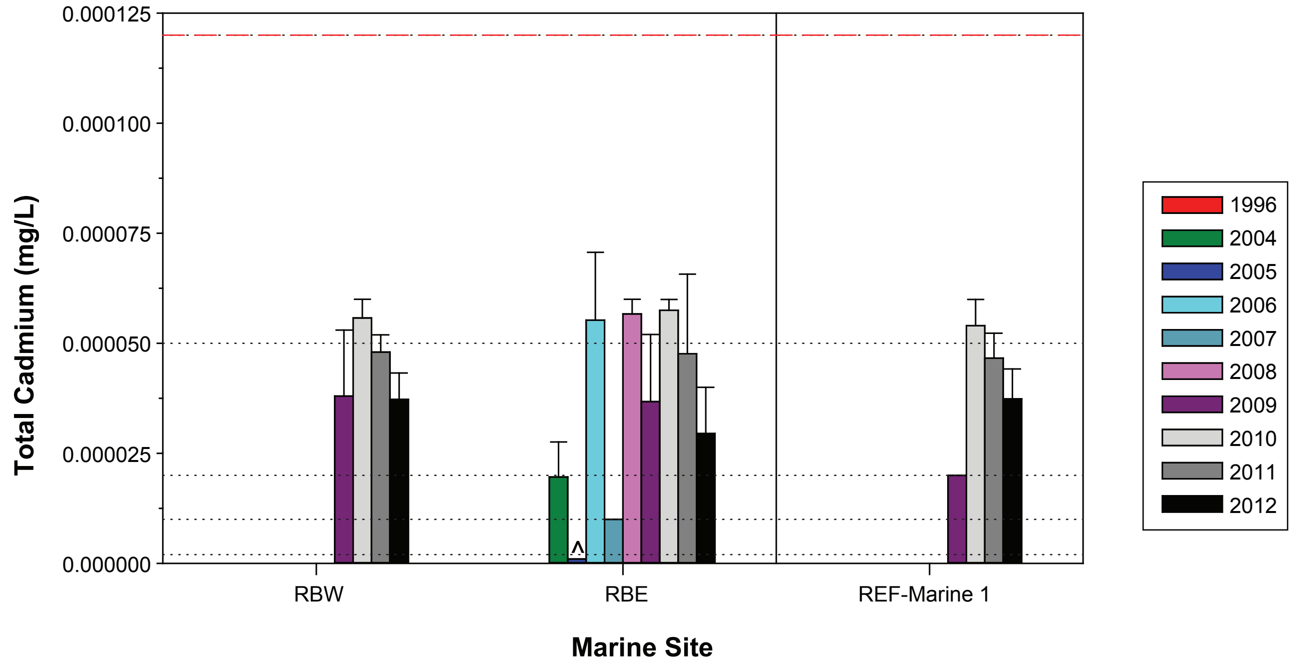
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, 2012 total iron concentrations were within the range of the widely varying baseline concentrations (Figure 3.3-49). At site RBW, there was a slight increase in the mean iron concentration in 2012 compared to 2009 (Figure 3.3-49). For both of these Roberts Bay sites, the before-after analysis showed that 2012 means were not distinguishable from baseline means ($p = 0.79$ for RBW and $p = 0.72$ for RBE), indicating that there was no effect of 2012 activities on total iron concentrations at the marine exposure sites.

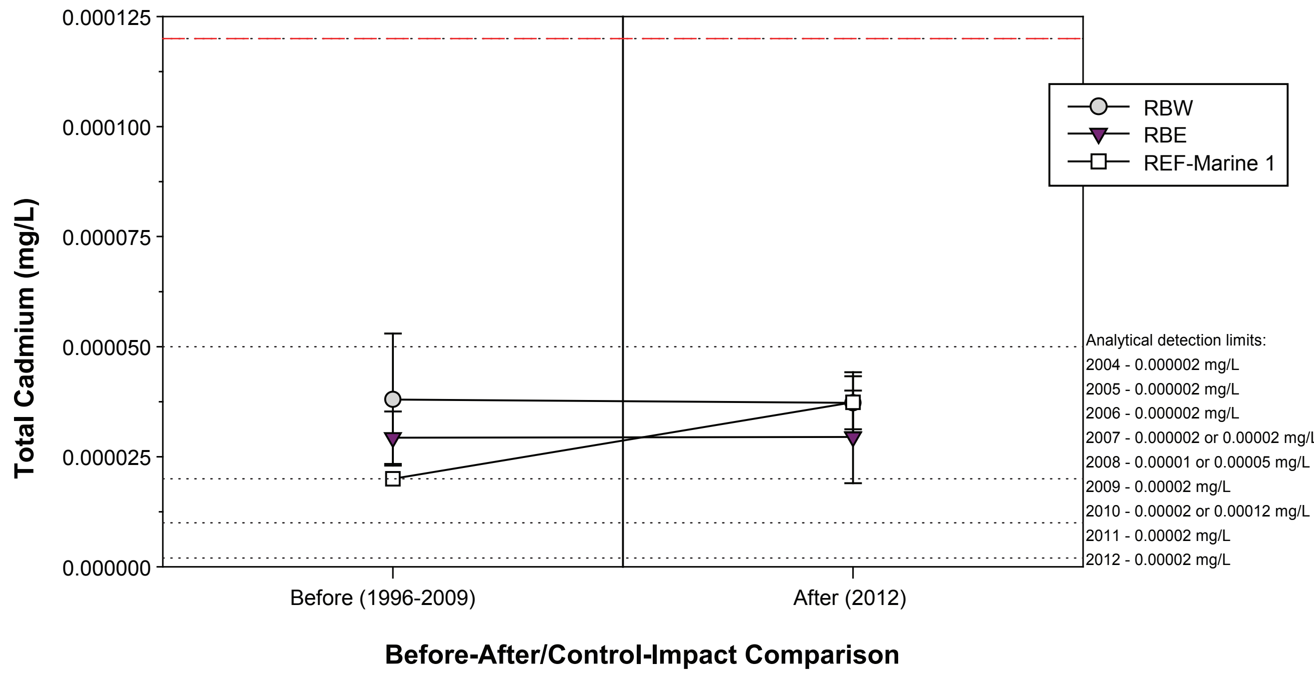
3.3.3.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2012 total lead concentrations at RBW and RBE were within the range of baseline concentrations, while 2012 concentrations at REF-Marine 1 were higher than in 2009 (Figure 3.3-50). The before-after comparison indicated that there was no difference between baseline and 2012 mean total lead concentrations at either marine exposure site ($p = 0.96$ for RBW and $p = 0.68$ for RBE). Therefore, there was no effect of 2012 Project activities on total lead concentrations at RBW and RBE.

3.3.3.15 Total Mercury

Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All baseline and 2012 total mercury concentrations were below the marine CCME guideline for inorganic mercury of 0.000016 mg/L (Figure 3.3-51). All total mercury concentrations measured in April 2012 were below the ultra-low detection limit of 0.0000005 mg/L. For samples collected between July and September 2012, concentrations at exposure sites ranged from 0.00000025 mg/L to 0.00000058 mg/L (Appendix A). Because 2009 was the only year of baseline data available for RBW and REF-Marine 1, total mercury concentrations appeared to decrease in 2012 compared to 2009, but this is an artifact of the higher detection limit achieved for 2009 (0.00001 mg/L) samples (Figure 3.3-51). A before-after comparison is not presented for RBW because a high proportion (71%) of the concentrations was below the analytical detection limit. However, the before-after plot indicates that mercury concentrations were decreasing. At RBE, where baseline concentrations between 2004 and 2008 were also measured using ultra-low detection limits, 2012 concentrations were within the range of baseline levels. The before-after comparisons confirmed that the mean 2012 concentrations were statistically indistinguishable from mean baseline concentrations at RBE ($p= 0.29$ for RBE). There was no apparent effect of 2012 Project activities on total mercury concentrations.

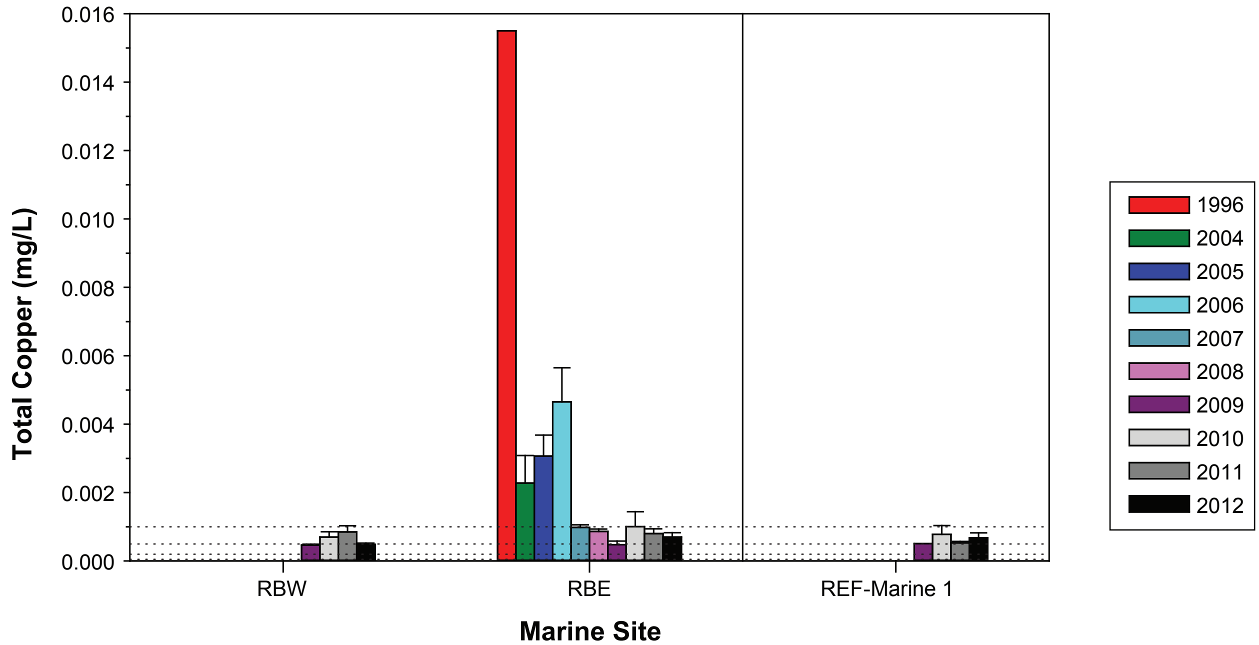


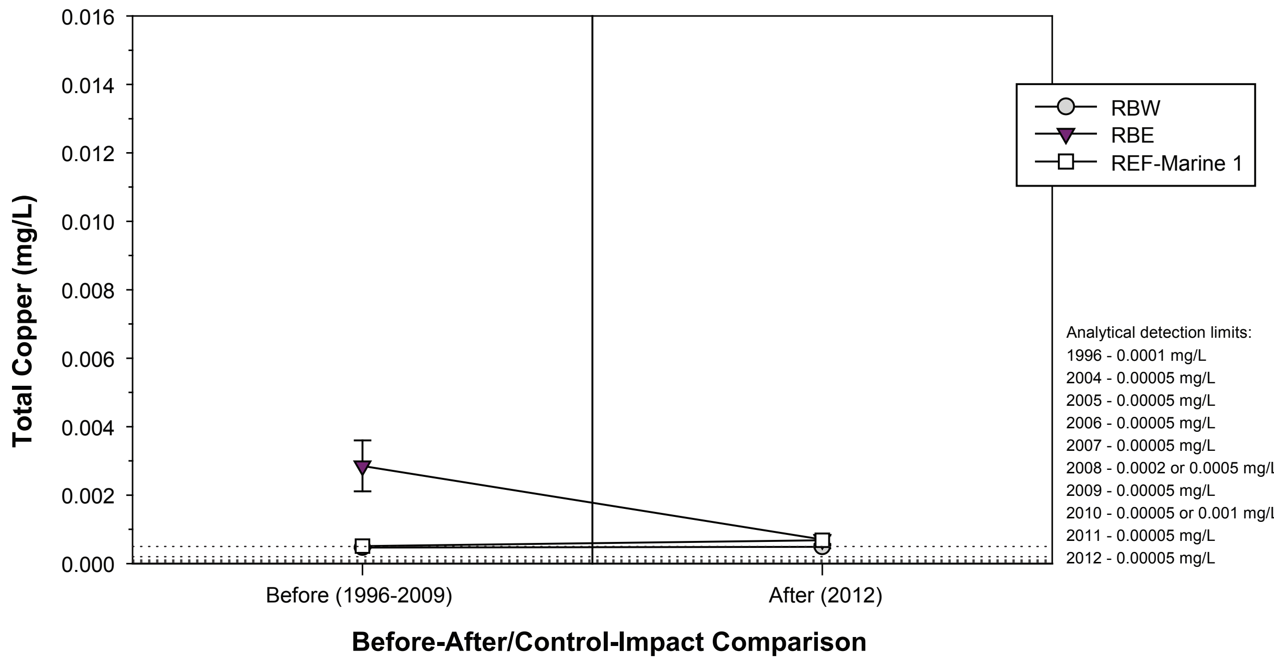


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine guideline for cadmium (0.00012 mg/L).
The anomalously high total cadmium concentration of 0.00348 mg/L reported for RBE in August 1996 was considered an outlier and was excluded from plots.
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Figure 3.3-47

Total Cadmium Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012





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, 1996 to 2012

Figure 3.3-48

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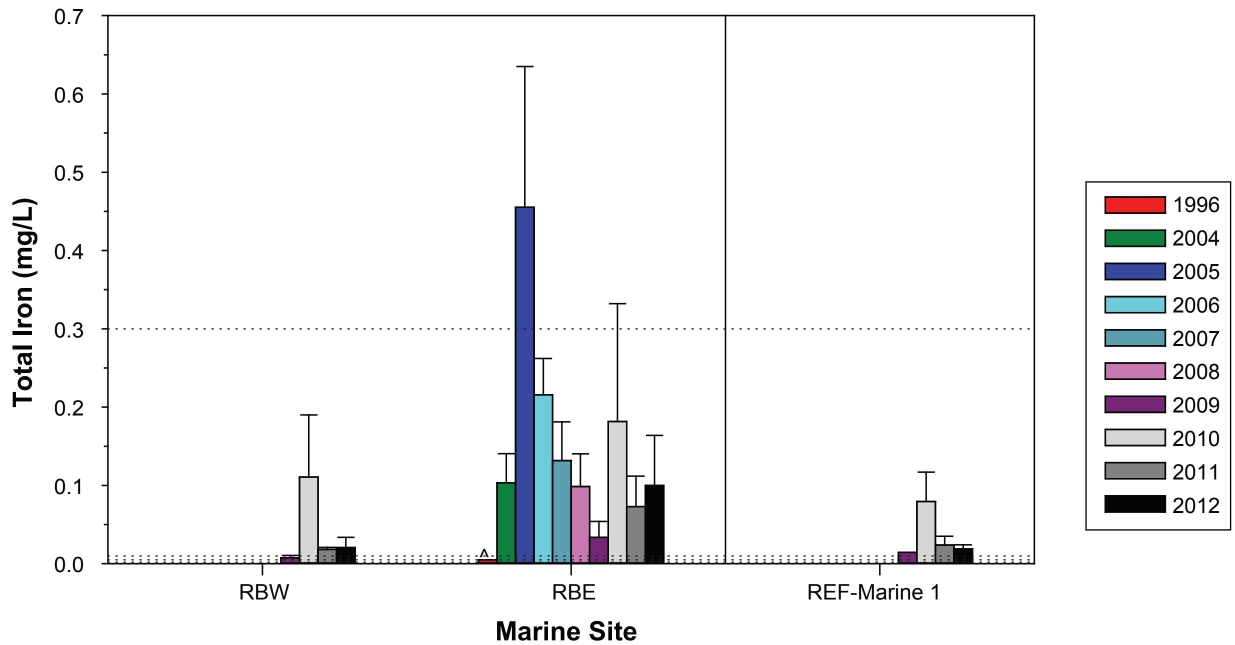

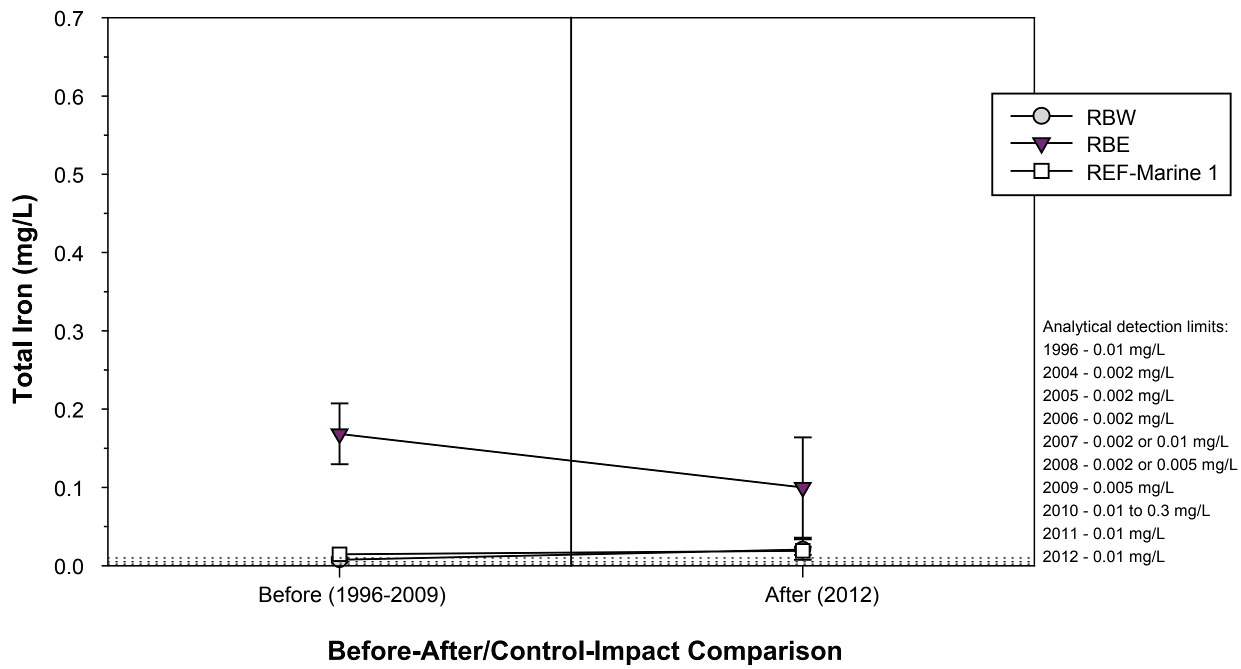

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total iron is a required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

Figure 3.3-49

Total Iron Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

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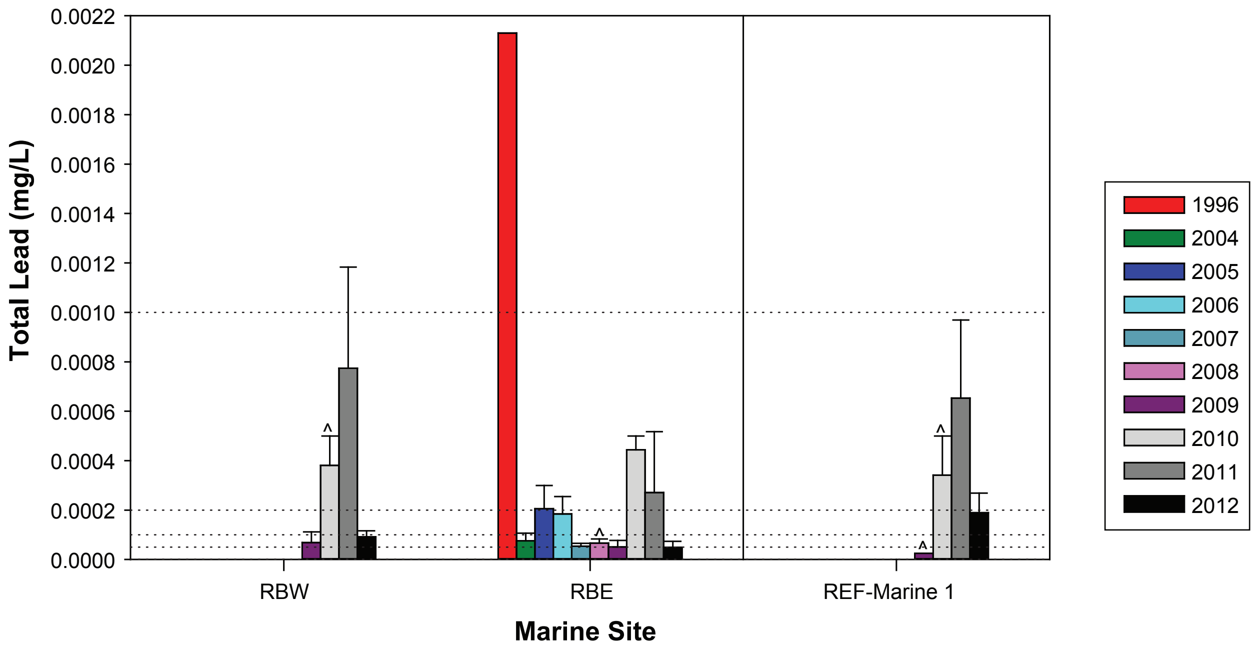
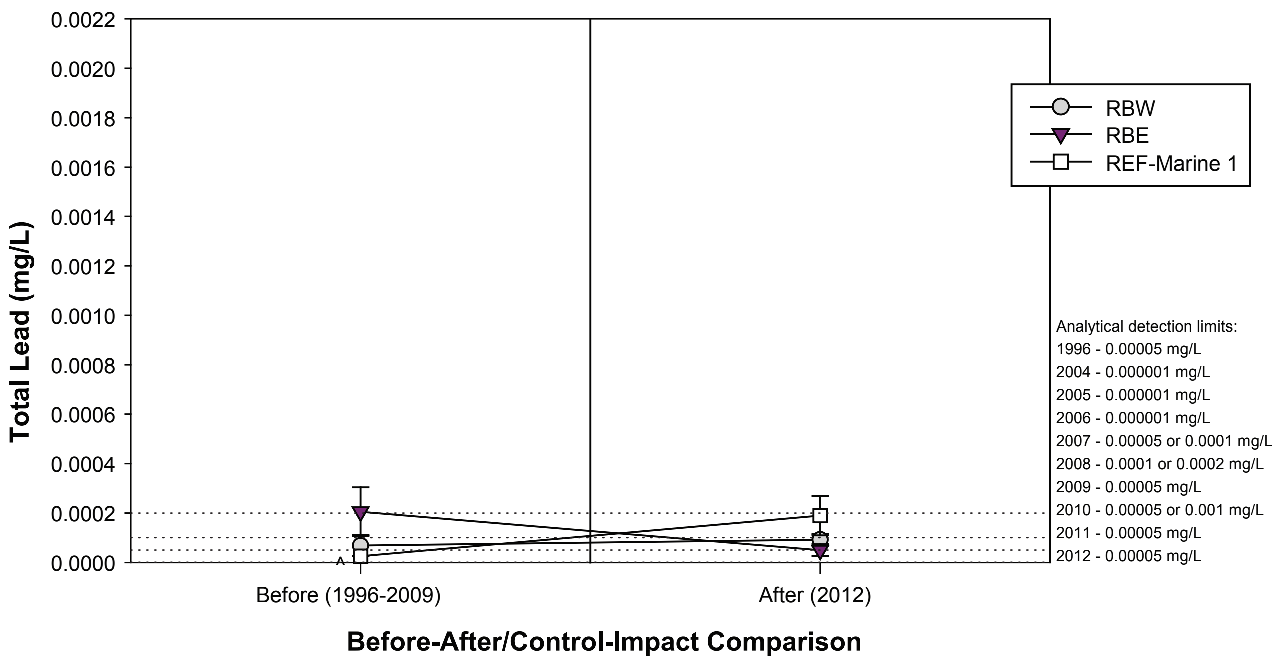
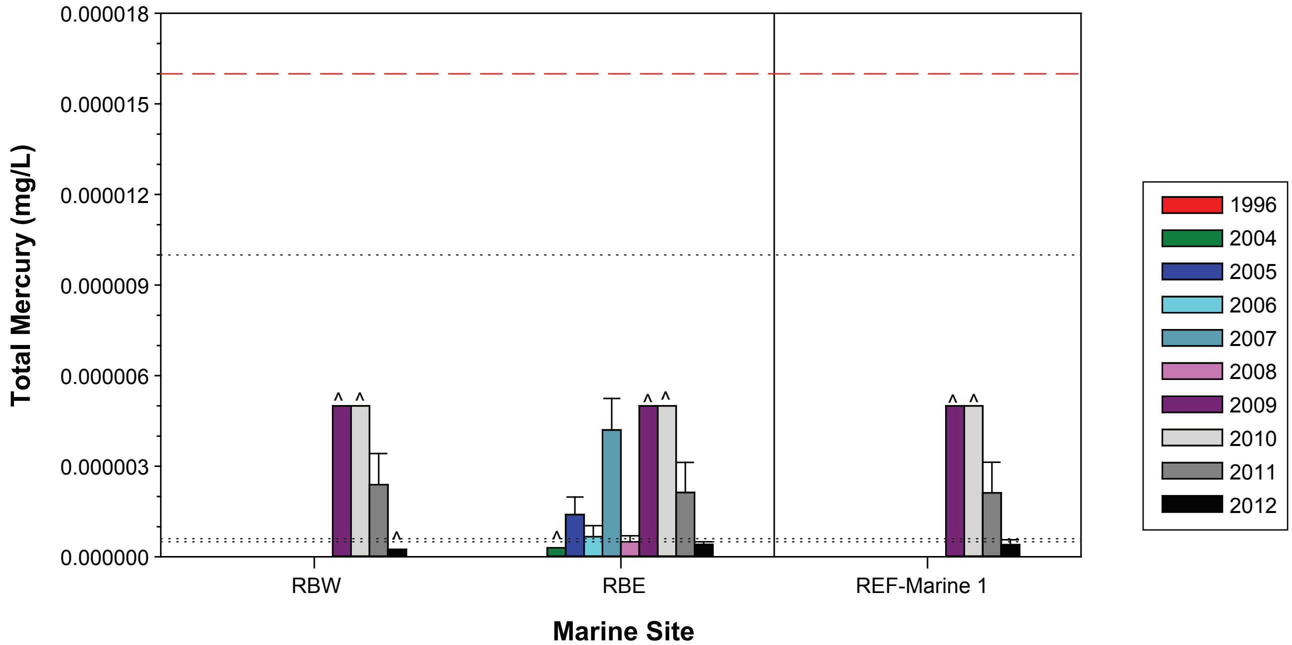
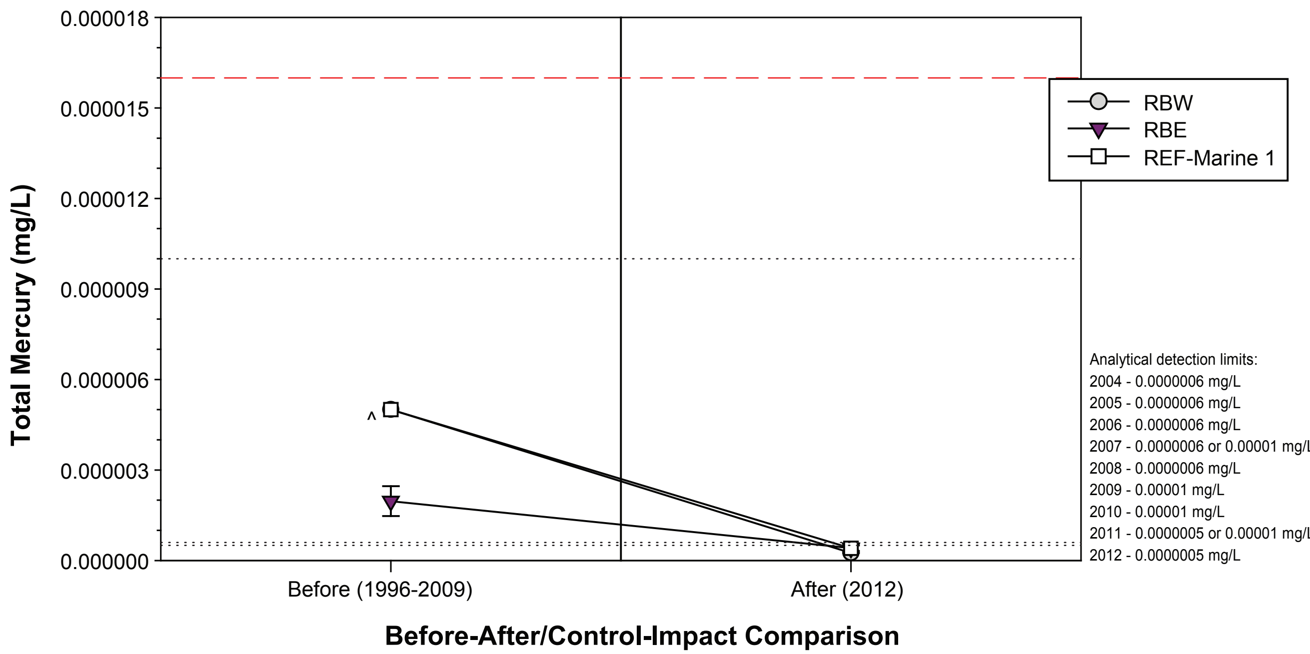




Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total lead is regulated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





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 marine 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.

Figure 3.3-51

Total Mercury Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

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3.3.3.16 Total Molybdenum

Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean 2012 total molybdenum concentrations at the two marine exposure sites were similar to baseline levels (Figure 3.3-52). The before-after comparison confirmed that there was no difference between 2012 mean concentrations and baseline means for the Roberts Bay sites ($p = 0.05$ for RBW and $p = 0.45$ for RBE). Therefore, 2012 activities had no apparent effect on total molybdenum concentrations at the marine exposure sites.

3.3.3.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2012 nickel concentrations at the marine exposure sites were similar to baseline concentrations (Figure 3.3-53), and the before-after analysis confirmed that 2012 mean nickel concentrations were not distinguishable from baseline means ($p = 0.33$ for RBW and $p = 0.81$ for RBE). Therefore, there was no effect of 2012 activities on total nickel concentrations at RBW and RBE.

3.3.3.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. At site RBW, the mean zinc concentration was higher in 2012 than in 2009, while at RBE, the 2012 mean was within the range of the means for the baseline years (Figure 3.3-54). The before-after comparison showed that there was no significant difference between 2009 and 2012 mean zinc concentrations for either of the Roberts Bay sites ($p = 0.22$ for RBW and $p = 0.57$ for RBE), indicating that 2012 activities did not affect zinc concentrations at the marine exposure sites.

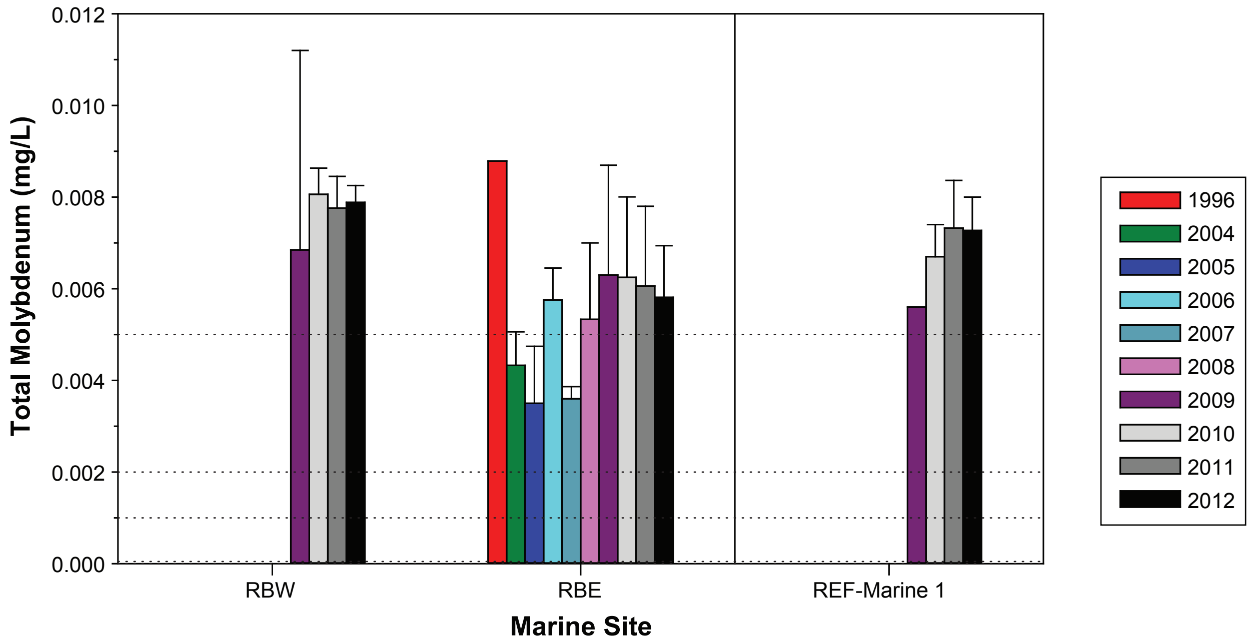
3.4 SEDIMENT QUALITY

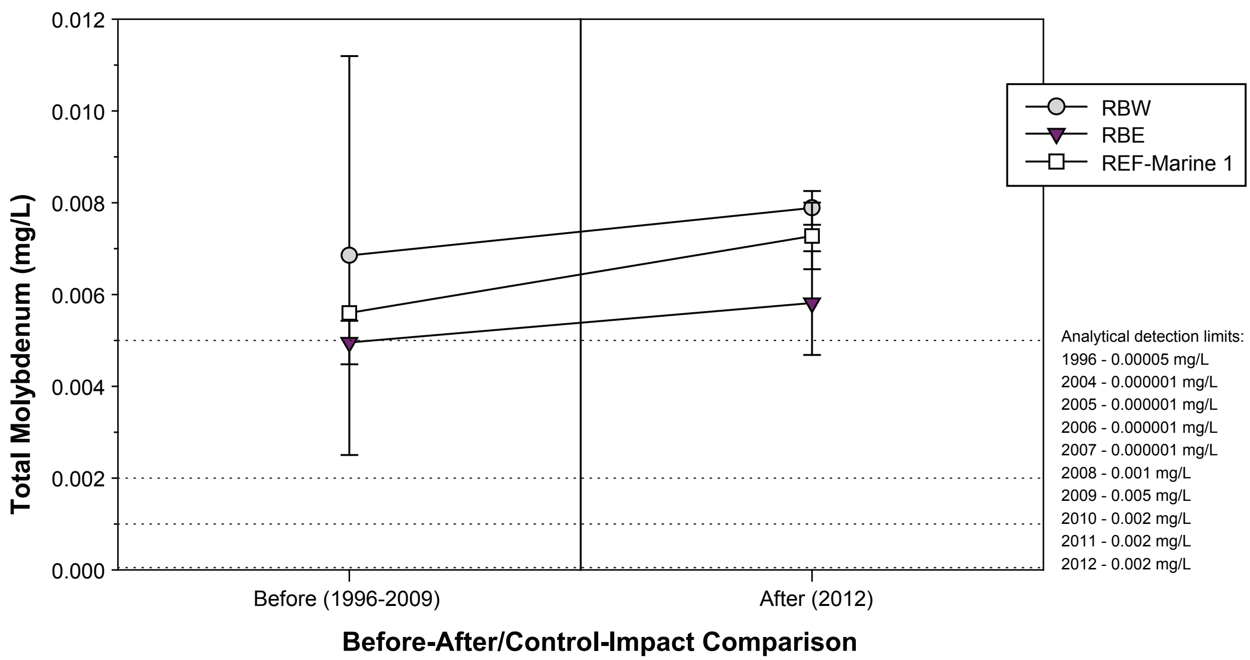
As per the MMER, Schedule 5, s. 16(a)(iii), sediment samples are to be collected and analyzed for particle size and TOC content to complement the benthic invertebrate community surveys. In this section, the sediment quality data collected from stream, lake, and marine sites in 2012 were compared against available baseline information as well as reference sites to evaluate whether 2012 Project activities caused changes to these sediment quality parameters. Sediment quality parameters for which there are CCME sediment quality guidelines for the protection of aquatic life (CCME 2012a) 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 2012a). All sediment quality parameters were compared to applicable CCME guidelines 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.

For both graphical and statistical analyses, half the detection limit was substituted for sediment quality parameters that were below analytical detection limits. Graphs showing sediment quality trends in AEMP waterbodies over time are shown in Figures 3.4-1 to 3.4-27, and all statistical results are presented in Appendix B.

3.4.1 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). Baseline data for stream sediments are available only from 2009 and only for Doris, Little Roberts, and Reference B Outflows. Data from 2012 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 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, 1996 to 2012

Figure 3.3-52

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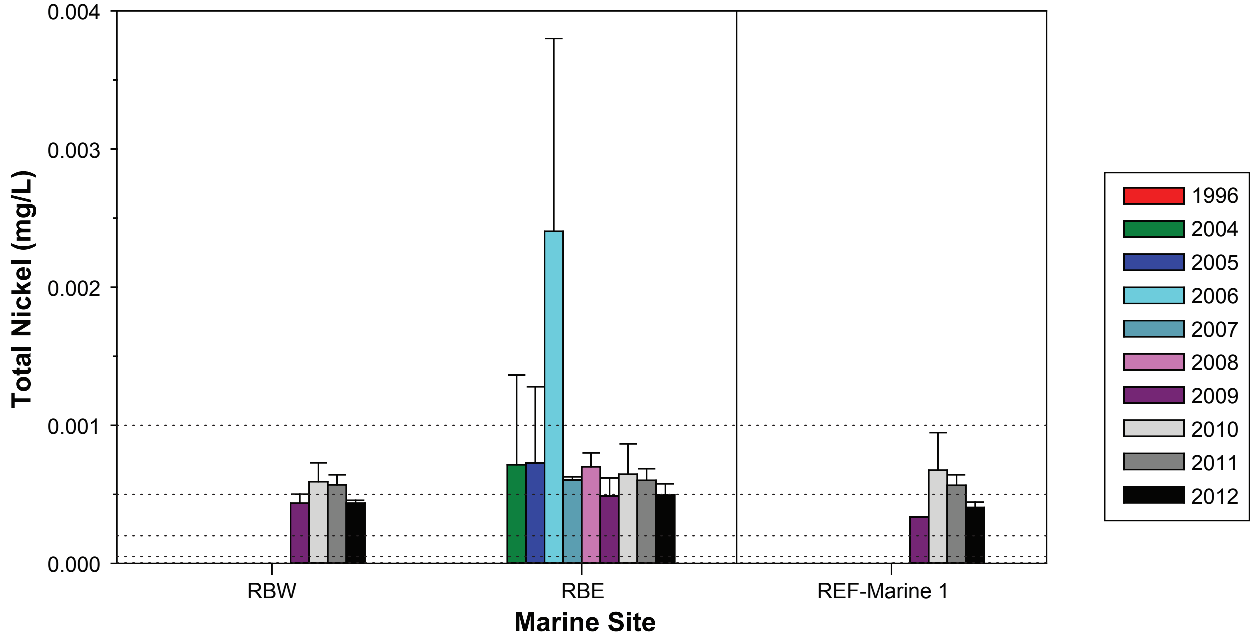

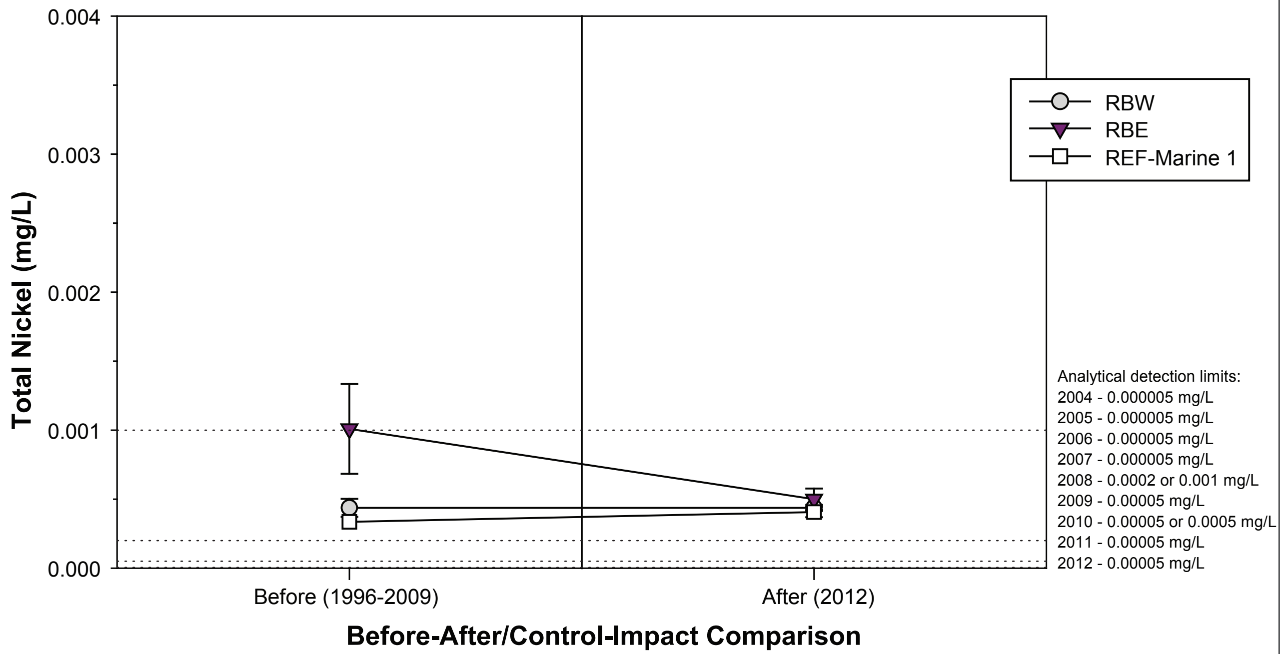

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The anomalously high total nickel concentration of 0.0215 mg/L reported for RBE in August 1996 was considered an outlier and was excluded from plots.
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

Figure 3.3-53

Total Nickel Concentration in AEMP Marine Sites, Doris North Project, 1996 to 2012

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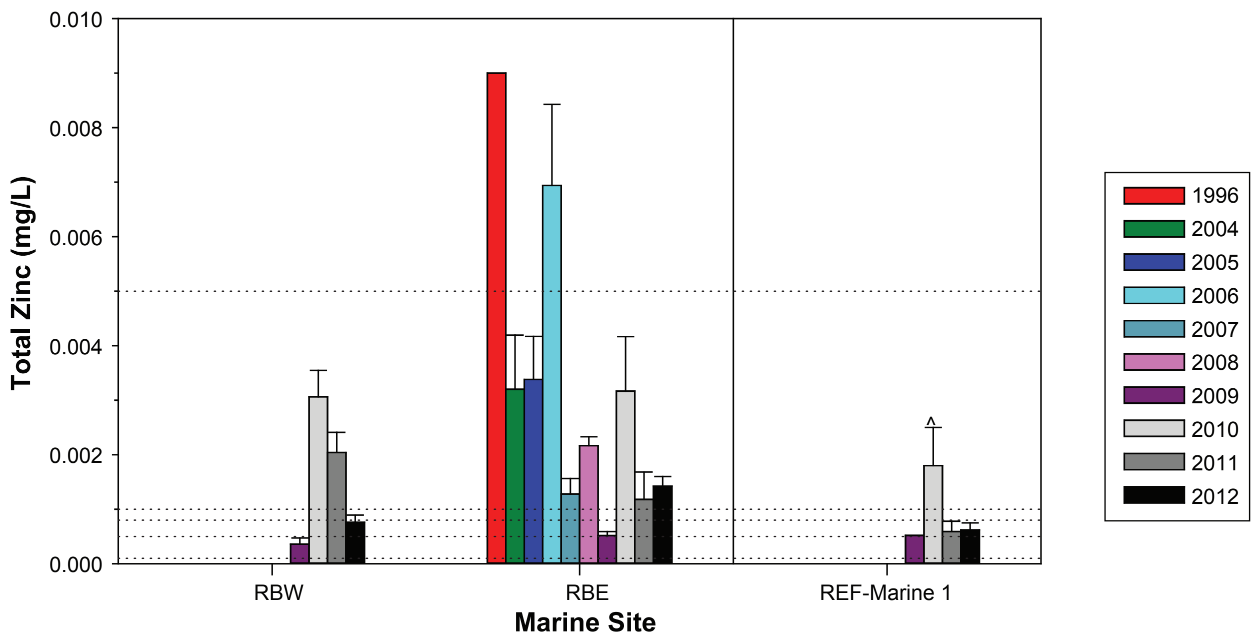

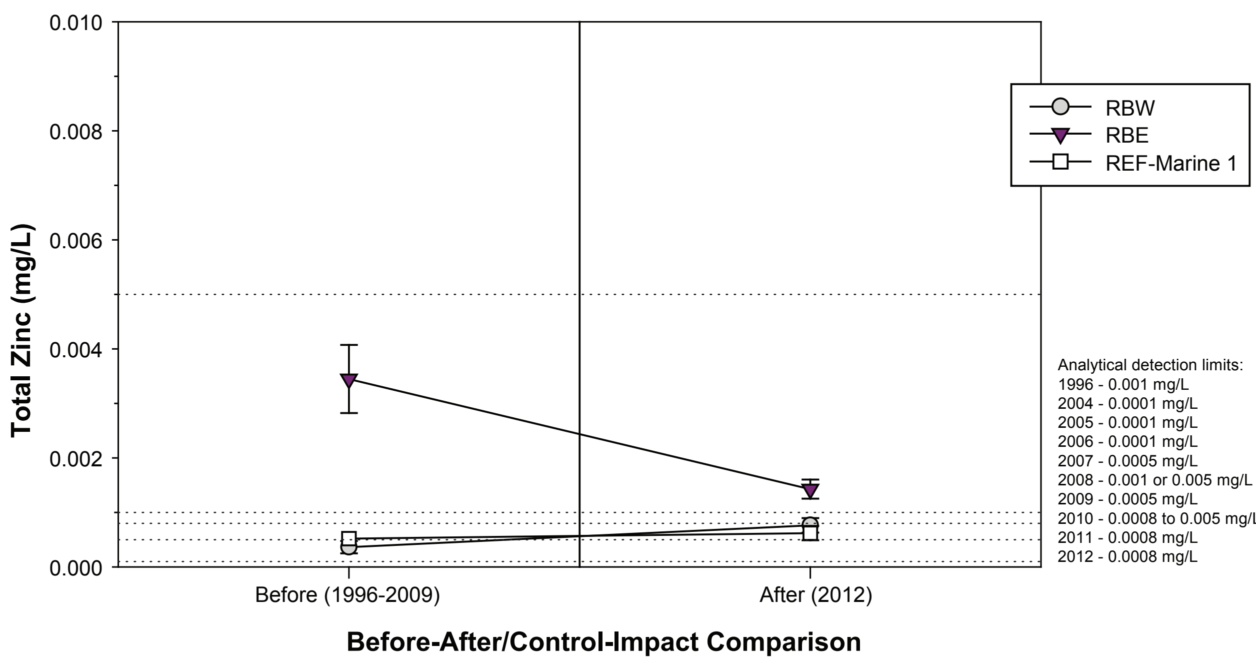

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total zinc is regulated 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, 1996 to 2012

Figure 3.3-54

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3.4.1.1 Particle Size

Particle size is a required sediment parameter to complement the benthic invertebrate surveys as per Schedule 5, s. 16(a)(iii) of the MMER. There were some differences in the particle size composition of stream sediments in 2012 compared to 2009 (Figure 3.4-1). In Doris Outflow, 2012 sediments consisted of a larger proportion of sand and a lower proportion of gravel compared to 2009. In Little Roberts Outflow, the gravel content was higher and the clay and silt content was lower in 2012 than 2009. The particle size composition of sediments of the Reference B Outflow samples were relatively similar between years, but sand made up a slightly higher proportion and fine sediments (clay and silt) made up a lower proportion of the sediments in 2012 than in 2009 (Figure 3.4-1).

The before-after analysis showed that only the observed changes in particle size in the Doris Outflow sediments were statistically significant ($p = 0.0018$ for the gravel and $p = 0.0001$ for the sand content). The content of gravel in Doris Outflow sediments was significantly lower than in 2009, indicating no adverse effect of 2012 Project activities on this sediment parameter. A BACI analysis of the content of sand in Doris Outflow sediments revealed a statistically significant ($p = 0.0024$) increase in sand content compared to Reference B Outflow sediments. Variation in sediment particle size composition is unlikely related to 2012 Project activities, and probably reflects natural spatial heterogeneity in stream sediments. However, these differences between 2009 and 2012 may complicate the evaluation of effects because fine sediments are often associated with higher metal concentrations than coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003).

3.4.1.2 Total Organic Carbon

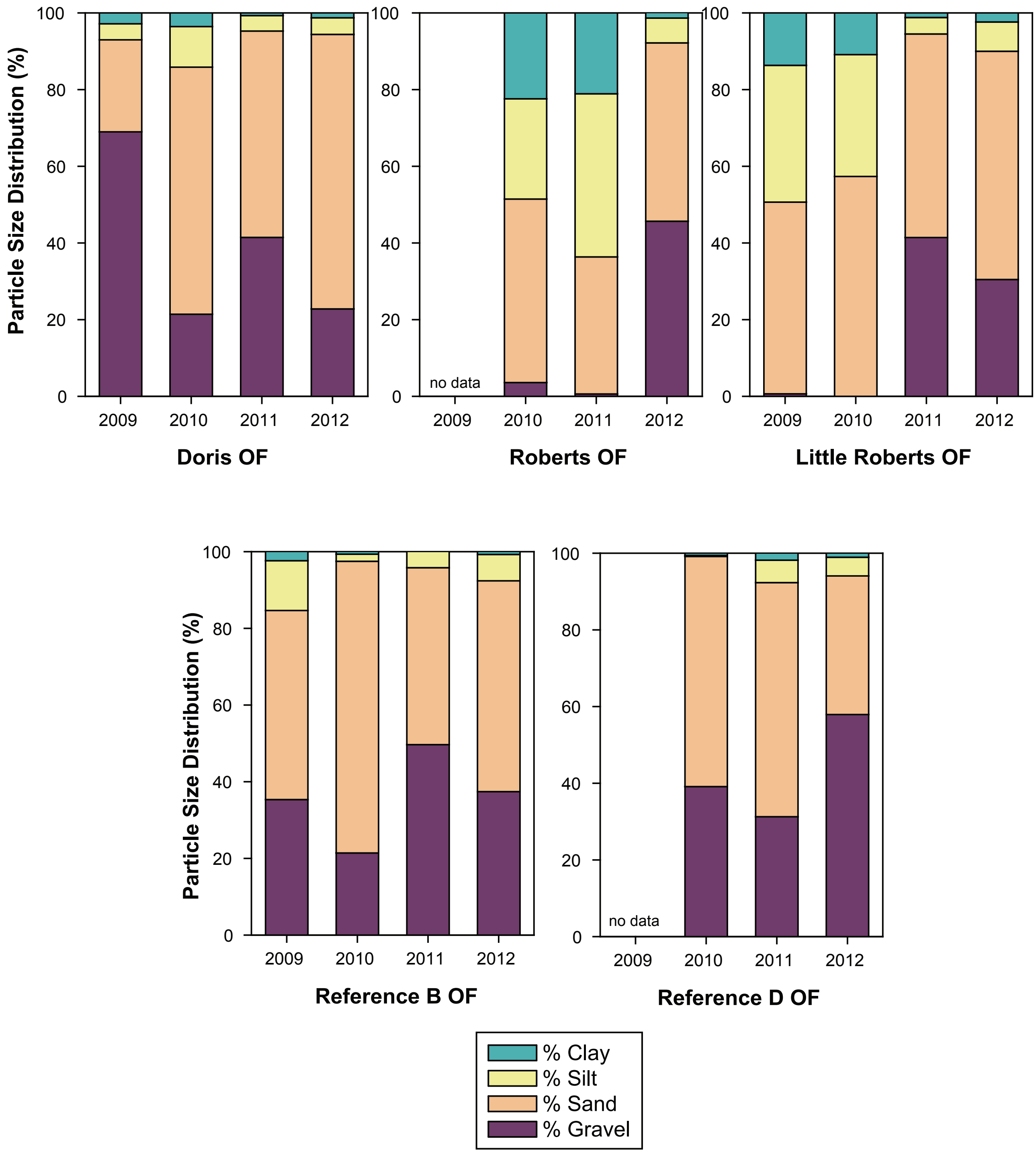
TOC content is a required sediment parameter that is meant to support the benthic invertebrate surveys as per Schedule 5, s. 16(a)(iii) of the MMER. In both exposure and reference stream sediments, TOC content was highly variable both inter-annually and among replicates collected within a year (Figure 3.4-2). The before-after comparison showed that the mean 2012 TOC content in the exposure streams was not distinguishable from their 2009 means ($p = 0.80$ for Doris Outflow, $p = 0.33$ for Little Roberts Outflow). Although Roberts Outflow TOC concentrations could not be statistically evaluated (because no baseline data were available), the 2012 TOC content of Roberts Outflow sediments was similar to the TOC content of Reference B Outflow sediments. Therefore, there was no apparent effect of 2012 Project activities on sediment TOC content in any of the exposure streams.

3.4.1.3 Total Arsenic

Mean 2012 sediment arsenic concentrations were highest at Little Roberts Outflow (1.49 mg/kg), but were generally similar among the remaining exposure and reference streams (ranging from 0.5 to 1.28 mg/kg; Figure 3.4-3). All mean 2012 arsenic concentrations were below the CCME ISQG of 5.9 mg/kg and the PEL of 17 mg/kg (Figure 3.4-3). The before-after comparison showed that there were no significant difference between 2009 and 2012 mean total arsenic concentrations at Doris Outflow ($p = 0.72$) or Little Roberts Outflow ($p = 0.046$). Therefore, 2012 activities did not adversely affect arsenic concentrations in these exposure streams.

3.4.1.4 Total Cadmium

In Doris, Roberts and Little Roberts Outflows, all 2009 and 2012 sediment total cadmium concentrations were below the analytical detection limits of 0.1 mg/kg (2009) or 0.05 mg/kg (2012) (Figure 3.4-4). Given the high proportion of values (>70%) below the detection limits, no before-after analysis was conducted. The consistently low concentration of cadmium in the sediments of the exposure streams indicated that 2012 Project activities had no effect on cadmium concentrations. Furthermore, all 2009 and 2012 total cadmium concentrations measured in stream sediments were well below the CCME ISQG of 0.6 mg/kg and the PEL of 3.5 mg/kg.



Notes: Stacked bars represent the mean of replicate samples.
Particle size distribution of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Particle Size Distribution in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-1

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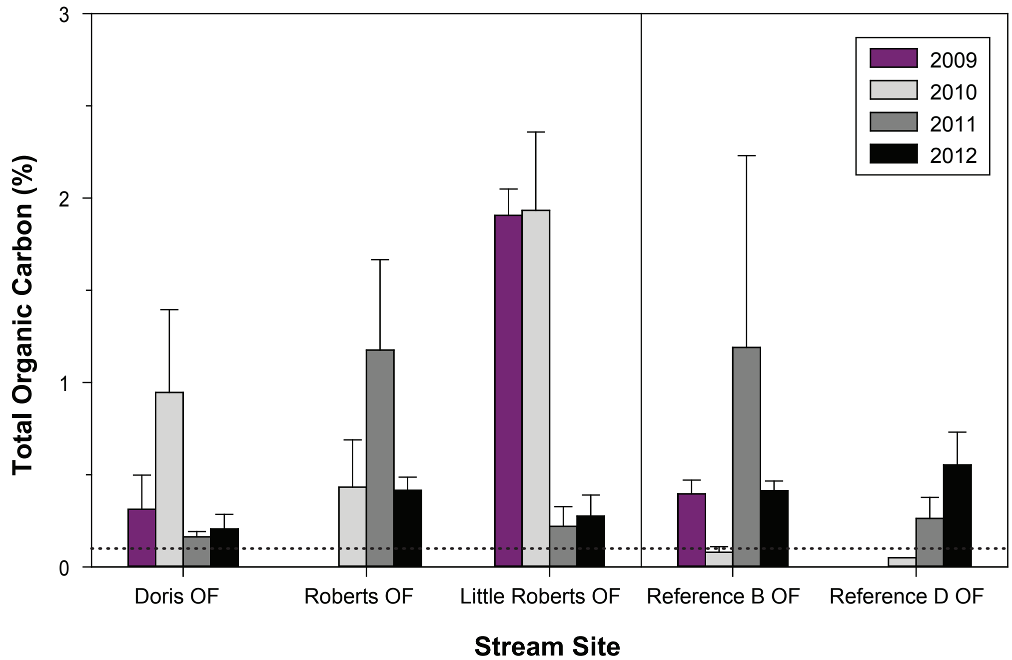

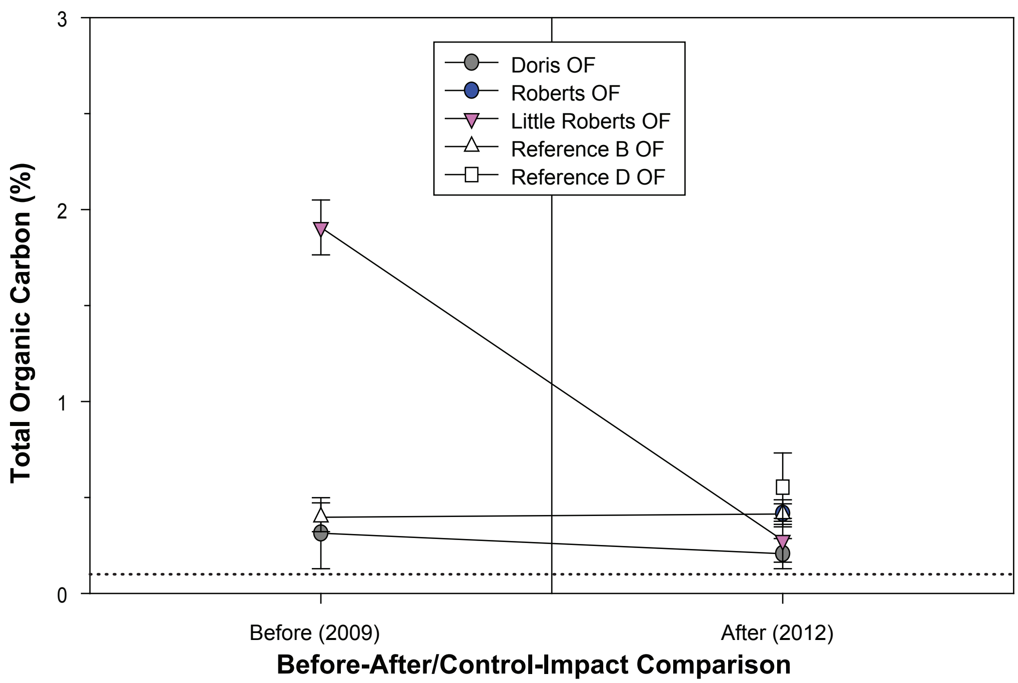

Analytical detection limits:
2009 - 0.1%
2010 - 0.1%
2011 - 0.1%
2012 - 0.1%

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.
^ Indicates that concentrations were below the detection limit in all samples.
Total organic carbon content of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Total Organic Carbon Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-2

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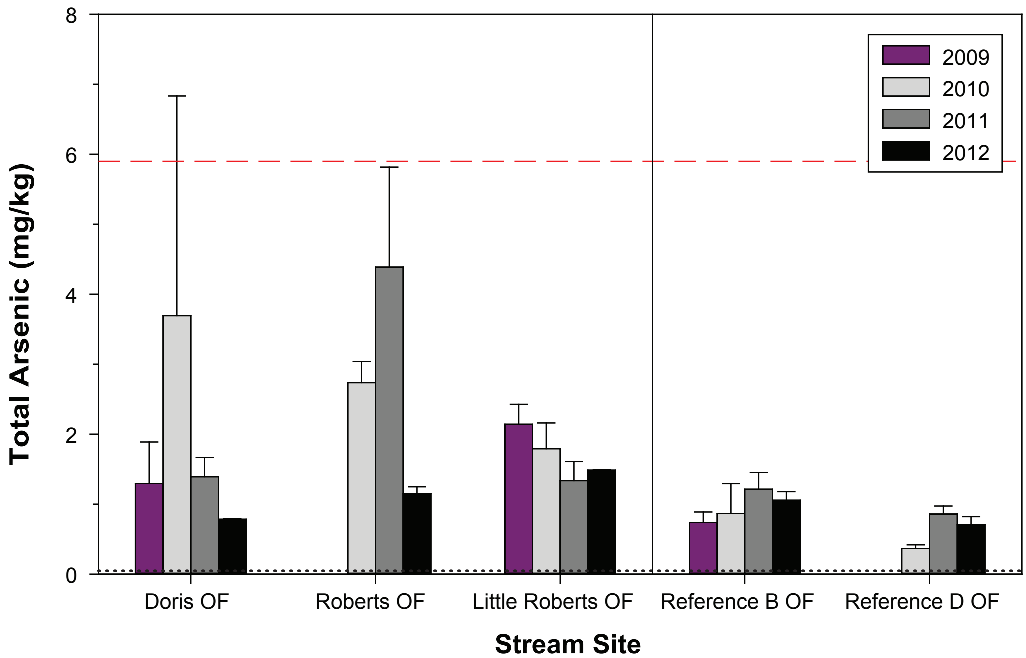

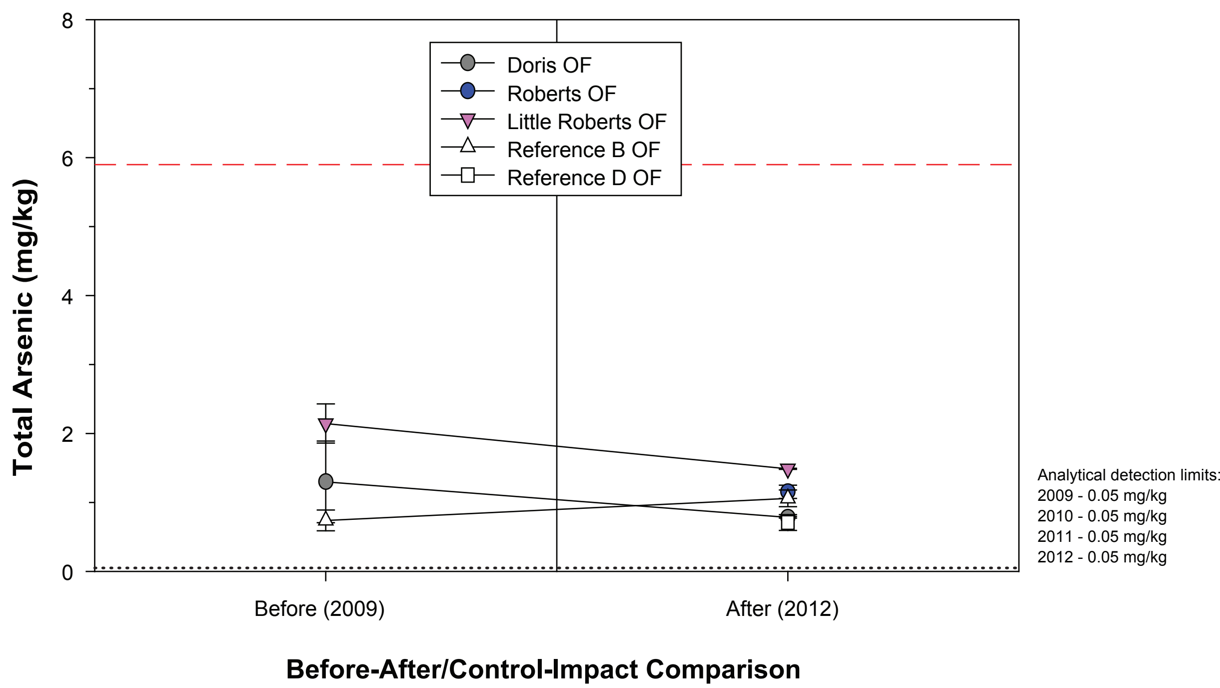

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for arsenic (5.9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

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Total Arsenic Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-3

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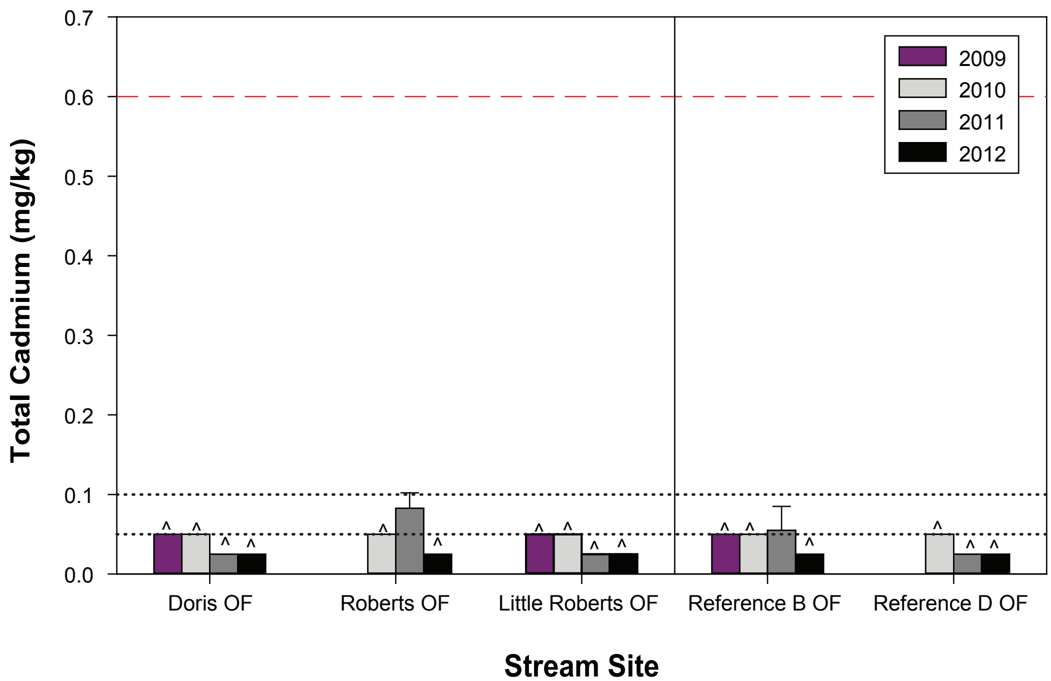

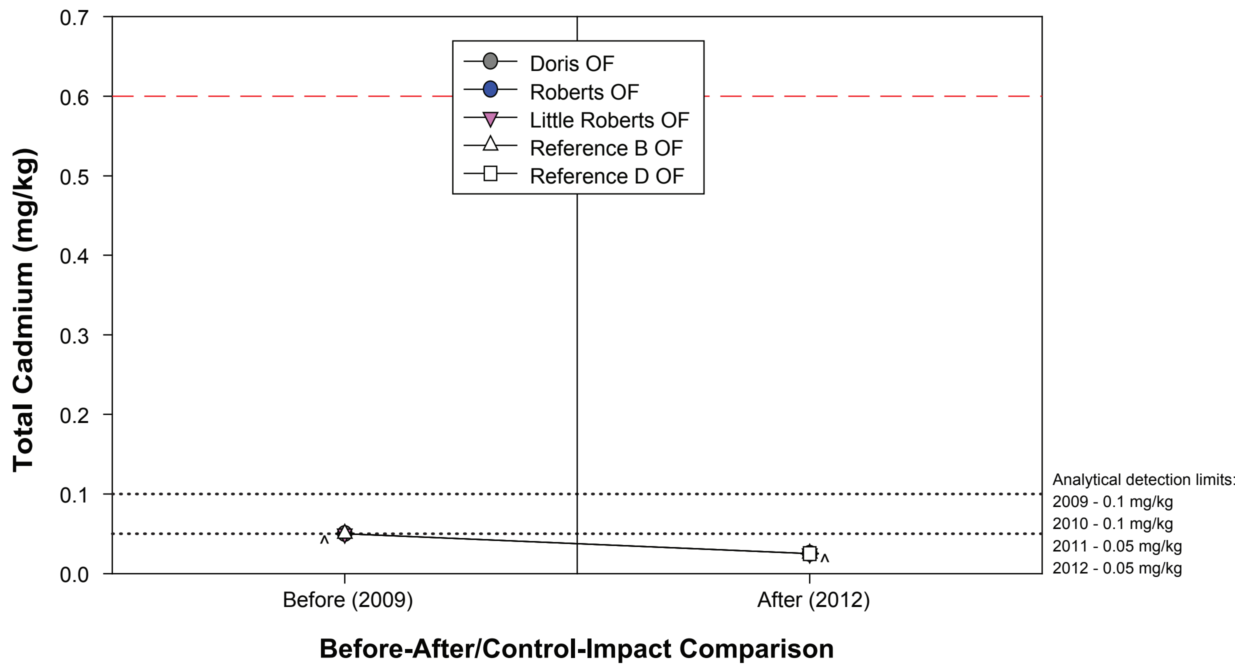

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for cadmium (0.6 mg/kg); the probable effects level (PEL) for cadmium (3.5 mg/kg) is not shown.

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Total Cadmium Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-4

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3.4.1.5 Total Chromium

Mean 2012 chromium concentrations in Doris Outflow and Little Roberts Outflow sediments were lower than mean 2009 concentrations (Figure 3.4-5), but there was a slight increase in chromium concentrations in Reference B Outflow sediments. In all three exposure streams, mean 2012 concentrations were lower than the CCME ISQG of 37.3 mg/kg and the CCME PEL of 90 mg/kg (Figure 3.4-5). The before-after analysis failed to find evidence of a difference in mean chromium concentrations between 2009 and 2012 for either Doris Outflow ($p = 0.89$) or Little Roberts Outflow ($p = 0.78$). Therefore, there was no apparent effect of 2012 Project activities on sediment chromium levels in exposure streams.

3.4.1.6 Total Copper

Mean 2012 sediment copper concentrations were highest at Reference D Outflow (17.3 mg/kg), but were generally similar among the exposure and remaining reference streams (ranging from 4.3 to 11.0 mg/kg; Figure 3.4-6). All mean copper concentrations in 2009 and 2012 were below the CCME ISQG of 35.7 mg/kg and the PEL of 197 mg/kg. In both Doris Outflow and Little Roberts Outflow, mean total copper concentrations were slightly lower in 2012 than in 2009. However, the before-after analysis indicated that mean 2012 copper concentrations in the exposure stream sediments were not statistically distinguishable from their 2009 means ($p = 0.48$ for Doris Outflow, $p = 0.012$ for Little Roberts Outflow). Therefore, 2012 activities had no effect on sediment copper concentrations in these exposure streams

3.4.1.7 Total Lead

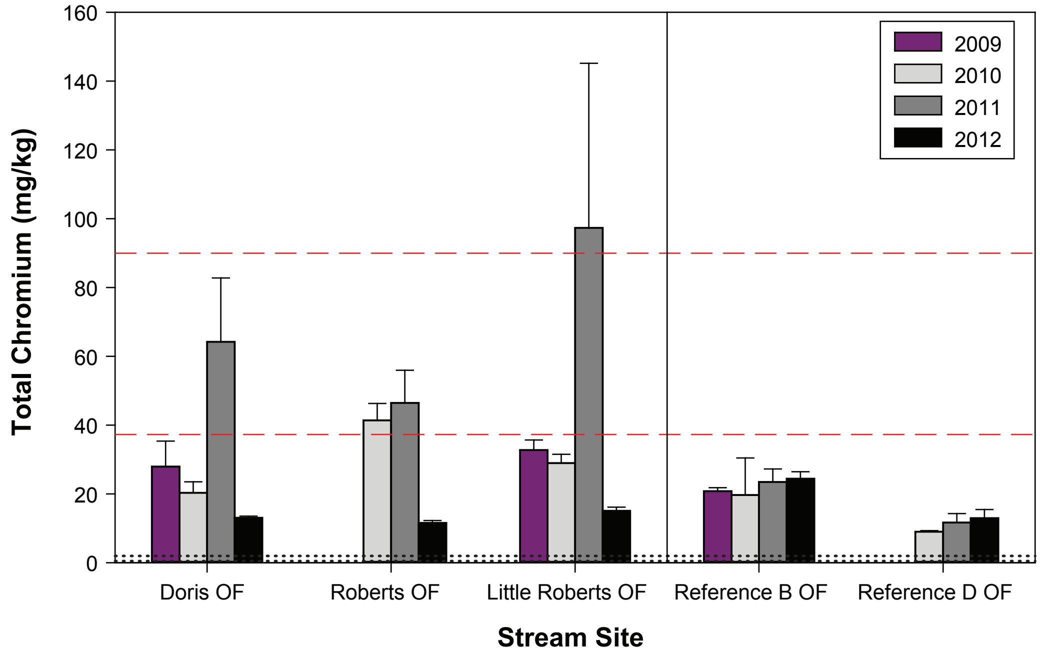
In all three exposure streams, 2012 lead concentrations in sediments were well below the CCME ISQG of 35 mg/kg and the PEL of 91.3 mg/kg (Figure 3.4-7). In both Doris Outflow and Little Roberts Outflow, mean total lead concentrations in sediments were slightly lower in 2012 than in 2009 (Figure 3.4-7). The before-after comparison indicated that there was no difference between mean 2012 and 2009 lead concentrations in the exposure streams ($p = 0.23$ for Doris Outflow and $p = 0.23$ for Little Roberts Outflow). As a result, there were no apparent adverse effects of 2012 activities on lead concentrations in stream sediments.

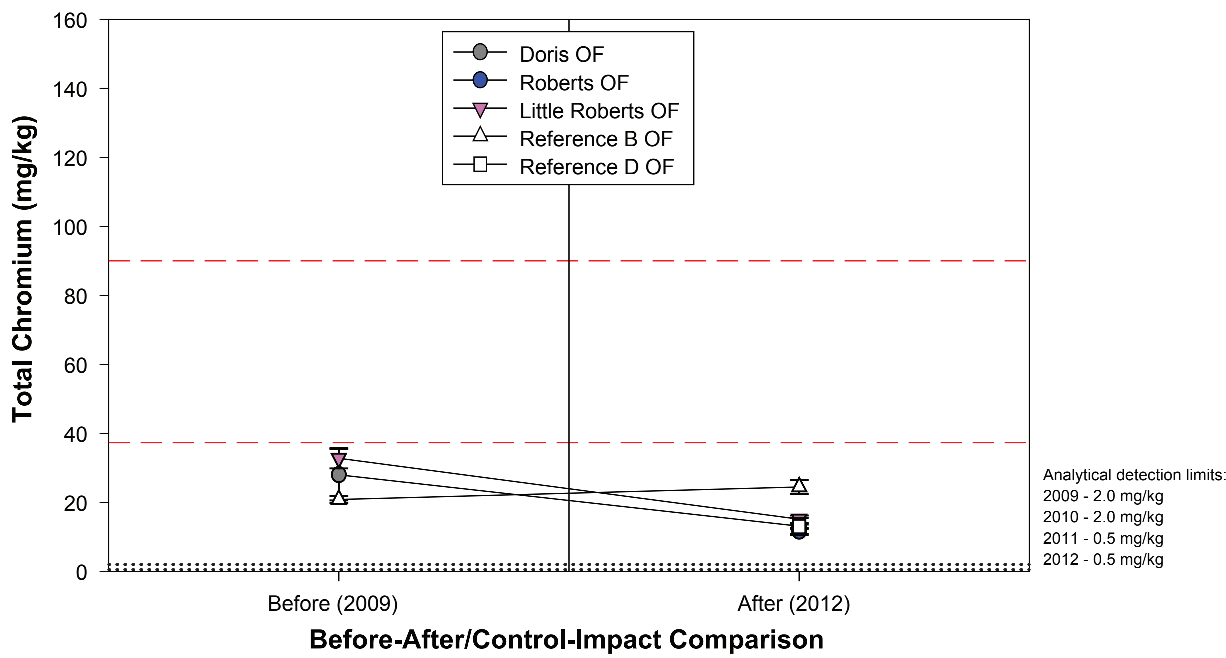
3.4.1.8 Total Mercury

All 2012 total mercury concentrations measured in Doris, Roberts and Little Roberts Outflow sediments were below the analytical detection limit of 0.005 mg/kg. As a result, all 2012 total mercury concentrations measured in exposure and reference stream sediments were well below the CCME ISQG of 0.17 mg/kg and the PEL of 0.486 mg/kg (Figure 3.4-8). A before-after analysis of mercury concentrations in Little Roberts Outflow sediment indicated no significant difference between 2009 and 2012 means ($p = 0.09$). While statistical analysis was not possible for Doris Outflow sediments due to a high proportion of values below the analytical detection limit (>70%), the before-after plot suggested no change in mercury concentrations between 2009 and 2012. Therefore, 2012 Project activities did not adversely affect total mercury concentrations in the sediments of exposure streams.

3.4.1.9 Total Zinc

In all three exposure streams, 2012 zinc concentrations in sediments were well below the CCME ISQG of 123 mg/kg and the PEL of 315 mg/kg (Figure 3.4-9). Compared to 2009 mean zinc concentrations, 2012 mean concentrations were slightly lower in Doris Outflow and Little Roberts Outflow (Figure 3.4-9). However, the before-after comparison indicated that mean 2012 zinc concentrations in exposure stream sediments were not distinguishable from 2009 means ($p = 0.75$ for Doris Outflow and $p = 0.07$ for Little Roberts Outflow). Consequently, there was no evidence that 2012 Project activities affected zinc concentrations in the AEMP exposure stream sediments.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for chromium (37.3 mg/kg) and the probable effects level (PEL) for chromium (90 mg/kg).

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Total Chromium Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-5

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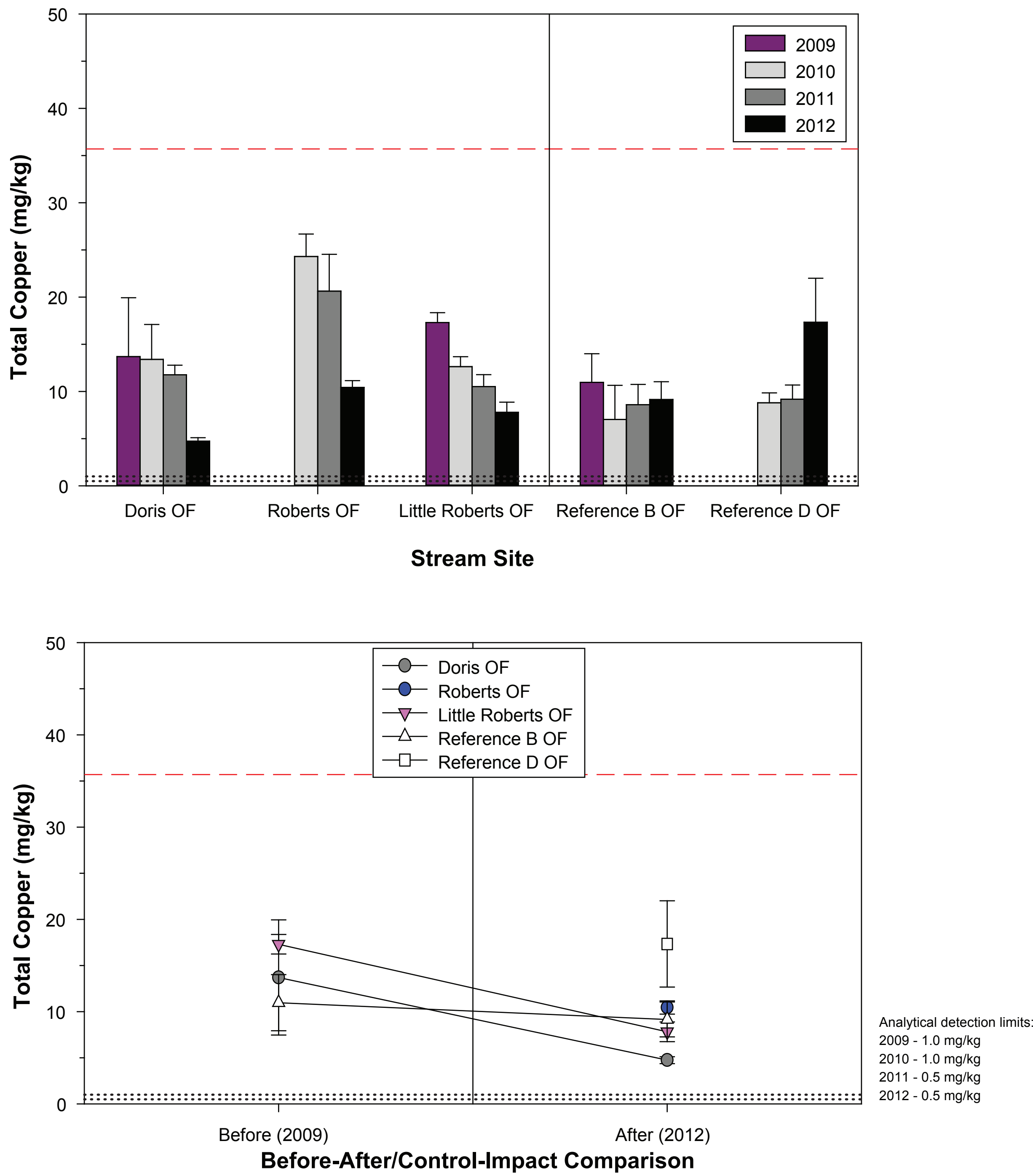

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for copper (35.7 mg/kg); the probable effects level (PEL) for copper (197 mg/kg) is not shown.

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Total Copper Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-6

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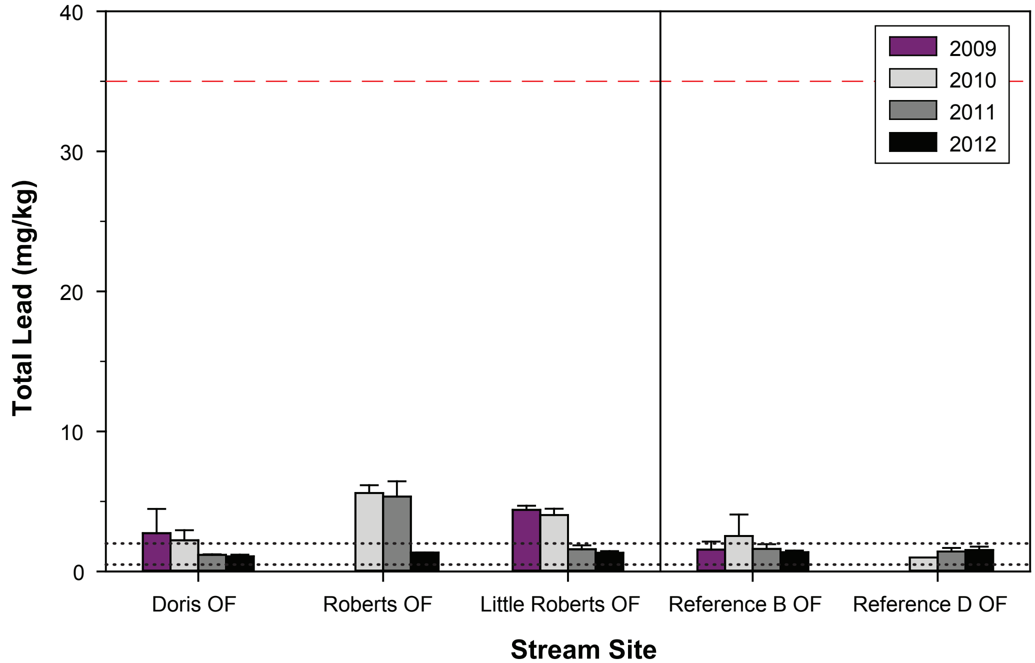

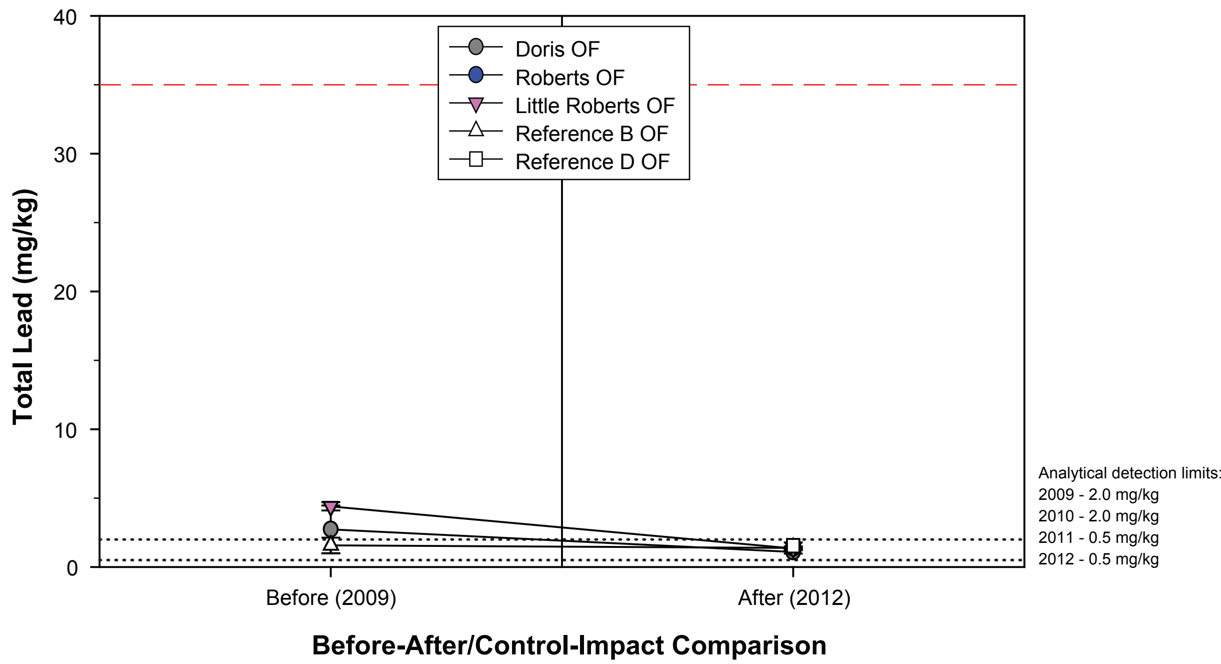

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for lead (35 mg/kg); the probable effects level (PEL) for lead (91.3 mg/kg) is not shown.

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Total Lead Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-7

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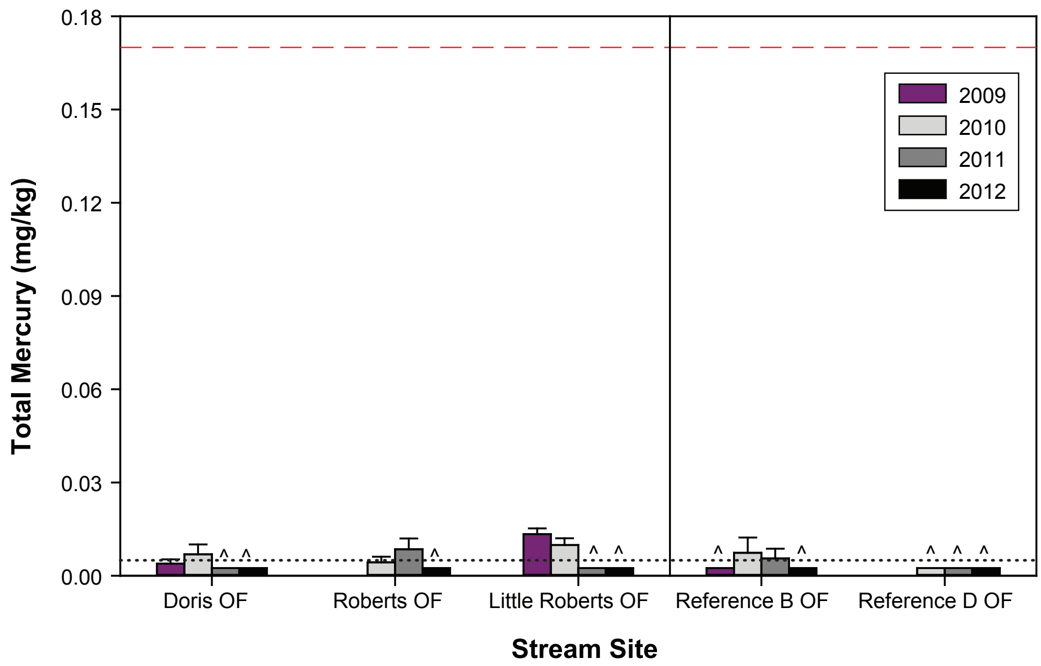

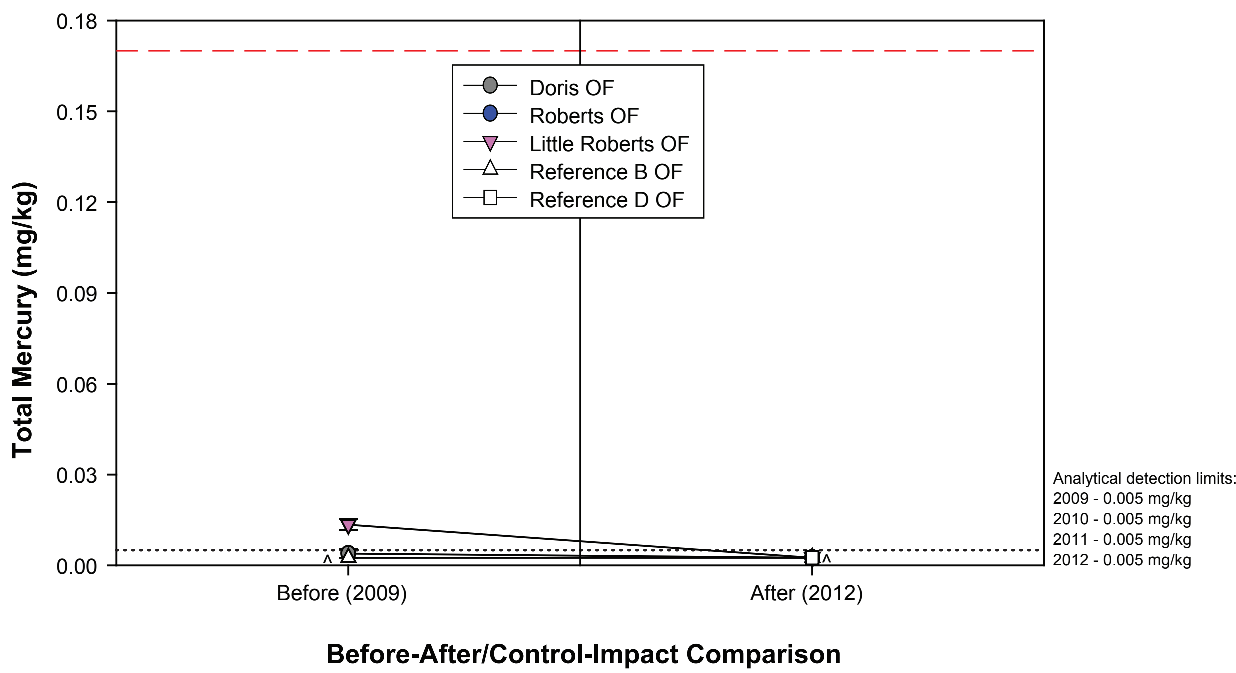

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for mercury (0.17 mg/kg); the probable effects level (PEL) for mercury (0.486 mg/kg) is not shown.

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Total Mercury Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-8

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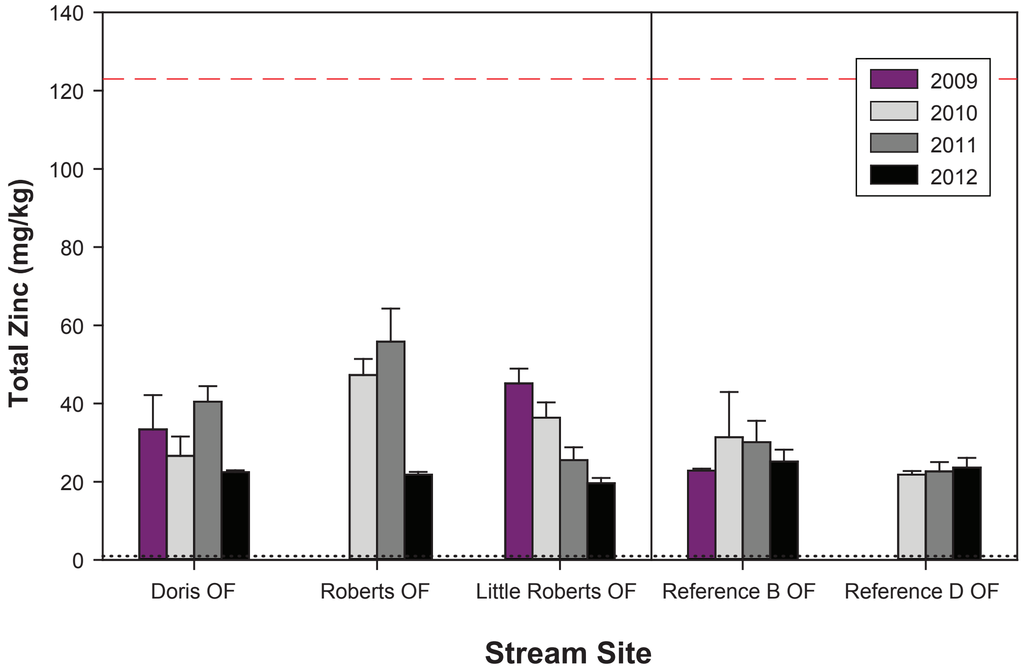

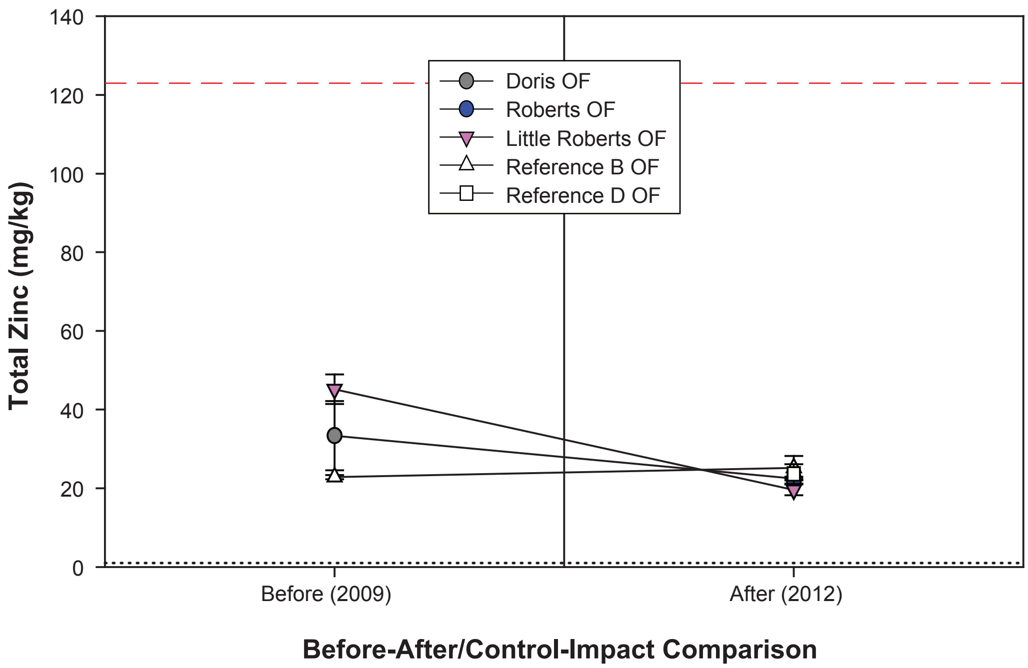

Analytical detection limits:
2009 - 1.0 mg/kg
2010 - 1.0 mg/kg
2011 - 1.0 mg/kg
2012 - 1.0 mg/kg

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 freshwater 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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Total Zinc Concentrations in AEMP Stream Sediments, Doris North Project, 2009 to 2012

Figure 3.4-9

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3.4.2 Lakes

AEMP sediment quality samples were collected from four exposure sites (Doris Lake North, Doris Lake South, Roberts Lake and Little Roberts Lake) and two reference sites (Reference Lake B and Reference Lake D) in 2012. Sediment samples have been collected in the Doris North area since 1996. However, most of the historical data were not directly comparable to 2012 data because of differences in sampling locations, depth strata, and sampling methodology (Appendix B). Sediment quality data from 1997 and 2009 were used for before-after comparisons for Doris Lake South and Little Roberts Lake, and data from 2009 were used for before-after comparisons for Doris Lake North. 1997 sediment sampling was conducted in July, and 2009 and 2012 sediment sampling was conducted in August. No baseline sediment quality data were available for the reference lakes; therefore, no BACI analyses were possible for the lake exposure sites. For the calculations of annual means for each parameter, all lake sediment replicates collected in a given year were averaged.

3.4.2.1 Particle Size

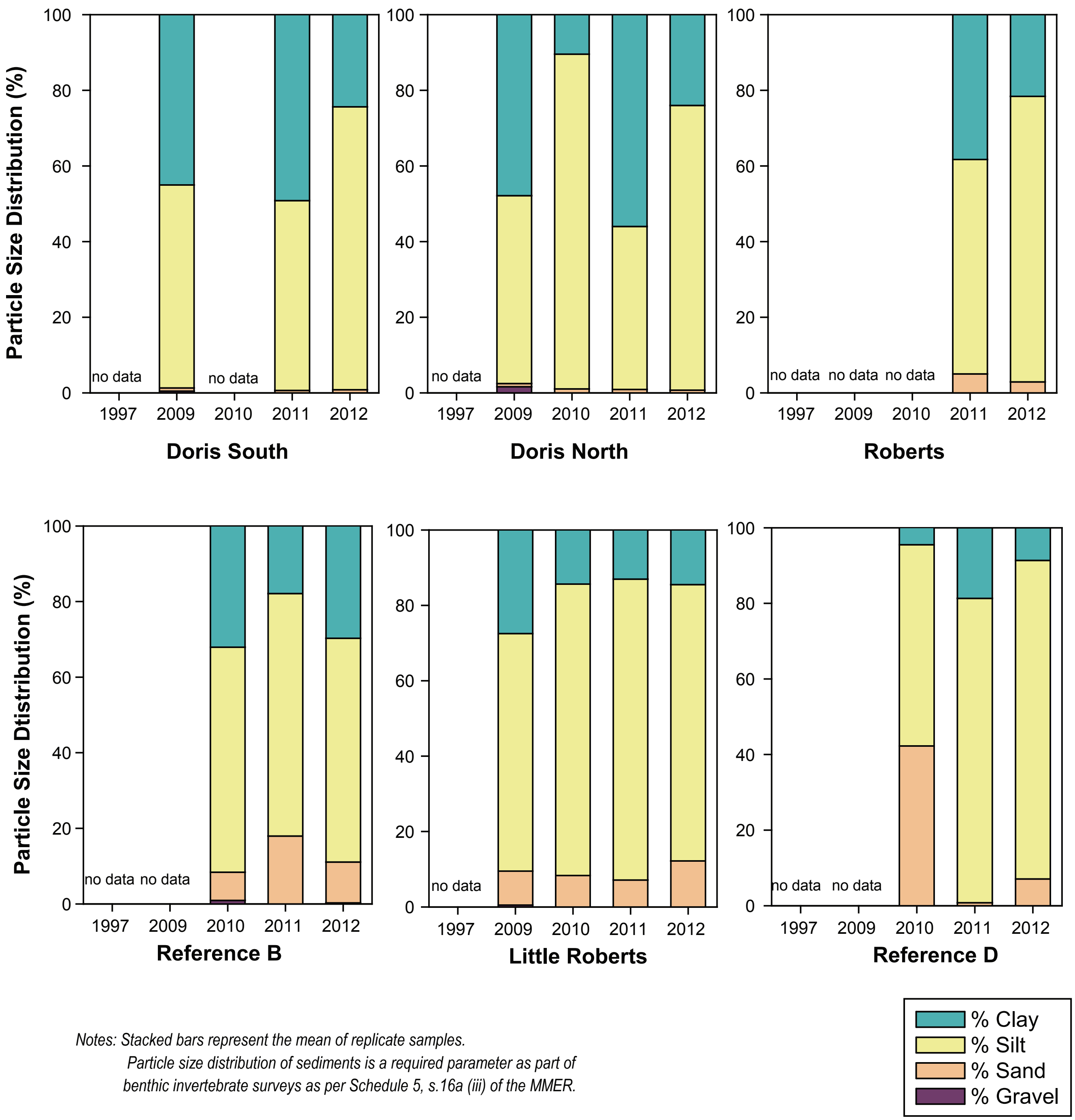
The AEMP lakes were dominated by fine sediments in 2012 (Figure 3.4-10). Silt made up the largest proportion of the sediment composition in all the four exposure lakes and the two reference lakes (range: 59.2 to 84.3%) (Figure 3.4-10). In the three exposure lakes where baseline data were available, the particle size composition was generally similar between 2009 and 2012. However, the before-after analysis indicated that the gravel content decreased significantly in Doris Lake South and Little Roberts Lake between 2009 and 2012 ($p < 0.001$ for both lakes), the silt content increased significantly in Doris Lake North ($p = 0.006$) and the proportion of clay decreased significantly in both Doris Lake North and Little Roberts Lake ($p = 0.009$ and $p = 0.001$, respectively). Variation in sediment particle size composition is unlikely related to 2012 Project activities, and probably reflects natural spatial heterogeneity in lake sediments.

3.4.2.2 Total Organic Carbon

The mean 2012 TOC concentrations in Doris Lake North, Doris Lake South and Little Roberts Lake sediments were within the range of baseline TOC levels (Figure 3.4-11). The before-after comparison confirmed that there was no significant difference between mean baseline and mean 2012 TOC levels in the sediments of any exposure lake ($p = 0.10$ for Doris Lake South, $p = 0.11$ for Doris Lake North, and $p = 0.47$ for Little Roberts Lake). Therefore, there was no effect of 2012 Project activities on the TOC content of exposure lake sediments.

3.4.2.3 Total Arsenic

Total arsenic concentrations in lake sediments were inter-annually variable (Figure 3.4-12). In both Doris Lake South and Little Roberts Lake, mean 2012 concentrations were higher than mean baseline levels, while in Doris Lake North, 2012 arsenic concentration was lower than the 2009 concentrations (Figure 3.4-12). The mean 2012 total arsenic concentration in Doris Lake South (20.8 mg/kg), Doris Lake North (6.87 mg/kg) and Roberts Lake (7.60 mg/kg) was higher than the CCME ISQG of 5.9 mg/kg. The Doris Lake South concentrations were also higher than the PEL of 17 mg/kg. Mean baseline total arsenic concentrations at the both Doris Lake South and North sites were also higher than the ISQG, but not the PEL (though one replicate Doris Lake South from 2009 was higher than the PEL). Mean 2012 concentrations were below the CCME ISQG and PEL guidelines in Little Roberts Lake and both reference lakes (B and D). The before-after comparison indicated that baseline and 2012 mean arsenic levels were not statistically different in either Doris Lake South ($p = 0.02$) or Doris Lake North ($p = 0.13$). However, mean 2012 Little Roberts Lake arsenic concentrations were significantly higher than baseline concentrations ($p = 0.005$). Unfortunately, no BACI analysis is possible due to a lack of baseline data. However, mean arsenic concentrations in Reference Lake D showed a general increase over time (Figure 3.4-12), suggesting that the change in concentration observed in Little Roberts Lake are likely due to natural variability in the in the region. The increase sediment arsenic concentrations in Little Roberts Lake could also be related to the increased proportion of silt, which has higher affinities for metals, in 2012 compared to the 2009. Either way changes there were no 2012 Project effects on arsenic levels in the AEMP exposure lake sediments.



Notes: Stacked bars represent the mean of replicate samples.
Particle size distribution of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

Figure 3.4-10

Particle Size Distribution in AEMP Lake Sediments, Doris North Project, 1997 to 2012

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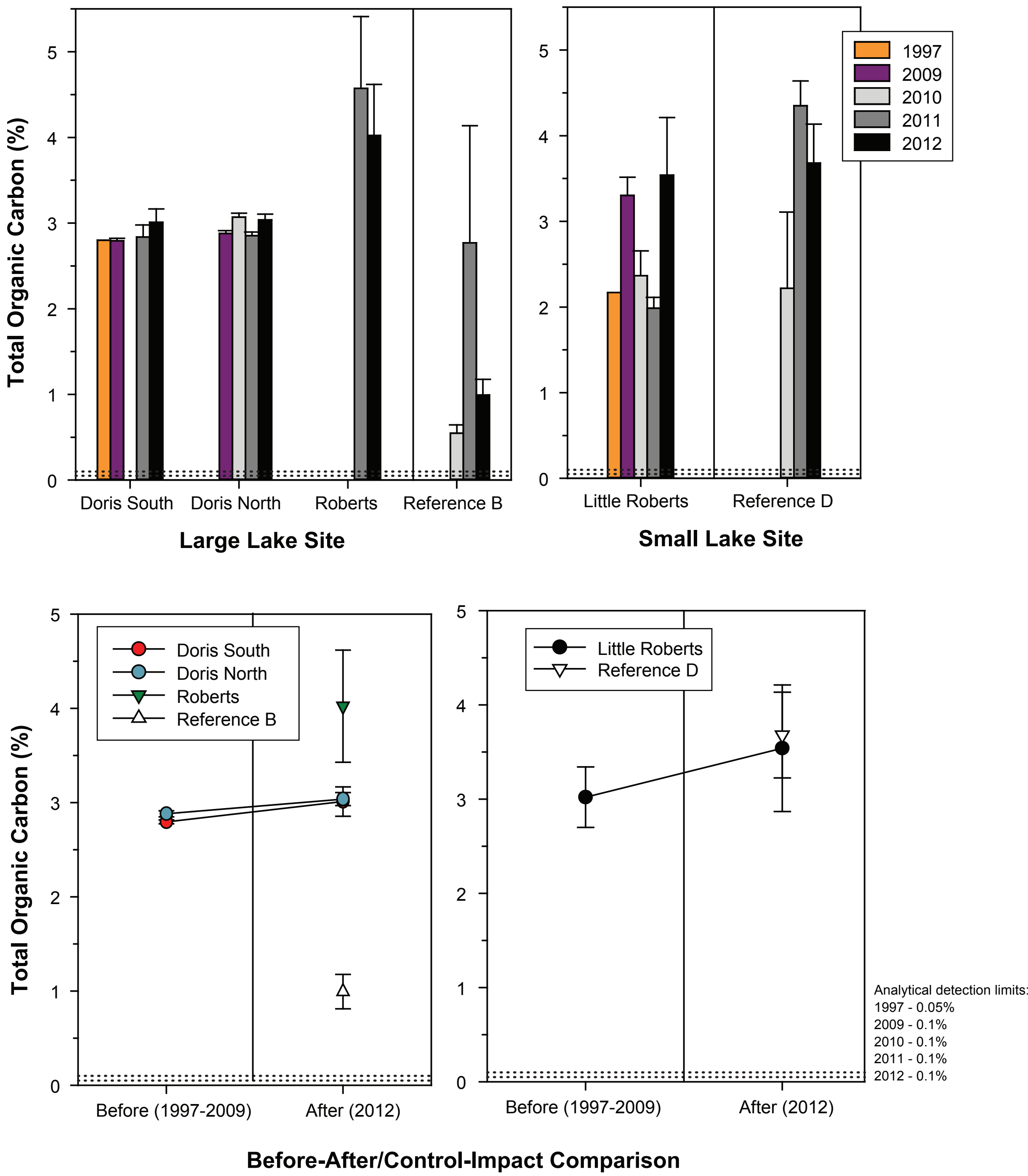

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Total organic carbon content of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Total Organic Carbon Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012

Figure 3.4-11

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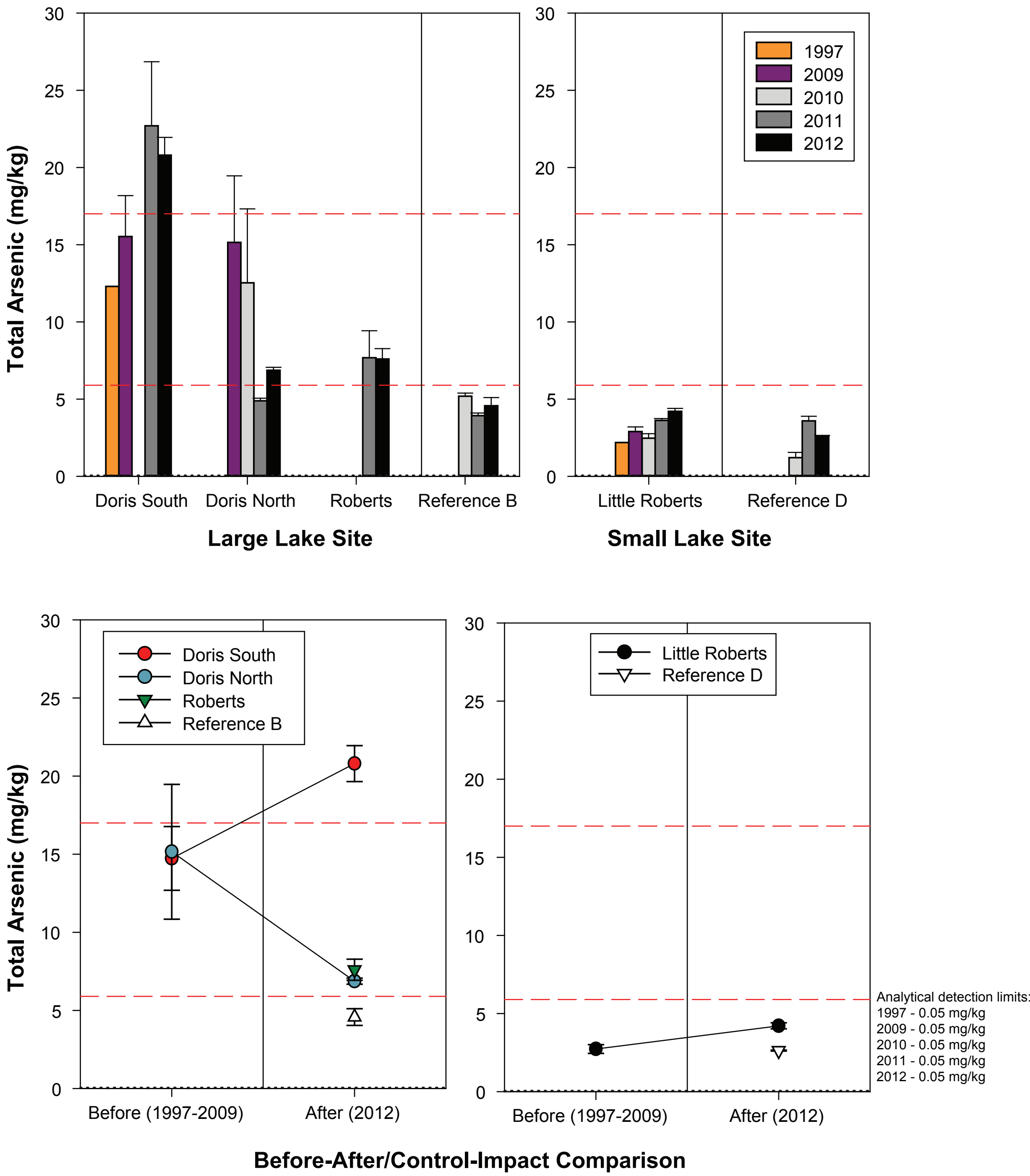

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for arsenic (5.9 mg/kg) and the probable effects level (PEL) for arsenic (17 mg/kg).

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Total Arsenic Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012

Figure 3.4-12

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3.4.2.4 Total Cadmium

Mean 2012 cadmium levels in Doris Lake South and Little Roberts Lake sediments were within the range of baseline means, while the mean 2012 cadmium concentration in Doris Lake North sediments was slightly lower than the 2009 mean (Figure 3.4-13). All baseline and 2012 mean cadmium concentrations in exposure and reference lake sediments were below the CCME ISQG of 0.6 mg/kg and the PEL of 3.5 mg/kg (Figure 3.4-13). Based on the before-after analysis, there were no significant changes in mean sediment cadmium concentrations between baseline years and 2012 in the exposure lakes ($p = 0.88$ for Doris Lake South, $p = 0.016$ for Doris Lake North, and $p = 0.99$ for Little Roberts Lake). Therefore, 2012 activities had no apparent effect on cadmium concentrations in the exposure lake sediments.

3.4.2.5 Total Chromium

Sediment chromium levels were naturally high in the exposure and reference lake sediments, as 2012 concentrations were always above the CCME ISQG of 37.3 mg/kg (Figure 3.4-14). Baseline chromium levels were also commonly higher than this guideline. All chromium concentrations measured in 2012 were below the CCME PEL of 90 mg/kg. In the exposure lakes, 2012 concentrations were similar to or lower than mean baseline chromium concentrations and the before-after confirmed that there was no difference in means between baseline years and 2012 ($p = 0.59$ for Doris Lake South, $p = 0.48$ for Doris Lake North, and $p = 0.41$ for Little Roberts Lake). Therefore, there was no evidence of an effect of 2012 activities on total chromium concentrations in exposure lake sediments.

3.4.2.6 Total Copper

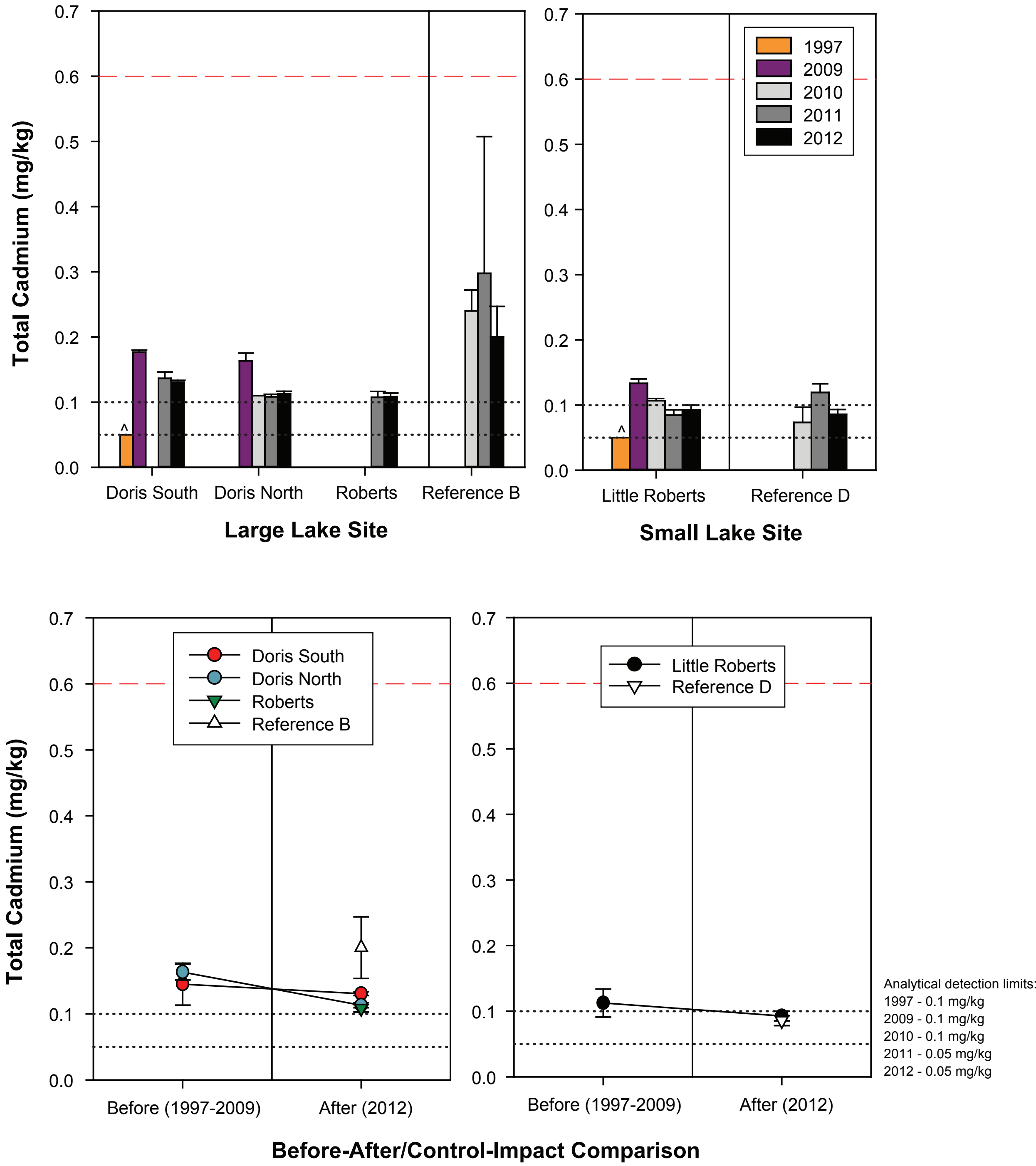
Mean baseline and 2012 copper concentrations were slightly higher than the CCME ISQG of 35.7 mg/kg in both Doris Lake South and Doris Lake North, but were well below the PEL of 197 mg/L. In Little Roberts Lake, mean baseline and 2012 concentrations were below both ISQG and PEL guidelines (Figure 3.4-15). At all three exposure lake sites, the before-after plot showed that mean 2012 sediment copper concentrations were slightly lower than baseline means (Figure 3.4-15). The before-after analysis indicated that this decrease was statistically significant for Doris Lake South and Doris Lake North sediments ($p < 0.0001$ and $p = 0.0006$, respectively), but that there was no significant difference between baseline and the 2012 mean for Little Roberts Lake ($p = 0.55$) sediments. A decrease in total copper concentrations in Doris Lake South and North sediments is not of concern; therefore, 2012 activities did not adversely affect copper concentrations in the sediments of exposure lakes.

3.4.2.7 Total Lead

Mean sediment lead concentrations decreased slightly in all exposure lakes between baseline years and 2012, and remained well below the CCME ISQG of 35 mg/kg and the PEL of 91.3 mg/kg (Figure 3.4-16). The before-after comparison showed that the mean 2012 lead concentration in Doris Lake North and Little Roberts Lake sediments were significantly lower than their 2009 means ($p = 0.001$ and $p < 0.0001$, respectively), but that the 2012 mean was not significantly different from the baseline mean in Doris Lake South ($p = 0.04$). A decrease in sediment lead concentrations in Doris Lake North and Little Roberts Lake are not of concern; therefore, 2012 activities did not adversely affect lead concentrations in the sediments of exposure lakes.

3.4.2.8 Total Mercury

In all exposure lakes, sediment mercury concentrations measured in 2012 were similar to baseline concentrations, and were well below the CCME ISQG of 0.17 mg/kg and the PEL of 0.486 mg/kg (Figure 3.4-17). The before-after comparison confirmed that 2012 mean concentrations were not statistically different from baseline means in any exposure lake ($p = 0.90$ for Doris Lake South, $p = 0.013$ for Doris Lake North, and $p = 0.94$ for Little Roberts Lake). There was no indication that 2012 activities affected sediment mercury concentrations in exposure lakes.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit 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 freshwater interim sediment quality guideline (ISQG) for cadmium (0.6 mg/kg); the probable effects level (PEL) for cadmium (3.5 mg/kg) is not shown.

Figure 3.4-13

Total Cadmium Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012

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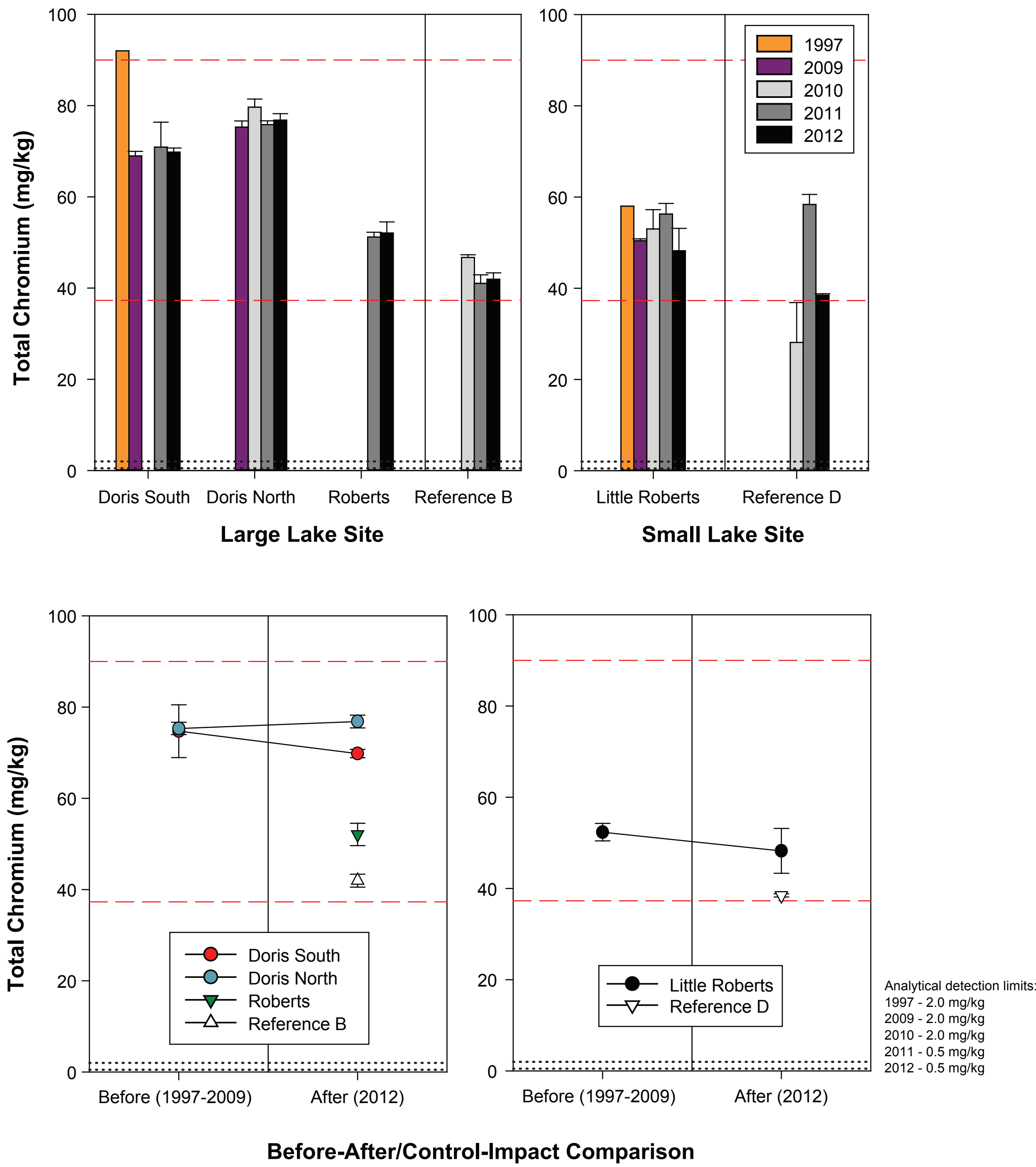

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for chromium (37.3 mg/kg) and the probable effects level (PEL) for chromium (90 mg/kg).

Figure 3.4-14

Total Chromium Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012

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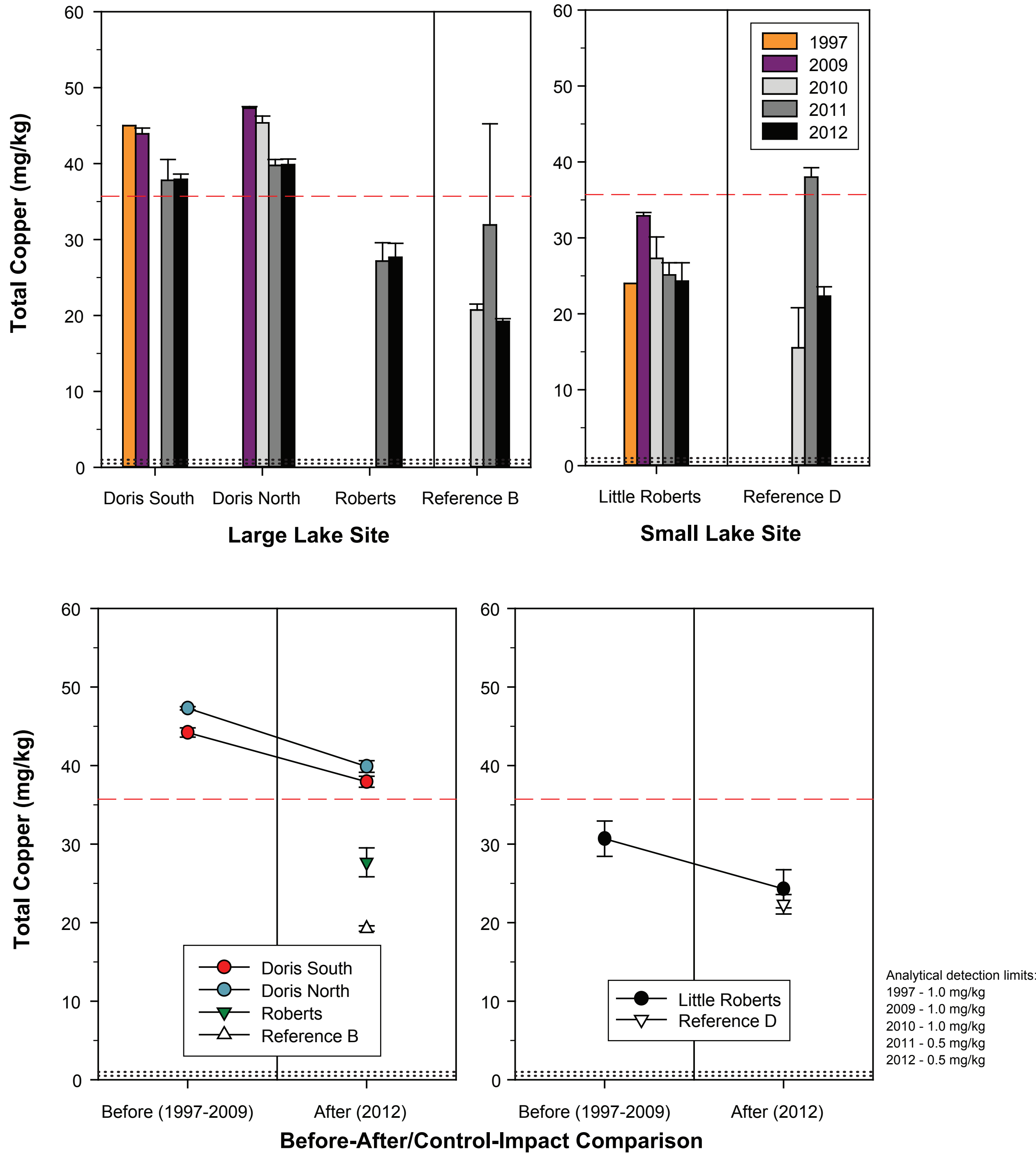
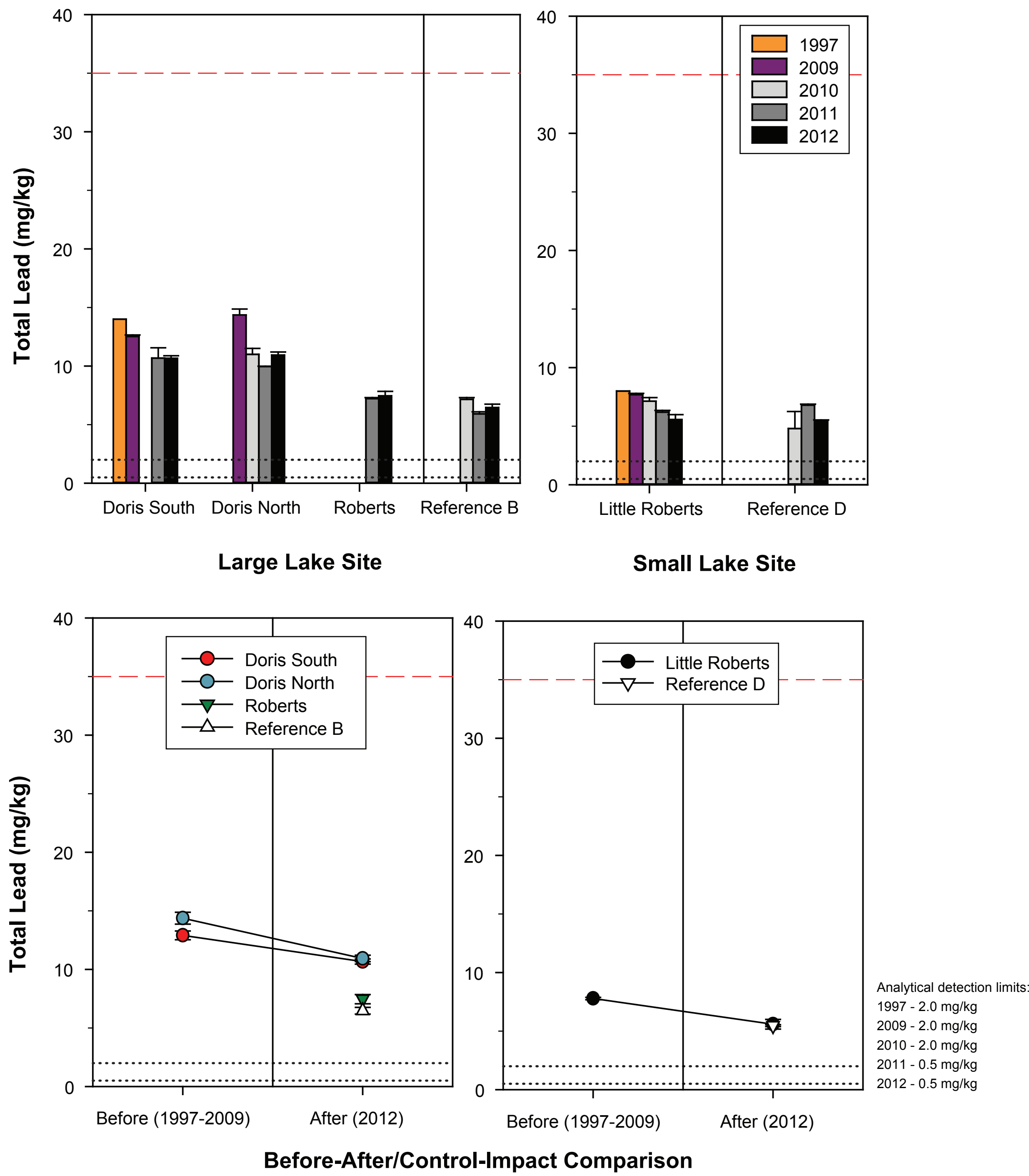


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG)
for copper (35.7 mg/kg); the probable effects level (PEL) for copper (197 mg/kg) is not shown.

Figure 3.4-15

Total Copper Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG)
for lead (35 mg/kg); the probable effects level (PEL) for lead (91.3 mg/kg) is not shown.

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Total Lead Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012

Figure 3.4-16

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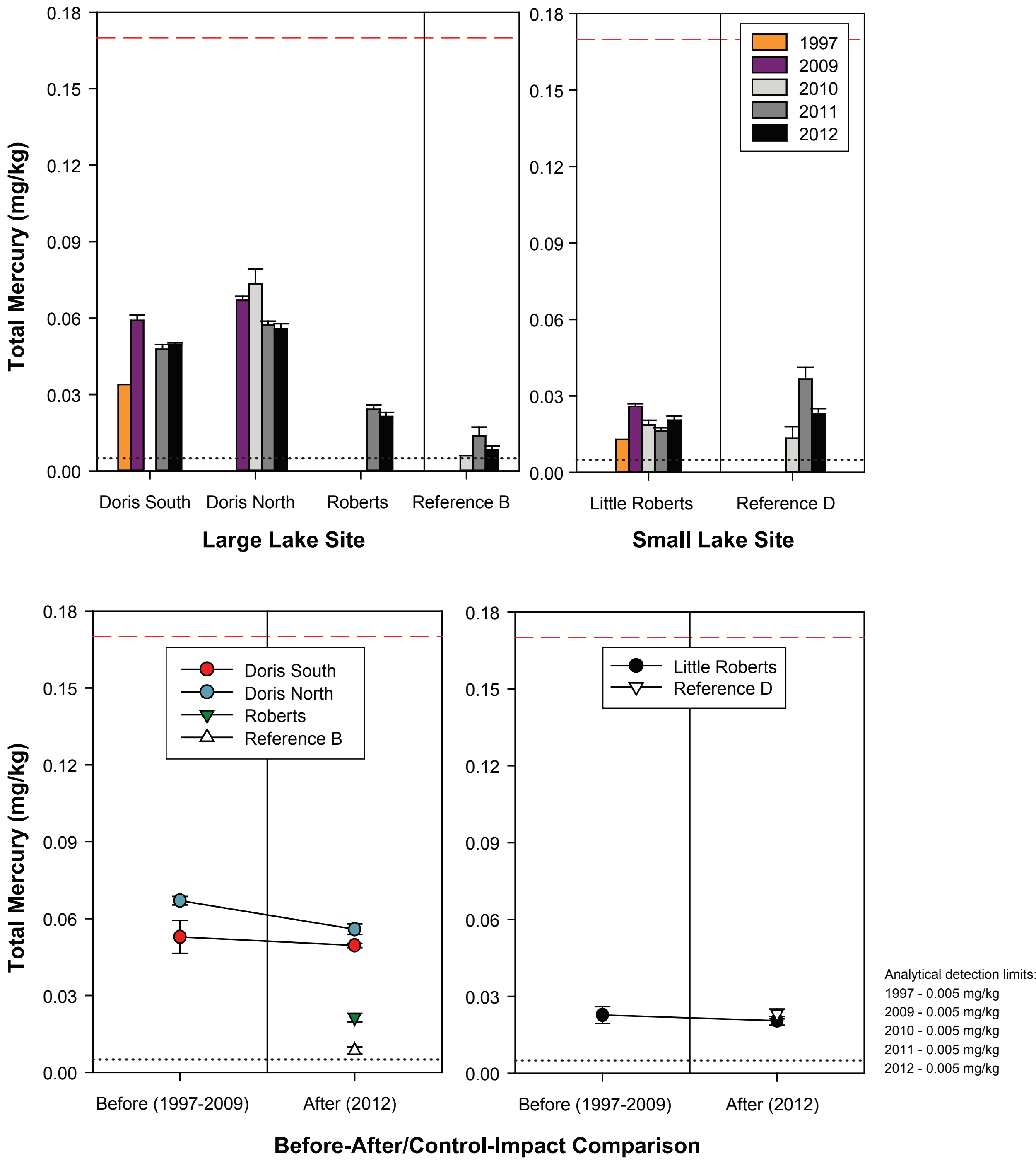

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG)
for mercury (0.17 mg/kg); the probable effects level (PEL) for mercury (0.486 mg/kg) is not shown.

Figure 3.4-17

Total Mercury Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012

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3.4.2.9 Total Zinc

Mean 2012 zinc concentrations in the sediments of the exposure lake sites were similar between baseline years and 2012, and were always below the CCME ISQG of 123 mg/kg and the PEL of 315 mg/kg (Figure 3.4-18). At all the exposure lake sites, the before-after analysis failed to find evidence of a difference between baseline and 2012 means ($p = 0.53$ for Doris Lake South, $p = 0.17$ for Doris Lake North and $p = 0.47$ for Little Roberts Lake). Thus, there were no apparent adverse effects of 2012 activities on zinc concentrations in the sediments of the exposure lakes.

3.4.3 Marine

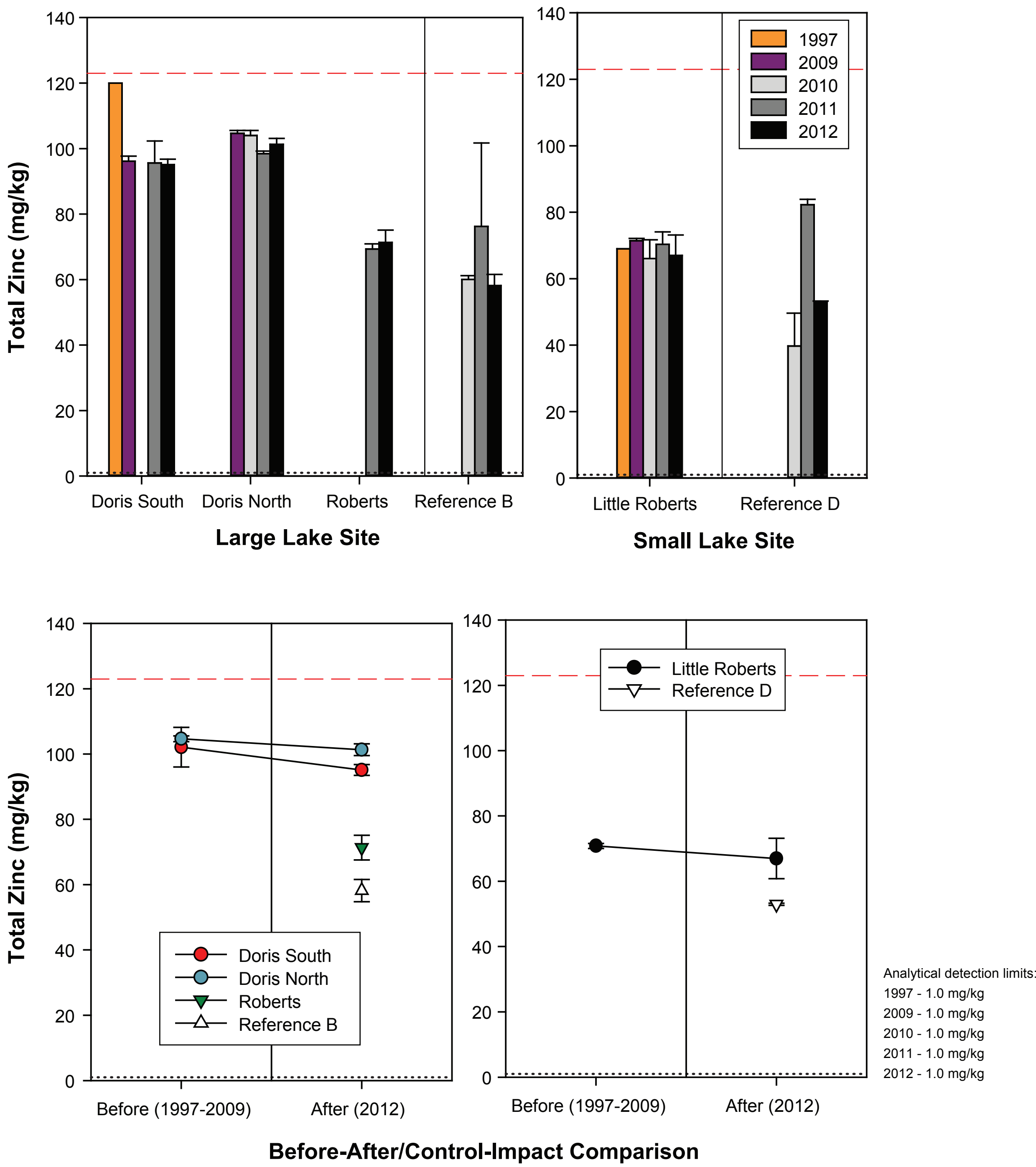
Sediment quality samples from the marine environment were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Ida Bay (REF-Marine 1). Baseline sediment quality data were collected in Roberts Bay in 1997, 2002, and 2009. However, not all of the baseline data were directly comparable to the 2012 samples either because they were not collected in the immediate vicinity of the AEMP sampling sites or they were collected from different depth strata than 2012 samples (Appendix B). There were no suitable baseline data available for RBE, but there was one year of historical data available for each RBW (2002) and REF-Marine 1 (2009).

Because the available baseline data were from two different years, a change in any parameter at the exposure site, RBW, from 2002 to 2012 cannot be directly compared to the change at the reference station, REF-Marine 1, between 2009 and 2012. Any change at REF-Marine 1 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 was a nine-year gap between the collection of before and after data. Furthermore, no BACI analysis was possible for RBW because of a lack of degrees of freedom in the before period and no statistical analyses could be performed for RBE because there was no suitable baseline sediment data collected near this exposure site.

3.4.3.1 Particle Size

In 2012, the sediment composition at the RBW and REF Marine1 sites was largely made up of sand and silt, with some clay (Figure 3.4-19), while RBE was mostly sand, gravel and some silt. At site RBW, there were some changes in the 2012 particle size composition of sediments compared to 2002 (Figure 3.4-19). The before-after comparison showed that the sand content decreased significantly from 52.3% in 2002 to 37.2 % in 2012 ($p = 0.0002$), the silt content increased significantly (27.5% in 2002 to 46.7% in 2012; $p < 0.00001$), and the gravel and clay content remained relatively consistent between 2002 and 2012 ($p = 0.68$ and $p = 0.019$, respectively). Variation in sediment particle size composition is unlikely related to 2012 Project activities, and probably reflects natural spatial heterogeneity in marine sediments. However, the observed increase in silt has important implications for the before-after comparisons of metals because metal concentrations tend to be higher in fine sediments than in coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003). As described in the following sections, mean concentrations of TOC and all evaluated metals (except cadmium and mercury) increased significantly at RBW in 2012 compared to 2002 and this increase was likely associated with the higher silt content of the sediment samples.

At site REF-Marine 1, there was a clear difference in the sediment composition in 2012 compared to 2009, as 2012 samples consisted of finer sediments than 2009 samples (Figure 3.4-19). The before-after analysis showed that the clay content increased significantly from 3.3% to 13.6% ($p < 0.0001$) between 2009 and 2012, the silt content increased significantly from 14.0% to 69.7% ($p < 0.0001$), and the sand content decreased significantly from 82.0% to 16.5 ($p < 0.0001$). Again, this has important implications for the before-after comparisons of metals because metal concentrations tend to be higher in fine sediments than in coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003). As described in the following sections, mean concentrations of TOC and all evaluated metals (except cadmium) increased significantly at REF-Marine 1 in 2012 compared to 2009. Consequently, the before-after analysis for both sites becomes difficult to interpret because of the variation in the particle size content of the sampled sediments.



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 freshwater 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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Total Zinc Concentrations in AEMP Lake Sediments, Doris North Project, 1997 to 2012

Figure 3.4-18

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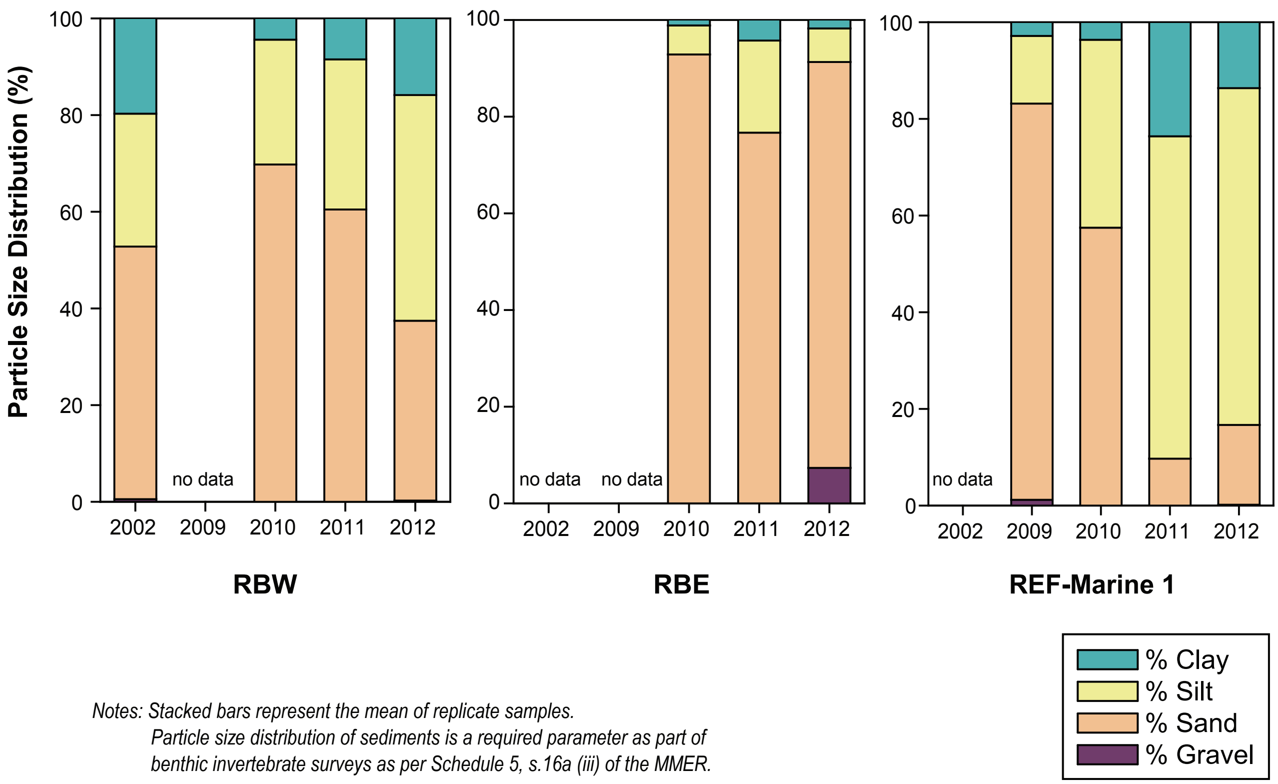

Notes: Stacked bars represent the mean of replicate samples.
Particle size distribution of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Particle Size Distribution in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-19

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3.4.3.2 Total Organic Carbon

The mean TOC content in sediments from RBW appeared to increase from 2002 to 2012 (Figure 3.4-20). However, this was an artifact of the five-fold higher analytical detection limit for TOC in 2002 (0.5%) compared to 2012 (0.1%). The before-after comparison indicated that there was a significant increase in the mean sediment TOC content at RBW between 2002 and 2012 ($p < 0.0001$), but this can be entirely explained by the variability in detection limits and the substitution of half the detection limit for values that were below the detection limit. Sediment samples from RBE contained very little TOC (Figure 3.4-20); all concentrations were near or below the detection limit of 0.1% as is expected from sand-dominated sediments. There was no evidence that 2012 Project activities had any effect on the proportion of TOC in the exposure site sediments.

3.4.3.3 Total Arsenic

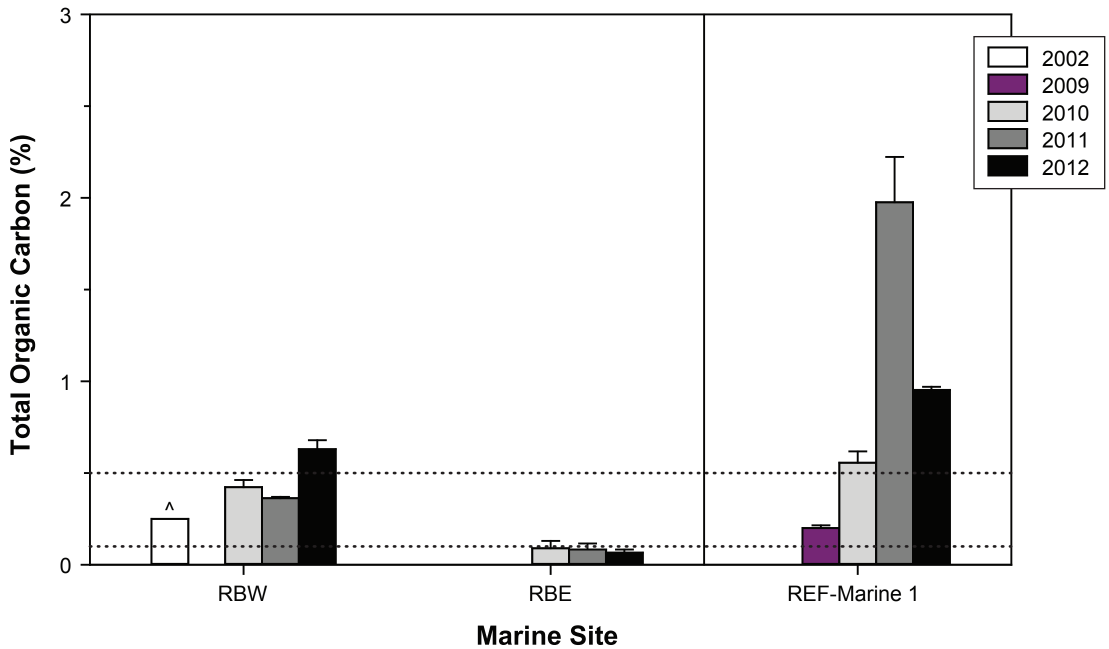
Mean arsenic concentrations in sediments from RBW increased from 1.9 mg/kg in 2002 to 4.1 mg/kg in 2012 (Figure 3.4-21). This increase was statistically significant ($p < 0.0001$) based on the before-after analysis. However, mean arsenic concentrations also increased significantly at REF-Marine 1 from 2009 (0.6 mg/kg) to 2012 (4.0 mg/kg; $p < 0.001$). In both cases, the increase in sediment arsenic concentrations was related to the significant increase in proportion of fine sediments in the samples that have higher affinities for metals. This suggests that the change in arsenic concentrations that occurred in sediments from RBW in 2012 was unrelated to 2012 Project activities. At RBE, the mean 2012 arsenic concentration in sediments (1.2 mg/kg) was lower than concentrations in sediments from the other AEMP sites (Figure 3.4-21). All 2012 concentrations were well below the CCME ISQG of 7.24 mg/kg and the PEL of 41.6 mg/kg. There was no evidence that 2012 activities affected sediment arsenic concentrations at the marine exposure sites.

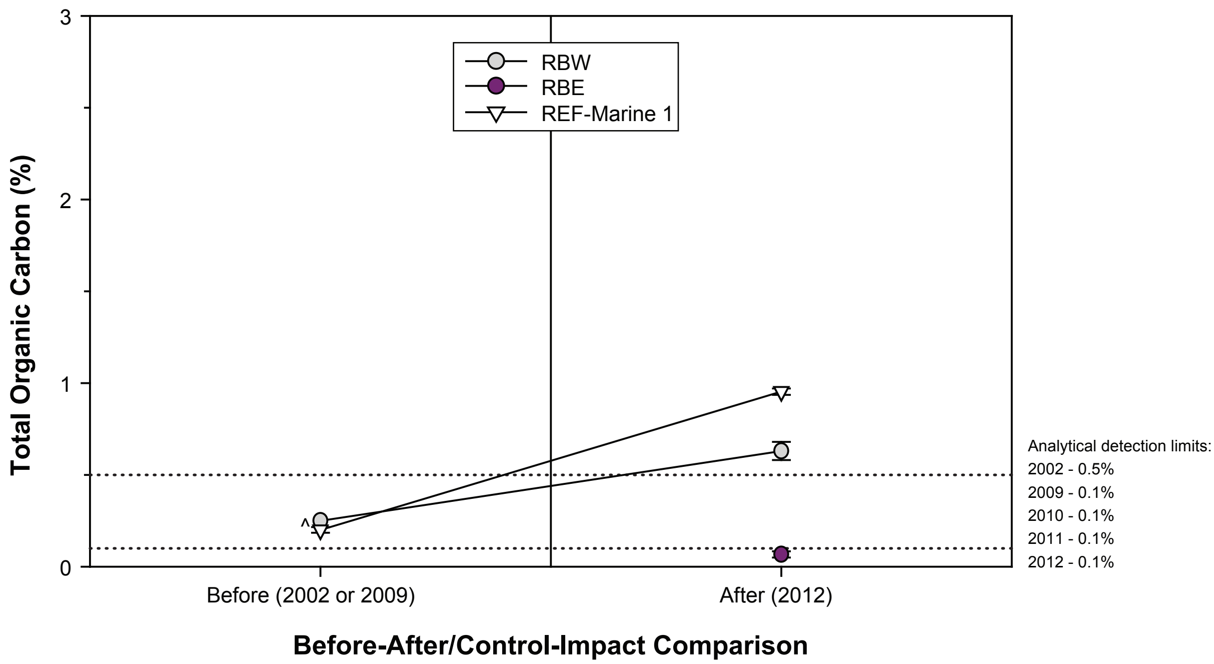
3.4.3.4 Total Cadmium

Total cadmium concentrations were below the detection limit (< 0.05 mg/kg) in all sediment samples collected from RBE and REF-Marine-1 in 2012, and were only detectable in one sample from RBW (mean: 0.034 mg/kg; Figure 3.4-22). All 2012 concentrations were well below the CCME ISQG of 0.7 mg/kg and the PEL of 4.2 mg/kg. Before-after statistical results were not performed for cadmium concentrations because a high proportion (>70%) of the values were below the analytical detections limits. Although the before-after plot indicates that cadmium concentrations were lower than baseline concentrations, this was an artifact of higher analytical detection limit in 2002 and 2009 (0.2 mg/kg and 0.1 mg/kg, respectively) compared to 2012 (0.05 mg/kg). Therefore, there was no indication that 2012 activities had any effect on cadmium concentrations in sediments at the marine exposure sites.

3.4.3.5 Total Chromium

Mean chromium concentrations in RBW sediments increased significantly from 18.2 mg/kg in 2002 to 33.6 mg/kg in 2012 (before-after: $p < 0.0001$; Figure 3.4-23). A significant and considerably larger increase from 9.4 mg/kg in 2009 to 28.4 mg/kg in 2012 (before-after: $p < 0.0001$) occurred in sediments from REF-Marine 1 (Figure 3.4-23). In both cases, the increase in sediment chromium concentrations was related to the significant increase in the proportion of fine sediments in the samples which have higher affinities for metals. This suggests that the change in chromium concentrations that occurred in sediments from RBW in 2012 was unrelated to 2012 Project activities. At RBE, the mean 2012 chromium concentration in sediments (13.9 mg/kg) was lower than concentrations in sediments from the other AEMP sites (Figure 3.4-23). All 2012 concentrations were below the CCME ISQG of 52.3 mg/kg and the PEL of 160 mg/kg. There was no evidence of an effect of 2012 activities on sediment chromium concentrations at the marine exposure sites in Roberts Bay.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total organic carbon content of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Total Organic Carbon Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-20

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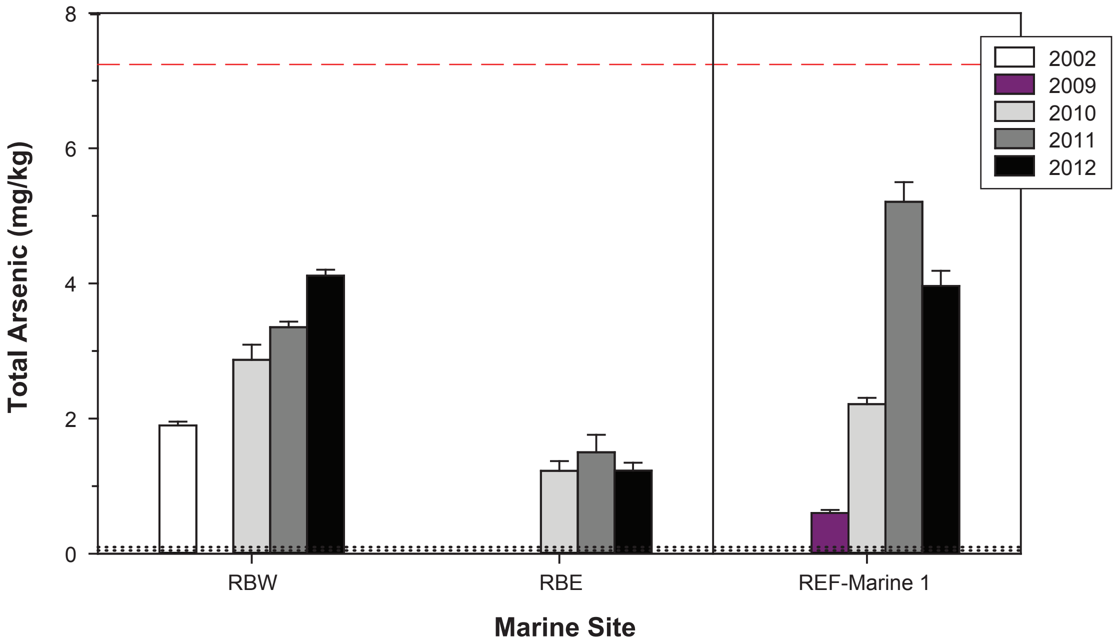

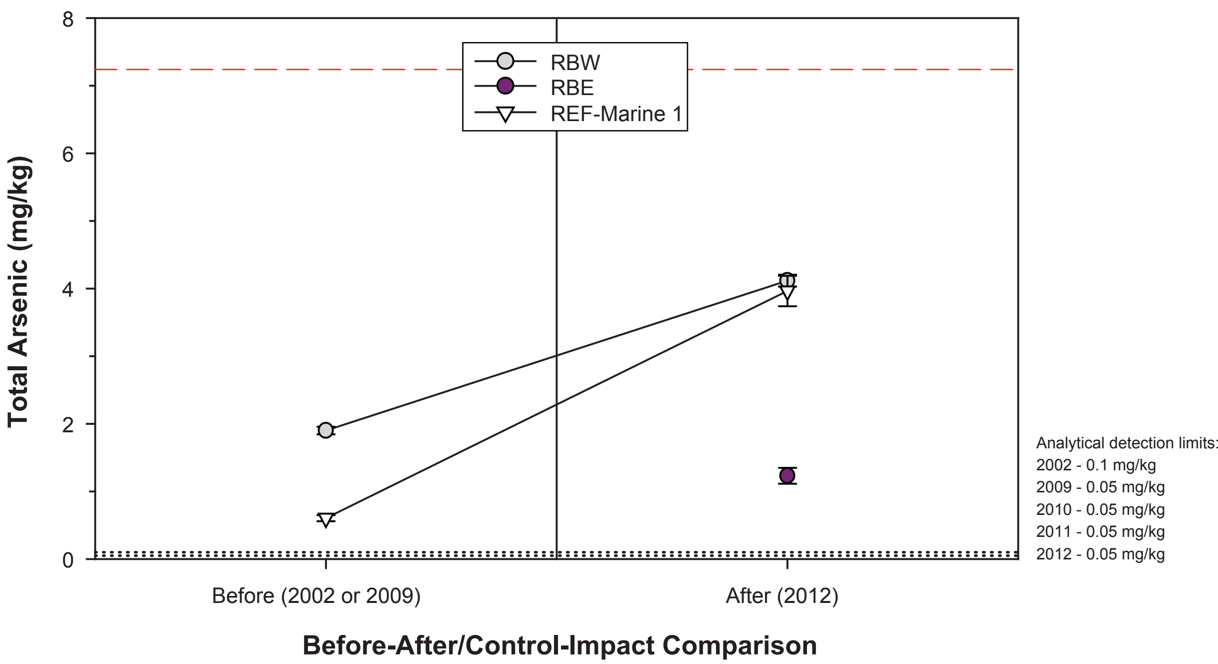

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG)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

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Total Arsenic Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-21

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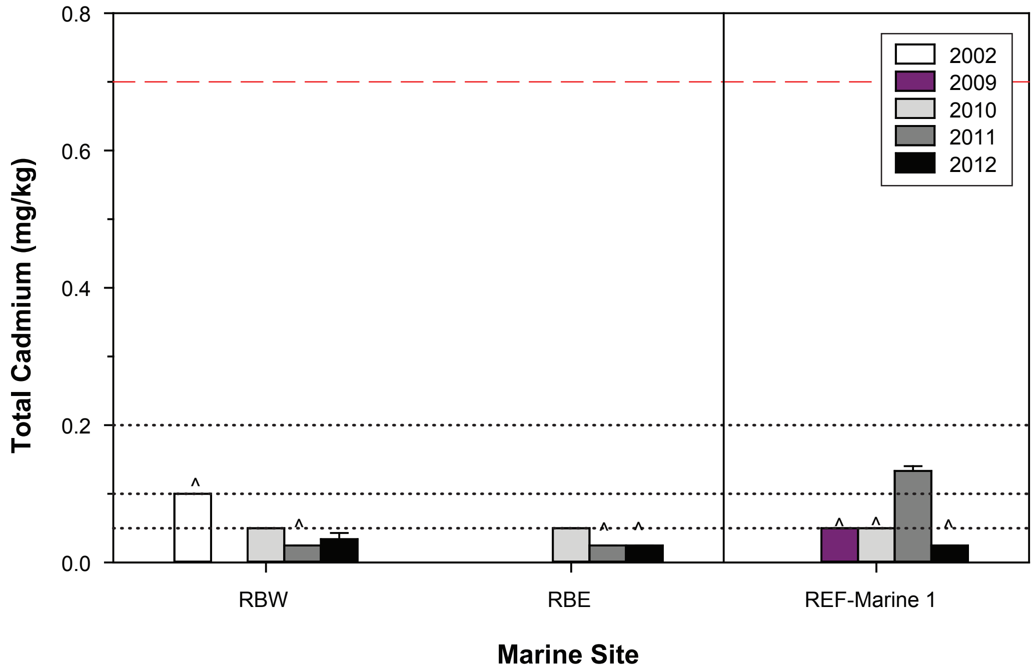

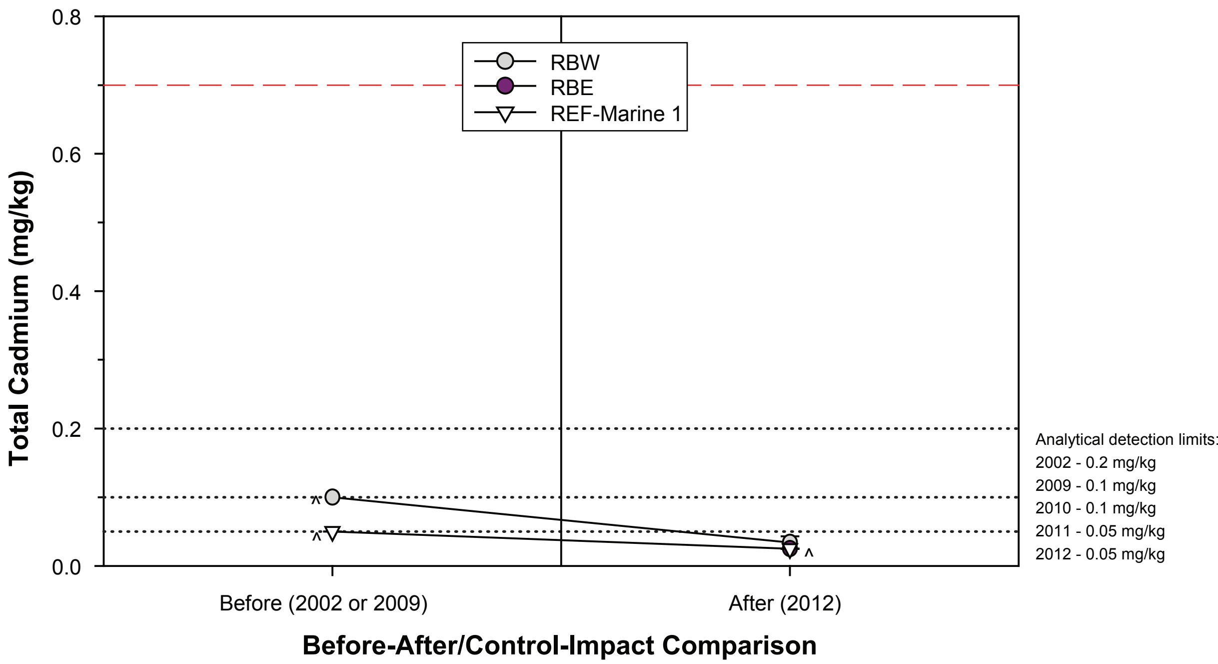

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for cadmium (0.7 mg/kg); the probable effects level (PEL) for cadmium (4.2 mg/kg) is not shown.

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Total Cadmium Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-22

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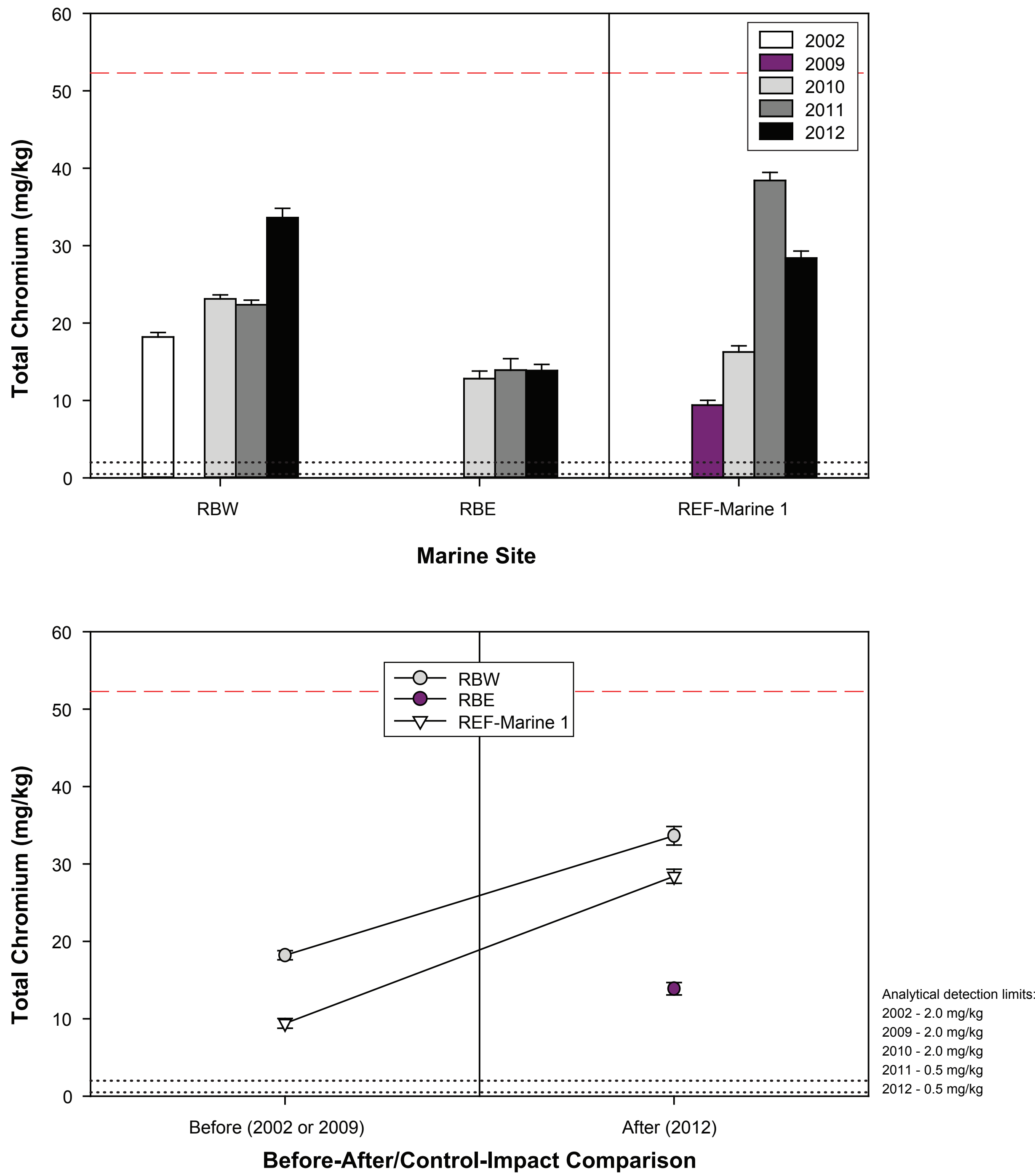

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for chromium (52.3 mg/kg); the probable effects level (PEL) for chromium (160 mg/kg) is not shown.

Total Chromium Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-23

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3.4.3.6 Total Copper

Mean copper concentrations in sediments from RBW increased from 8.4 mg/kg in 2002 to 26.9 mg/kg in 2012 and were above the CCME ISQG of 18.7 mg/kg, but below the PEL of 108 mg/kg. (Figure 3.4-24). This increase was statistically significant ($p < 0.0001$) based on the before-after analysis. However, mean copper concentrations also increased significantly at REF-Marine 1 from 2009 (4.9 mg/kg) to 2011 (11.6 mg/kg; $p < 0.0001$). In both cases, the increase in sediment copper concentrations was related to the significant increase in the proportion of fine sediments in the samples which have higher affinities for metals. This suggests that the increase in copper concentrations that occurred in sediments from RBW in 2012 was unrelated to 2012 Project activities. At RBE, the mean 2012 copper concentration in sediments (9.3 mg/kg) was lower than concentrations in sediments from the other AEMP sites (Figure 3.4-24). There was no indication that 2012 Project activities affected sediment copper concentrations at the marine exposure sites.

3.4.3.7 Total Lead

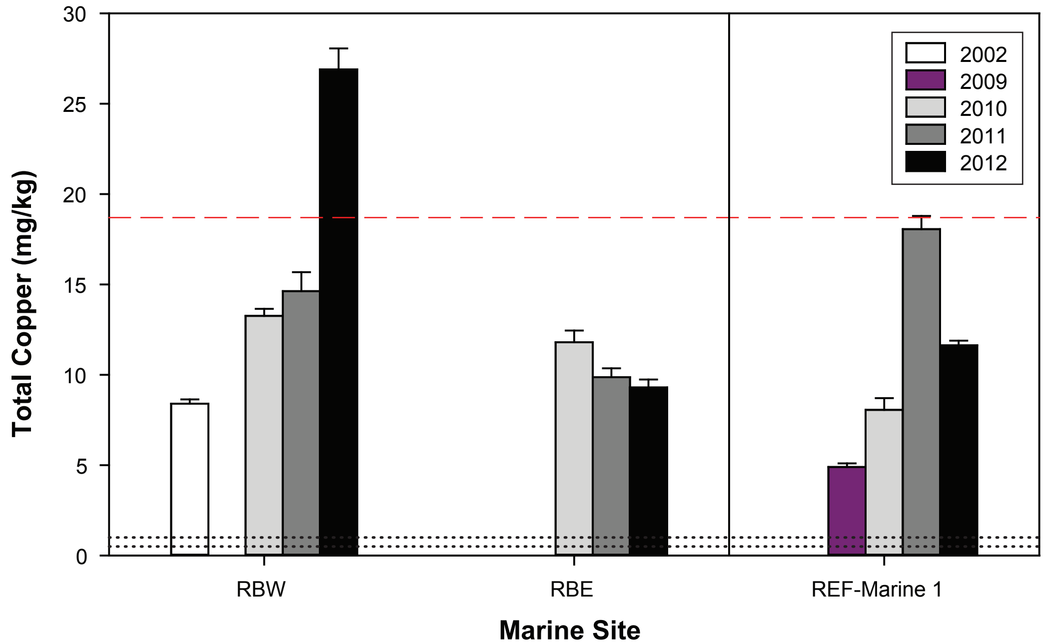
The mean 2012 lead concentration in RBW sediments (4.89 mg/kg) was higher than the 2002 mean (2.6 mg/kg; Figure 3.4-25), and the before-after analysis found a significant difference between 2012 and 2002 mean lead concentrations ($p = 0.0014$). However, mean lead concentrations also increased significantly at REF-Marine 1 from 2009 (1.0 mg/kg) to 2011 (4.16 mg/kg; $p < 0.0001$). In both cases, the increase in sediment lead concentrations was related to the significant increase in fine sediments in the samples which have higher affinities for metals. As a result, the increase in lead concentrations that occurred in sediments from RBW in 2012 was unrelated to 2012 Project activities. As observed for all other 2012 sediment metal concentrations, sediments from RBE had the lowest mean concentration of lead (1.56 mg/kg; Figure 3.4-25). All 2012 sediment lead concentrations were well below the CCME ISQG of 30.2 mg/kg and the PEL of 112 mg/kg (Figure 3.4-25). There was no apparent effect of 2012 activities on sediment lead concentrations at the marine exposure sites.

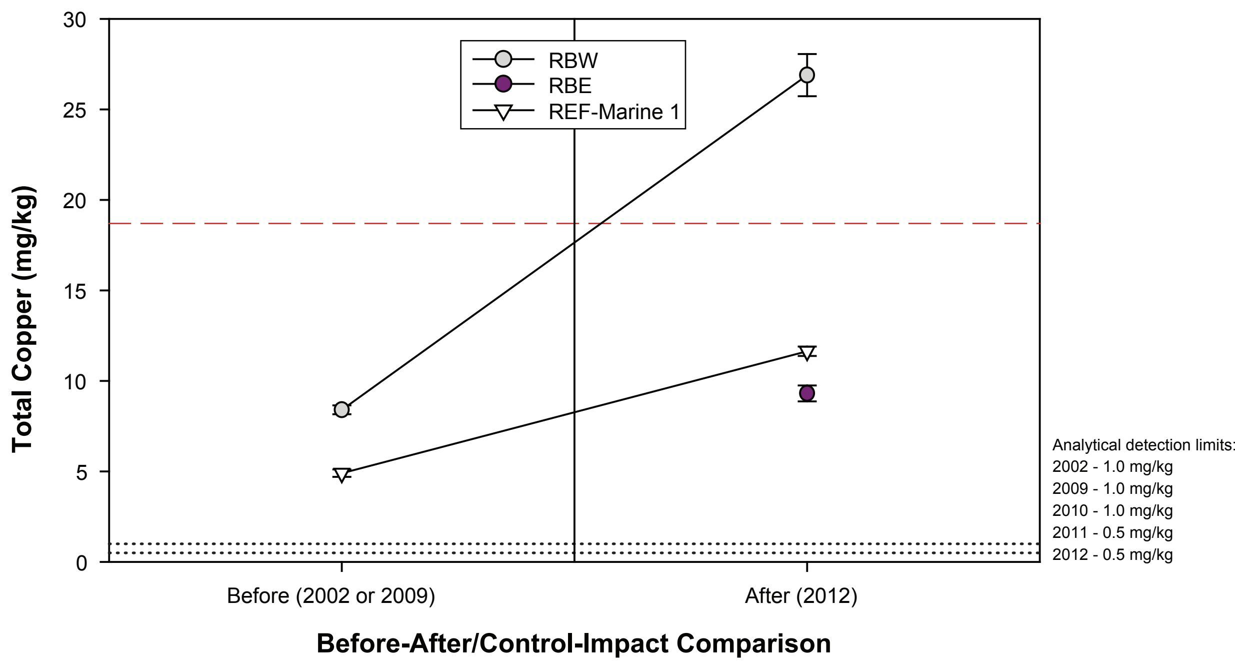
3.4.3.8 Total Mercury

Total mercury concentrations in RBW sediments were slightly lower than concentrations in 2002 sediments (Figure 3.4-26). Before-after statistical results were not performed for RBW because a high proportion (>70%) of the values were below the analytical detections limits. However, the before-after plot suggests that mercury concentrations did not change from baseline mercury concentrations. Therefore, there was no indication that 2012 activities had any effect on mercury concentrations in sediments at the marine exposure sites. Mercury concentrations were below detection limit in all sediment samples collected from the exposure sites in Roberts Bay East in 2012. Total mercury concentrations in all exposure and reference site samples collected in 2012 were well below the CCME ISQG of 0.13 mg/kg and the PEL of 0.7 mg/kg. There were no apparent effects of 2012 Project activities on total mercury concentrations in marine sediments.

3.4.3.9 Total Zinc

The mean 2012 zinc concentration (37.4 mg/kg) in sediments from RBW was higher than the 2002 mean (20.6 mg/kg; Figure 3.4-27), and the before-after analysis found a significant difference between the means ($p < 0.00001$). However, mean zinc concentrations also increased significantly at REF-Marine 1 from 2009 (15.0 mg/kg) to 2012 (34.2 mg/kg; $p < 0.00001$). In both cases, the increase in sediment zinc concentrations was related to the significant increase in the proportion of fine sediments in the samples which have higher affinities for metals. As a result, the increase in zinc concentrations that occurred in sediments from RBW in 2012 was unrelated to 2012 Project activities. Sediments from RBE had the lowest 2012 mean concentration of zinc (14.1 mg/kg; Figure 3.4-27). All 2012 sediment zinc concentrations were well below the CCME ISQG of 124 mg/kg and the PEL of 271 mg/kg (Figure 3.4-27). There was no apparent effect of 2012 activities on sediment zinc concentrations at the marine exposure sites.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for copper (18.7 mg/kg); the probable effects level (PEL) for copper (108 mg/kg) is not shown.

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Total Copper Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-24

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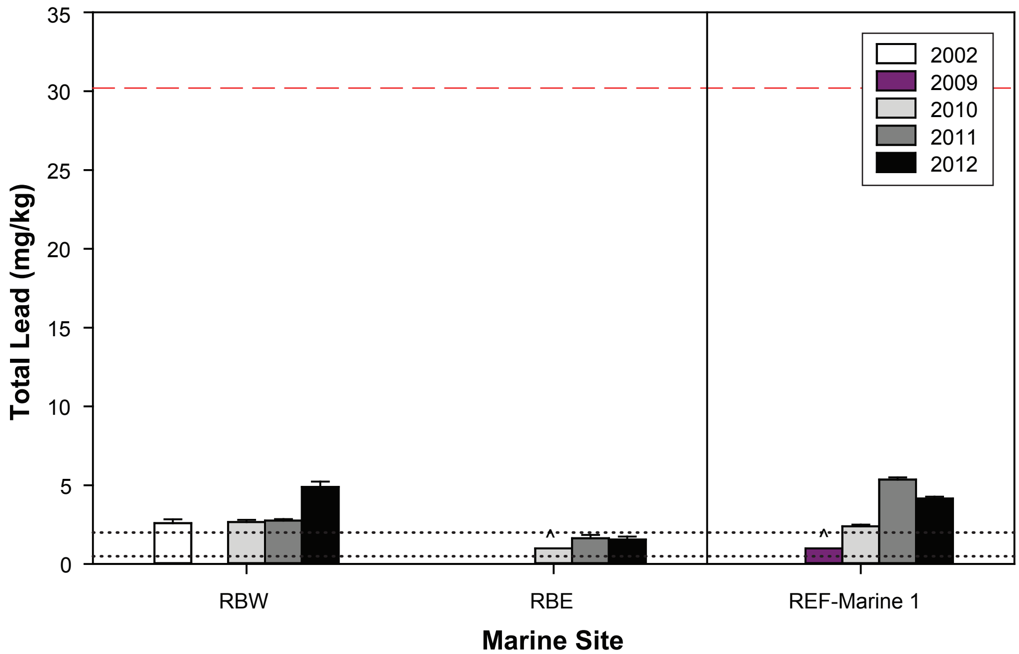

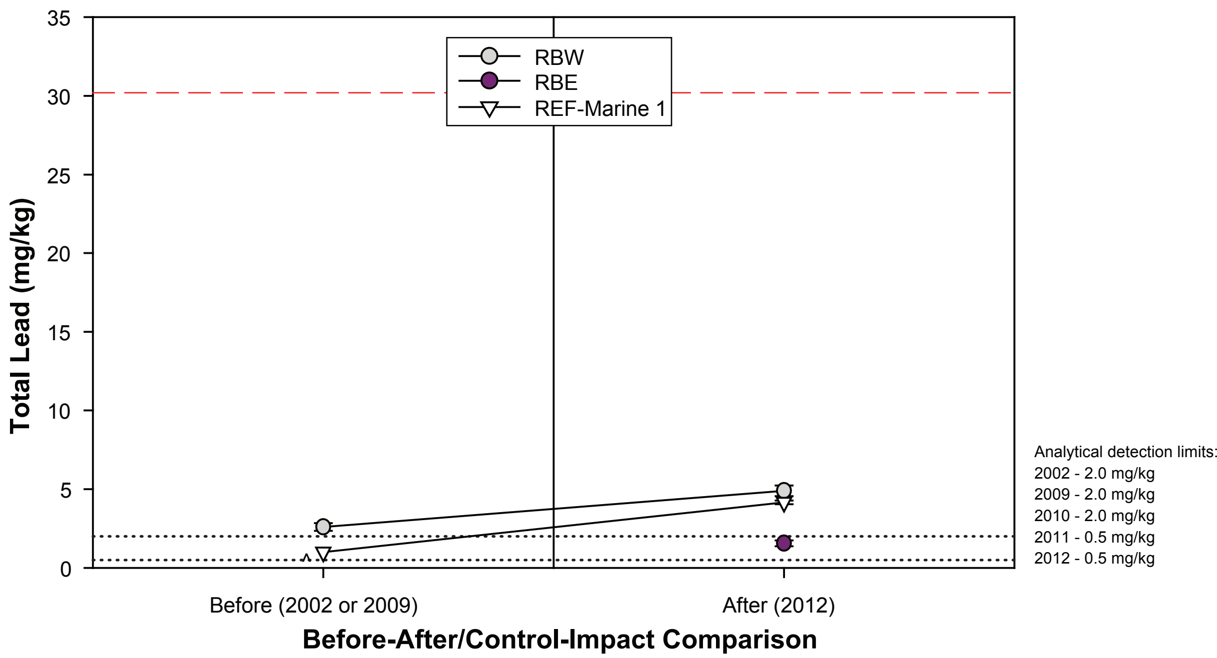

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for lead (30.2 mg/kg); the probable effects level (PEL) for lead (112 mg/kg) is not shown.

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Total Lead Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-25

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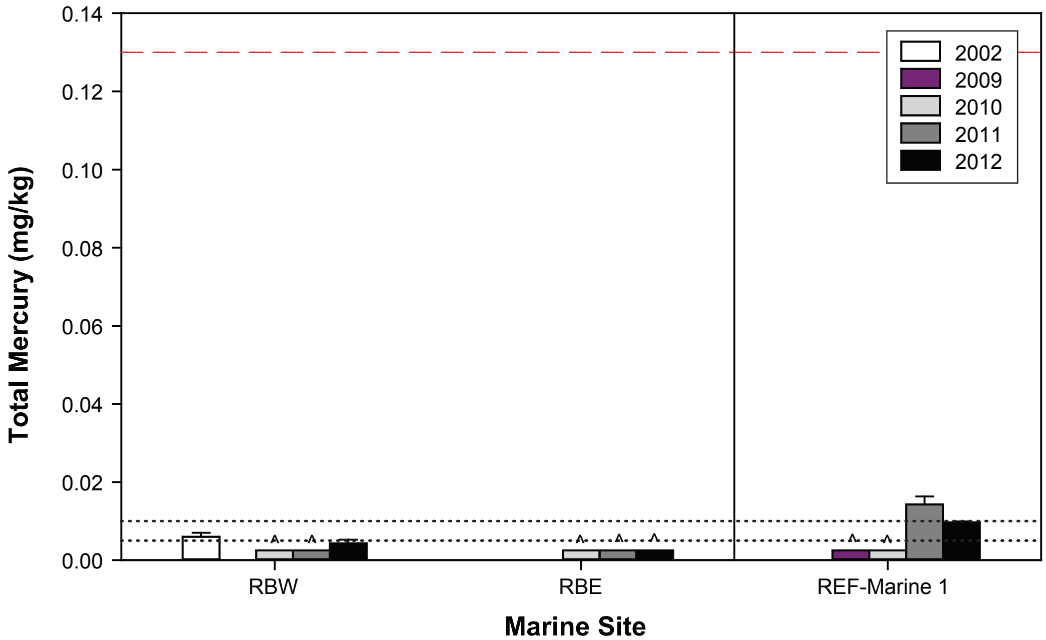

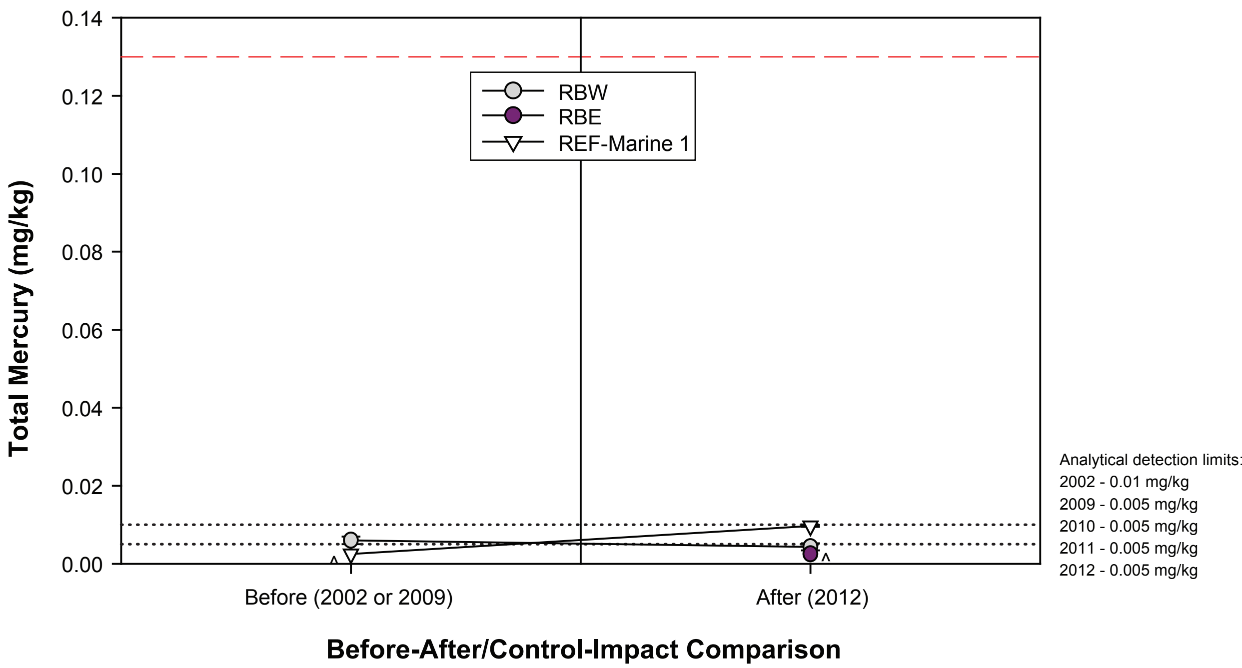

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for mercury (0.13 mg/kg); the probable effects level (PEL) for mercury (0.7 mg/kg) is not shown.

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Total Mercury Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-26

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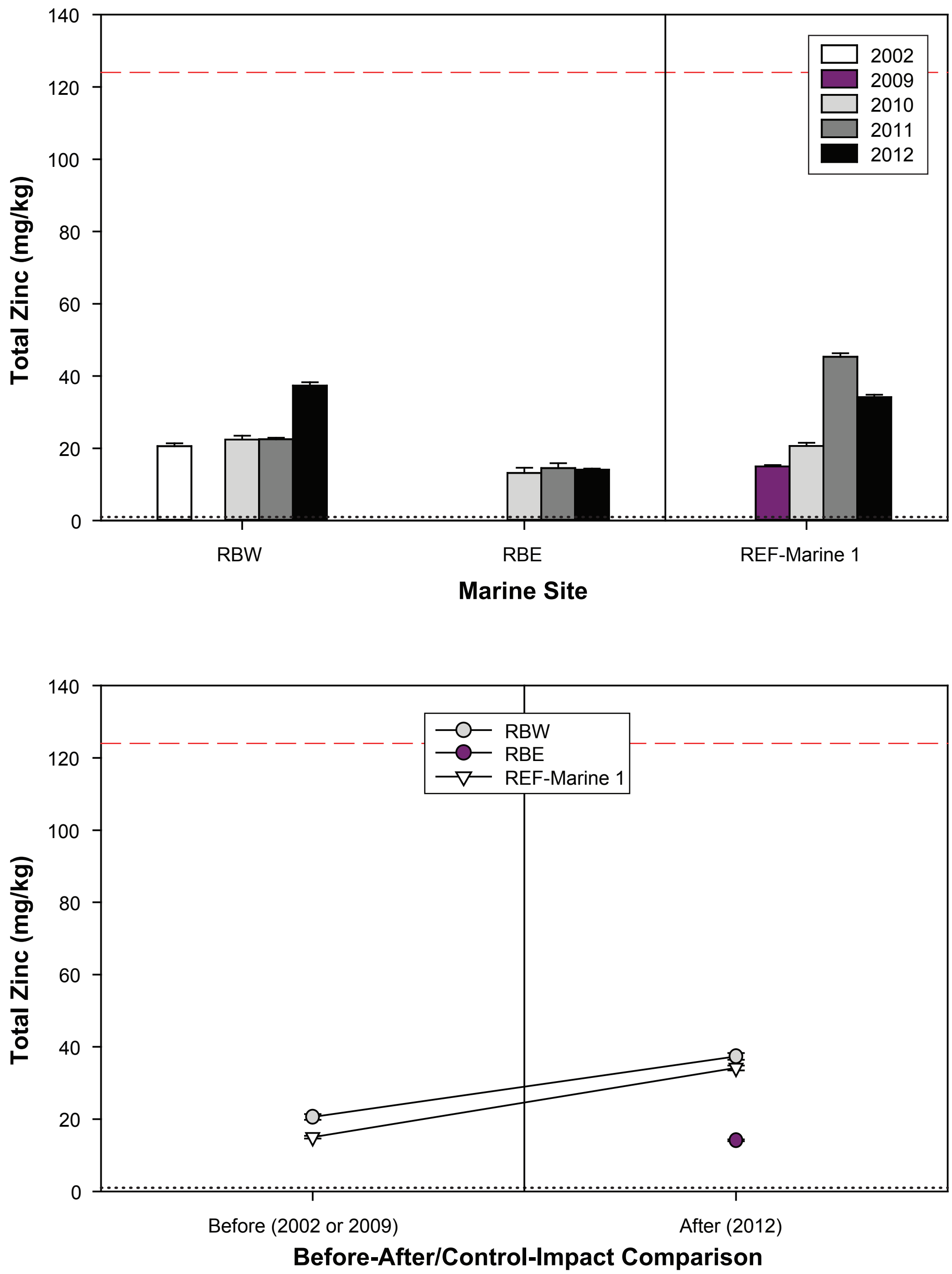

Analytical detection limits:
2002 - 1.0 mg/kg
2009 - 1.0 mg/kg
2010 - 1.0 mg/kg
2011 - 1.0 mg/kg
2012 - 1.0 mg/kg

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 marine and estuarine interim sediment quality guideline (ISQG) for zinc (124 mg/kg); the probable effects level (PEL) for zinc (271 mg/kg) is not shown.

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Total Zinc Concentrations in AEMP Marine Sediments, Doris North Project, 2002 to 2012

Figure 3.4-27

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3.5 PRIMARY PRODUCERS

Primary producer biomass (as chlorophyll *a*) samples were collected in streams, lakes, and the marine environment to assess potential changes in their standing stocks due to eutrophication or toxicity. Historical primary producer (phytoplankton and periphyton) biomass sampling has been conducted in the Doris North Project area since 1996. The main criteria for the selection of relevant baseline periphyton and phytoplankton biomass data for inclusion in the evaluation of effect were the proximity of baseline sampling sites to 2012 AEMP sampling sites, and that sampling methodologies were comparable.

Graphical analyses, before-after comparisons, and BACI analyses (where possible) were all used to determine if there were changes in primary producer biomass in the Doris North Project area. For all graphical and statistical analyses, replicate samples collected on the same date were averaged prior to analysis. The complete results of all statistical methods and analyses are provided in Appendix B.

3.5.1 Stream Periphyton Biomass

Stream periphyton biomass samples were collected from three exposure streams (Doris, Roberts, and Little Roberts Outflows) and two reference streams (Reference B and Reference D Outflows). Baseline data for stream periphyton biomass that were comparable to 2012 data in terms of sampling locations and methodologies were available from 1997, 2000, and 2009 for Doris Outflow, and from 2009 only for Little Roberts and Reference B Outflows (Appendix B). No baseline data were available for Roberts Outflow or Reference D Outflow and there was a lack of degrees of freedom in the before period for Reference B Outflow; therefore, before-after analyses could not be performed for periphyton data from these streams, and a BACI analysis could not be performed for Roberts Outflow data.

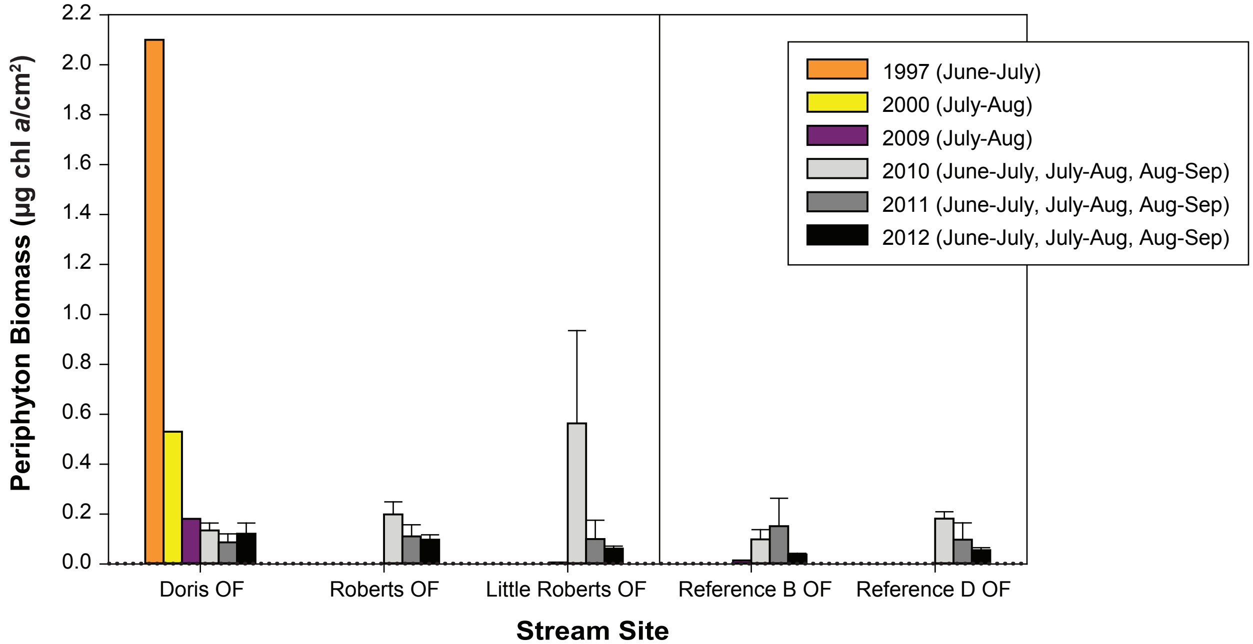
Periphyton biomass was highly variable over time, particularly at Doris Outflow where several years of baseline data were available (Figure 3.5-1). Chlorophyll *a* concentrations at this stream site decreased by an order of magnitude between 1997 and 2009, before the commencement of any Project activities. This degree of natural variability makes it difficult to isolate trends from natural background variability. Periphyton biomass levels at Doris Outflow in 2012 were similar to 2009 biomass levels, and the before-after analysis confirmed that there was no significant difference between the baseline mean biomass and the 2012 mean biomass at this site ($p = 0.16$).

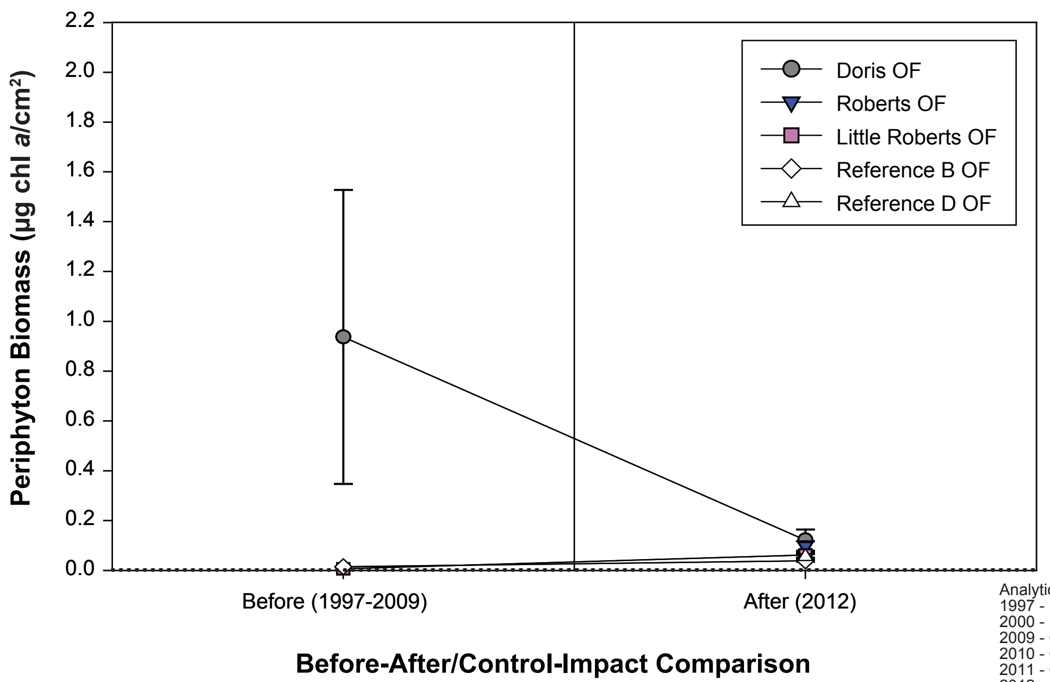
At Little Roberts Outflow, 2012 biomass levels were higher than 2009 levels (Figure 3.5-1), although the before-after analysis found no significant difference between the mean baseline biomass and the 2012 mean biomass ($p = 0.67$) The BACI analysis found that the before-after trend at Little Roberts Outflow paralleled the before-after trend that occurred at the reference streams ($p = 0.41$); therefore, the difference in biomass levels at Little Roberts Outflow between 2009 and 2012 was likely a natural occurrence.

Periphyton biomass levels at Roberts Outflow in 2012 were comparable to the biomass levels at the other exposure streams and the reference streams. Therefore, there was no indication that Project activities had any effect on periphyton biomass levels in exposure streams.

3.5.2 Lake Phytoplankton Biomass

Phytoplankton biomass samples were collected from four exposure lakes (Doris Lake South, Doris Lake North, Roberts Lake and Little Roberts Lake) and two reference lakes (Reference Lake B and Reference Lake D) in 2012. Baseline data for lake phytoplankton biomass that were comparable to 2012 data in terms of sampling locations and methodologies were available from 1997, 2000, and 2009 for Doris Lake South, 1997 and 2009 for Little Roberts Lake, and 2009 for Doris Lake North and Reference Lake B (Appendix B). No baseline data were available for Roberts Lake. Additionally, no baseline data were available for Reference Lake D, so a BACI analysis could not be performed for Little Roberts Lake.





Analytical detection limits:
1997 - not reported
2000 - not reported
2009 - 0.0004 or 0.004 µg chl *a*/cm²
2010 - 0.0001 or 0.001 µg chl *a*/cm²
2011 - 0.0001 or 0.001 µg chl *a*/cm²
2012 - 0.0001 or 0.001 µg chl *a*/cm²

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
The anomalously high periphyton biomass of 194.4 mg chl a/cm² reported for Doris Outflow in July-August 1997 was considered an outlier and was excluded from plots.

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Periphyton Biomass Concentration (as Chlorophyll *a*) in AEMP Stream Sites, Doris North Project, 1997 to 2012

Figure 3.5-1

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Mean 2012 phytoplankton biomass levels were similar at all three large lakes (Doris Lake South, Doris Lake North and Roberts Lake). At Doris Lake South, the mean 2012 phytoplankton biomass was within the range of baseline means (Figure 3.5-2). At Doris Lake North, the mean biomass level was less in 2012 than in 2009 (Figure 3.5-2). Because of lack of degrees of freedom in the before period for Reference Lake B, a before-after comparisons was not possible for this stream. However, the before-after analysis showed that the mean 2012 biomass level was not significantly different from the mean baseline level at any large exposure lake site ($p = 0.97$ for Doris Lake South, $p = 0.21$ for Doris Lake North). Accordingly, there was no apparent effect of 2012 activities on phytoplankton biomass in the AEMP exposure large lakes.

At the small lake exposure site (Little Roberts Lake), the mean 2012 phytoplankton biomass was within the range of baseline means (Figure 3.5-2). This trend was confirmed by a non-significant before-after analysis ($p = 0.13$). There was no effect of construction activities on phytoplankton biomass in Little Roberts Lake.

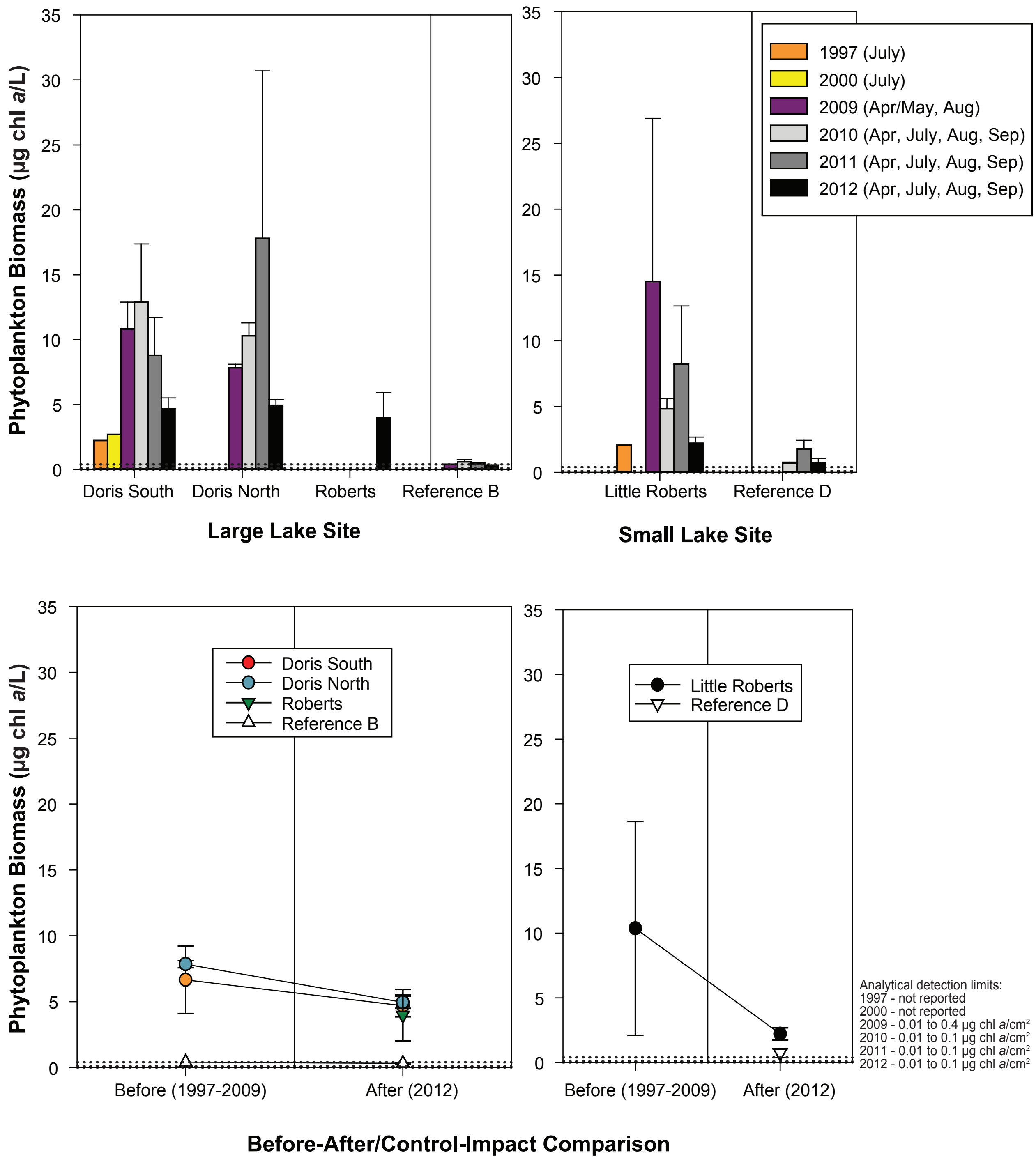
3.5.3 Marine Phytoplankton Biomass

Phytoplankton biomass samples from marine areas were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Ida Bay (REF-Marine 1) in 2012. Historical phytoplankton biomass data have been collected in Roberts Bay since 2006. However, only baseline data from 2009 were considered comparable to 2012 data. Historical data collected between 2006 and 2008 were excluded because of differences in sampling methodology (Appendix B). Baseline data from 2009 were available for all marine exposure and reference sites.

Within each year included in the evaluation of effects (2009 and 2012), marine phytoplankton biomass levels were similar among all exposure and reference sites. However, biomass levels were lower at all sites in 2009 than in 2012 (Figure 3.5-3). Mean phytoplankton biomass levels measured in 2009 were below the detection limit at both RBE and RBW (< 0.04 µg chl *a*/L) and barely above the detection limit at REF-Marine 1 (0.045 µg chl *a*/L). In 2012, mean biomass levels were more than an order of magnitude higher at all marine sites: 0.15 µg chl *a*/L at RBW, 0.44 µg chl *a*/L at RBE, and 0.15 µg chl *a*/L at REF-Marine 1 (Figure 3.5-3). These levels remained very low, and the apparent increase in biomass levels between 2009 and 2012 was likely attributable to natural seasonal differences in biomass levels, as samples collected in 2009 were collected only during one month (August) compared to four months in 2012 (April, July, August, and September). Furthermore, there was no significant increase in nitrate concentration at the exposure sites, which is the natural limiting nutrient in Roberts Bay. Although, it was not possible to perform before-after analysis on marine phytoplankton data (there were too few degrees of freedom to fit the model; Appendix B), the BACI analysis showed that the 2009 to 2012 trends observed at the exposure sites were parallel to the 2009 to 2012 trend observed at the reference site ($p = 0.60$ in RBW and $p = 0.47$ at RBE). Therefore, the increase in phytoplankton biomass at RBW and RBE cannot be attributed to 2012 Project activities.

3.6 BENTHOS

As required in Schedule 5 of the MMER, benthic invertebrate community surveys were conducted in 2012 at AEMP stream, lake, and marine sites, and the data gathered was used to calculate benthos density, evenness (Simpson's Evenness Index), taxa richness, and the similarity index (Bray-Curtis Index). Simpson's Diversity Index, which incorporates taxa richness and evenness, was also calculated. The level of taxonomic resolution used to calculate community descriptors was family-level, as recommended in the EEM guidance document (Environment Canada 2011). All summary statistics for these community descriptors are provided in Appendix A.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.

NEWMONT NORTH AMERICA

Phytoplankton Biomass Concentration (as Chlorophyll *a*) in AEMP Lake Sites, Doris North Project, 1997 to 2012

Figure 3.5-2

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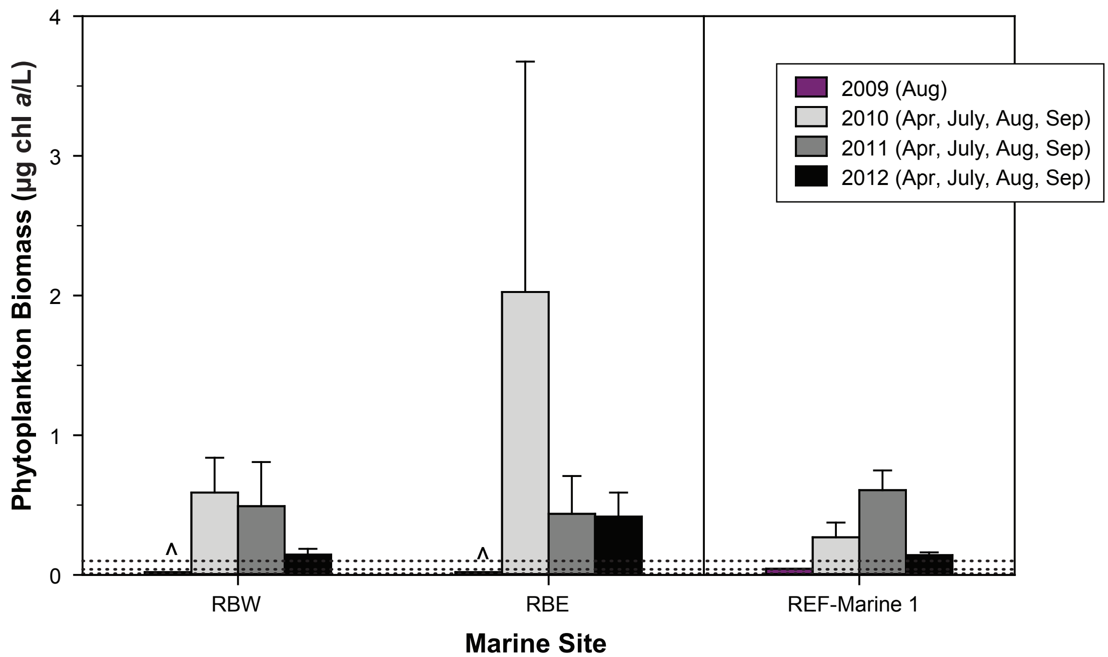

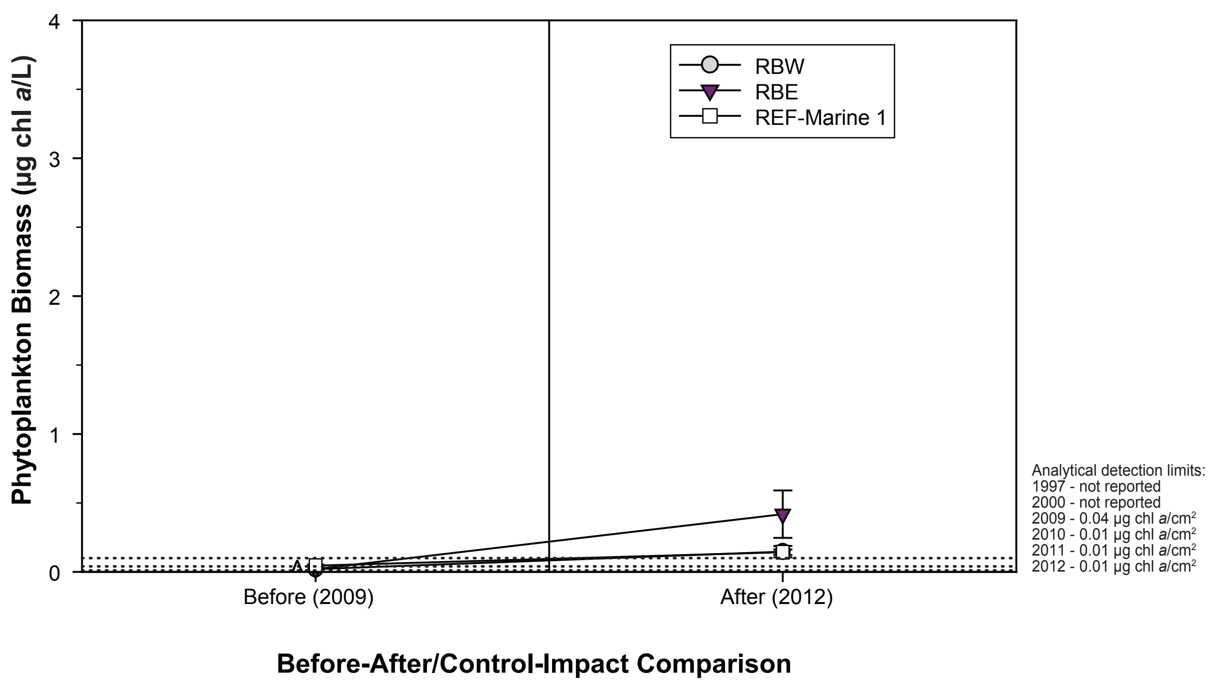

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.

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Phytoplankton Biomass Concentration (as Chlorophyll *a*) in AEMP Marine Sites, Doris North Project, 2009 to 2012

Figure 3.5-3

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The evaluation of effects for benthos required a different approach than that used for the other evaluated parameters because of the lack of comparable baseline data for benthos. The method used to collect benthos samples in 2010, 2011 and 2012 involved the pooling of three subsamples for each of five replicate samples; therefore, data collected in 2010, 2011 and 2012 were not considered comparable to pre-2010 data (as replicates collected during baseline studies were not composite samples). Instead of employing before-after or BACI comparisons for benthos data, an impact level-by-time analysis was used, whereby the benthos trends at exposure sites between 2010 and 2012 were compared to the 2010 to 2012 trends at reference sites to determine if there was evidence of non-parallelism over time. The results of the evaluation of effects for benthos are discussed below, and complete statistical methodology and results are presented in Appendix B.

3.6.1 Stream Benthos

3.6.1.1 Density

Benthic invertebrate density in 2012 was similar across all the exposure and reference stream sites (Figure 3.6-1). Furthermore, the changes in density that occurred in all three exposure stream sites (Doris, Roberts and Little Roberts Outflows) paralleled the changes that occurred in the reference streams ($p = 0.11$, $p = 0.11$ and $p = 0.96$, respectively), indicating that the changes in density was a natural phenomenon and was not related to Project activities.

3.6.1.2 Community Richness, Evenness, and Diversity

Benthos family richness was similar between 2010, 2011 and 2012 in all exposure and reference streams (Figure 3.6-2), and there was evidence of parallelism in trends between the exposure streams and the reference streams ($p = 0.32$ for Doris Outflow, $p = 0.32$ for Roberts Outflow, and $p = 0.25$ for Little Roberts Outflow).

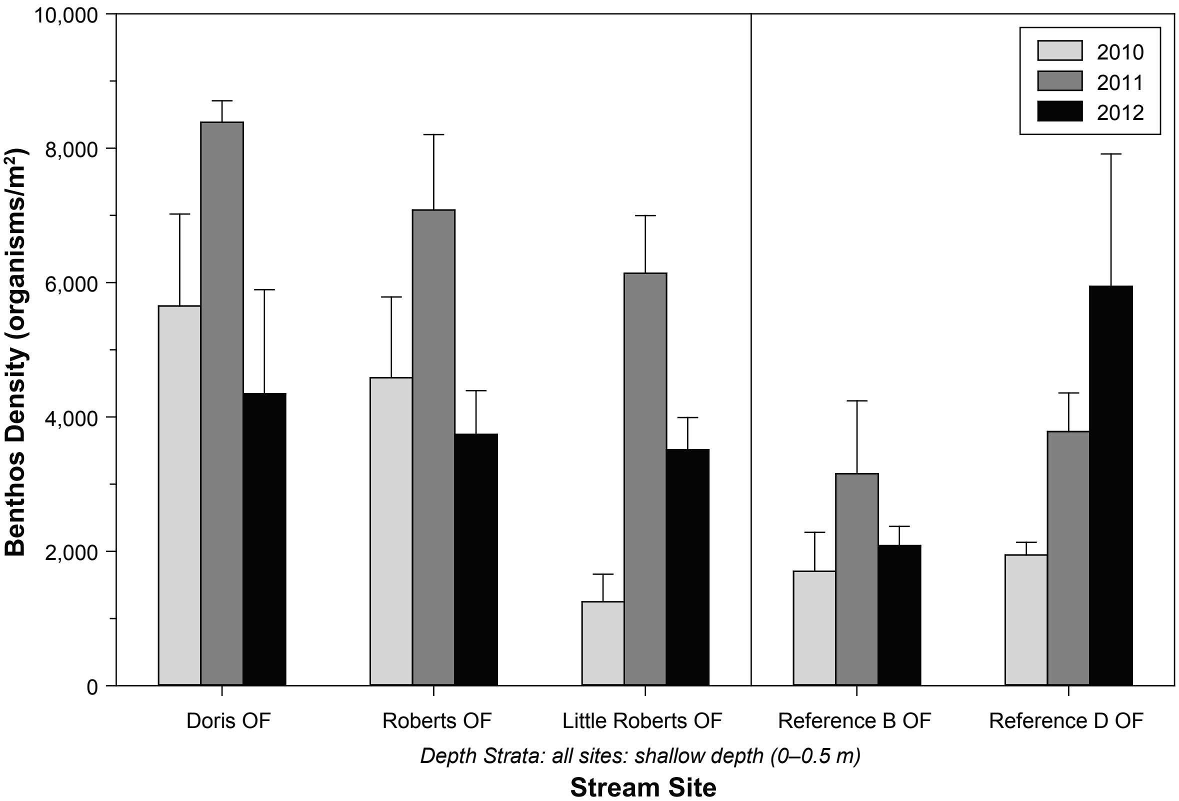
The mean 2012 Simpson's Evenness Index calculated for the benthos community was similar to the indices calculated for the stream sites in 2010 and 2011 (Figure 3.6-2). Accordingly, there was evidence of parallelism in trends between the exposed and reference streams ($p = 0.14$ for Doris Outflow, $p = 0.14$ for Roberts Outflow and $p = 0.55$ for Little Roberts Outflow)

Trends in the Simpson's Diversity Index between 2010, 2011 and 2012 were also similar between exposure and reference streams ((Figure 3.6-2; $p = 0.54$ for Doris Outflow, $p = 0.36$ for Roberts Outflow, and $p = 0.91$ for Little Roberts Outflow).

Therefore, there was no apparent effect of Project activities on the richness, evenness or diversity of the stream benthic invertebrate communities in the Doris North region.

3.6.1.3 Bray-Curtis Index

The Bray-Curtis Index, a measure of the percentage of difference between an exposure site benthos community composition and the median reference benthos community composition, was generally similar between 2010, 2011 and 2012 for each stream surveyed (Figure 3.6-3). At all sites, except for Reference D Outflow, there has been a slight but steady decrease in the Bray-Curtis index from 2010 to 2012, indicating that the benthic communities are more similar to the median reference invertebrate community. However, 2010 to 2012 trends for exposure streams were not significantly different than 2010 to 2012 trends for reference streams ($p = 0.19$ for Doris Outflow, $p = 0.06$ for Roberts Outflow, and $p = 0.15$ for Little Roberts Outflow); therefore, there was no apparent effect of Project activities on the benthos Bray-Curtis Index for exposure streams.



Note: Error bars represent the standard error of the mean.

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Benthos Density in AEMP Stream Sites, Doris North Project, 2010 to 2012

Figure 3.6-1

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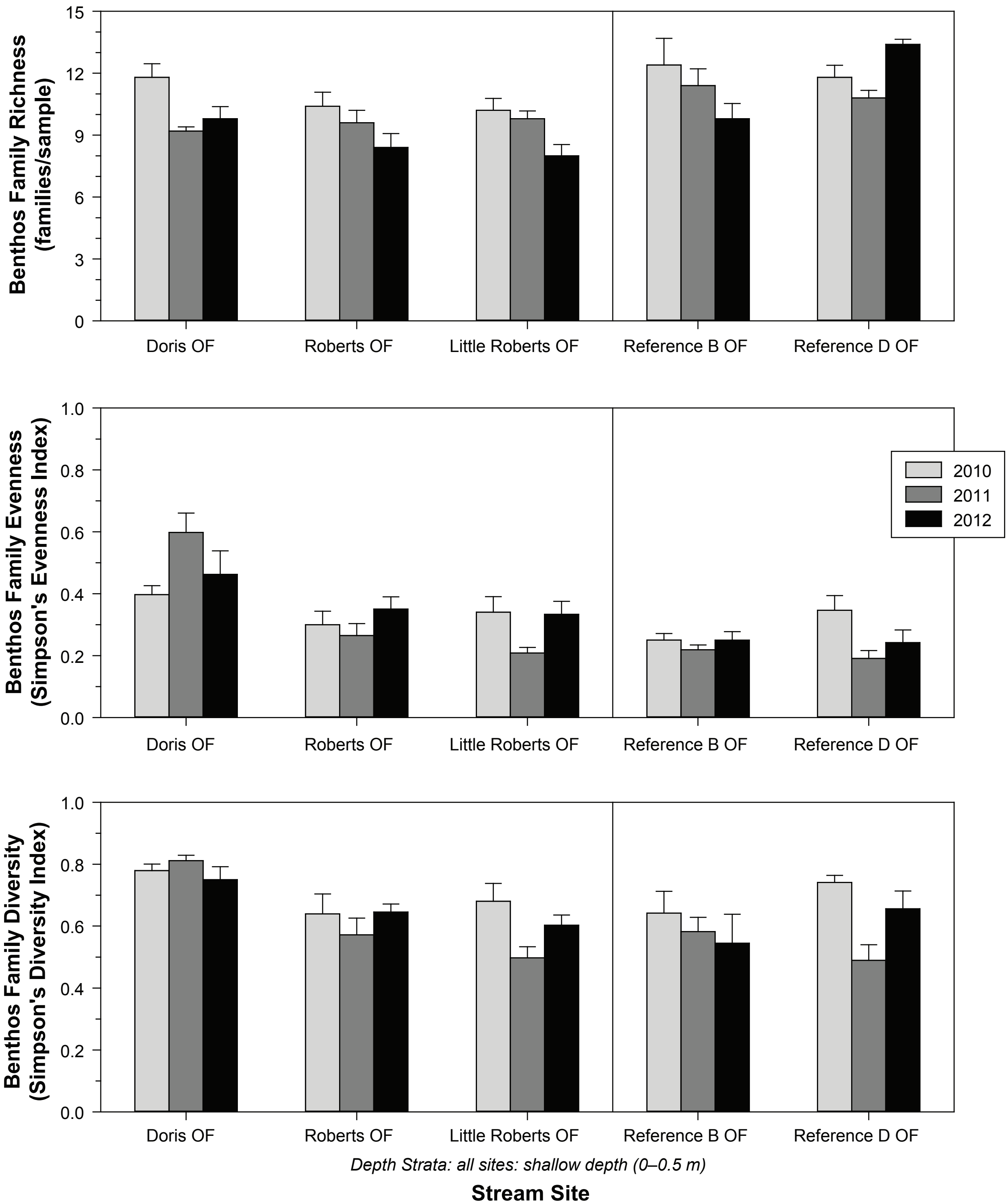

Note: Error bars represent the standard error of the mean.

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Figure 3.6-2

Benthos Richness, Evenness, and Diversity in AEMP Stream Sites, Doris North Project, 2010 to 2012

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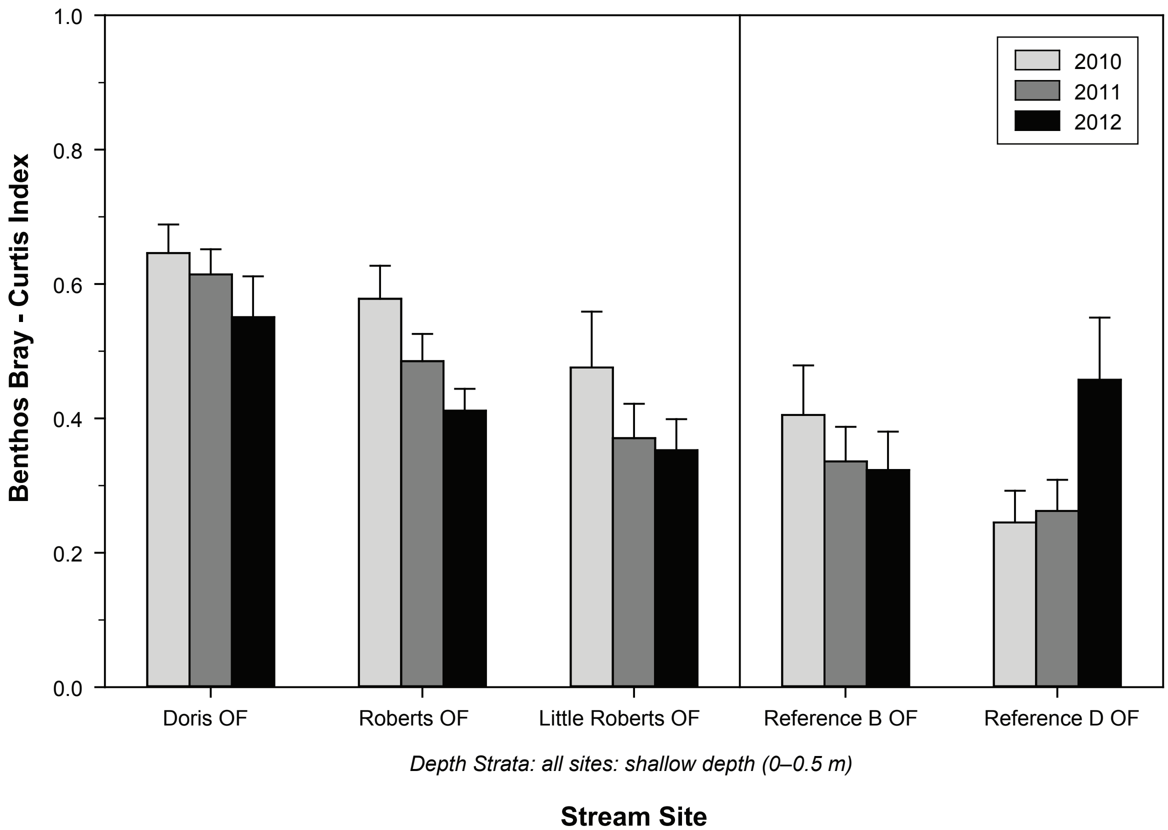

Note: Error bars represent the standard error of the mean.

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Benthos Bray-Curtis Index for AEMP Stream Sites, Doris North Project, 2010 to 2012

Figure 3.6-3

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3.6.2 Lake Benthos

For Doris Lake South, 2010 data were collected from a shallow site, whereas 2011 and 2012 data were collected from a deep site in the southern section of Doris Lake. Therefore, 2010 data were not considered comparable to 2011 and 2012 data and no evaluation of effects was possible for Doris Lake South. 2011 and 2012 benthos data collected from Doris Lake South are included in Figures 3.6-4 to 3.6-6, but no temporal trends were examined for this site. Data from the Roberts Lake site, a new sampling location, are included in Figures 3.6-4 to 3.6-6, but were not used in any parallel trend analyses.

3.6.2.1 Density

In 2010, 2011 and 2012, benthic invertebrate density was higher at the shallow lake sites (Little Roberts Lake and Reference Lake D) than at the deep lake sites (Doris Lake South, Doris Lake North, Roberts Lake and Reference Lake B; Figure 3.6-4).

Benthos density was generally similar between 2010, 2011 and 2012 at each large lake site, and there was evidence of parallelism between 2010 to 2012 trends at the exposure lake (Doris North) compared to the reference lake (Reference B; $p = 0.26$), suggesting that there was no effect of Project activities on benthos density in Doris Lake North.

The 2012 benthos density at both the small, shallow lakes (Little Roberts Lake and Reference D Lake) were substantially higher than densities from 2010 and 2011. However, this trend was parallel in both lakes ($p = 0.47$), indicating this increase is natural variability and not an effect of Project activities.

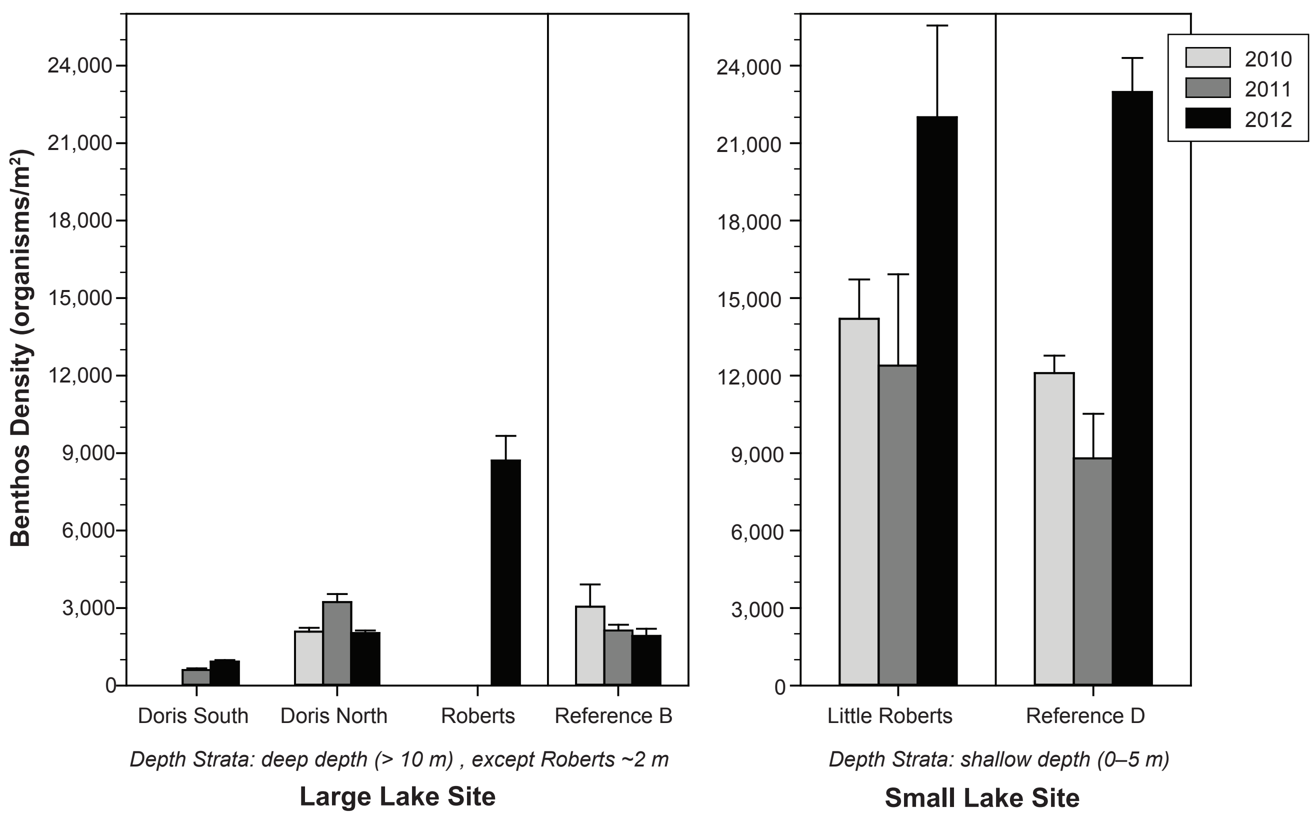
3.6.2.2 Community Richness, Evenness, and Diversity

Benthos family richness tended to be higher at the shallow lakes sites (Little Roberts Lake and Reference Lake D) than at the deep lake sites (Doris Lake South, Doris Lake North, Roberts and Reference Lake B; Figure 3.6-5). However, family richness was generally similar between 2010, 2011 and 2012 at each site, and within each lake type (large lakes verses small lakes).

In fact, the impact level-by-time analysis found that the 2010 to 2012 trends at the exposure sites were not significantly different from the 2010 to 2012 trends at the corresponding reference sites ($p = 0.57$ for Doris Lake North and $p = 0.99$ for Little Roberts Lake). Therefore, there was no evidence of a differential Project-related effect on benthos richness in the exposure lakes.

The mean Simpson's Evenness Index for all exposure and reference lakes was similar between 2010 and 2012, except for Reference Lake D (Figure 3.6-5). The evenness of the benthos community was substantially less in Reference D in 2012 compared to previous years. Despite this, the impact level-by-time analysis found that the 2010 to 2012 trends for all the exposure lakes paralleled the trends observed in the corresponding reference lakes ($p = 0.44$ for Doris Lake North and $p = 0.07$ for Little Roberts Lake); therefore, there was no apparent effect of 2012 activities on benthos evenness in the exposure lakes.

The mean 2012 Simpson's Diversity Indices in the large lakes were similar to those calculated from the previous benthos data, except the 2010 diversity index from Doris Lake North. (Figure 3.6-5). 2012 diversity indices in the small lakes, decreased from 2010 and 2011 values. However, in both lake types, there was evidence of parallelism in the diversity trends between the exposure lakes and their corresponding reference lake ($p = 0.08$ for Doris Lake North and $p = 0.19$ for Little Roberts Lake); therefore, there was no apparent effect of Project activities on the diversity of large or small lake benthos invertebrate communities.



Note: Error bars represent the standard error of the mean.

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Benthos Density in AEMP Lake Sites, Doris North Project, 2010 to 2012

Figure 3.6-4

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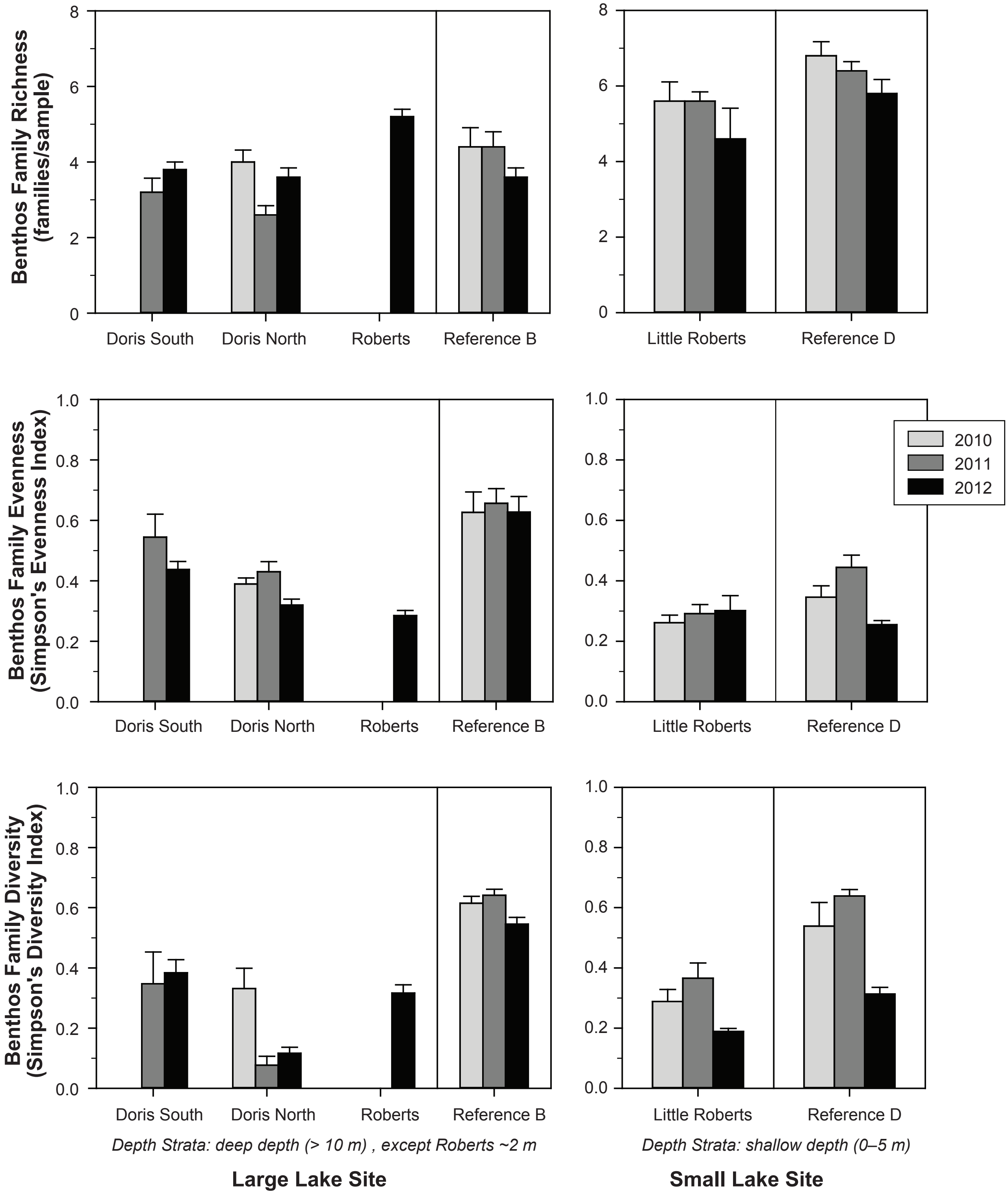

Note: Error bars represent the standard error of the mean.

Figure 3.6-5

Benthos Richness, Evenness, and Diversity in AEMP Lake Sites, Doris North Project, 2010 to 2012

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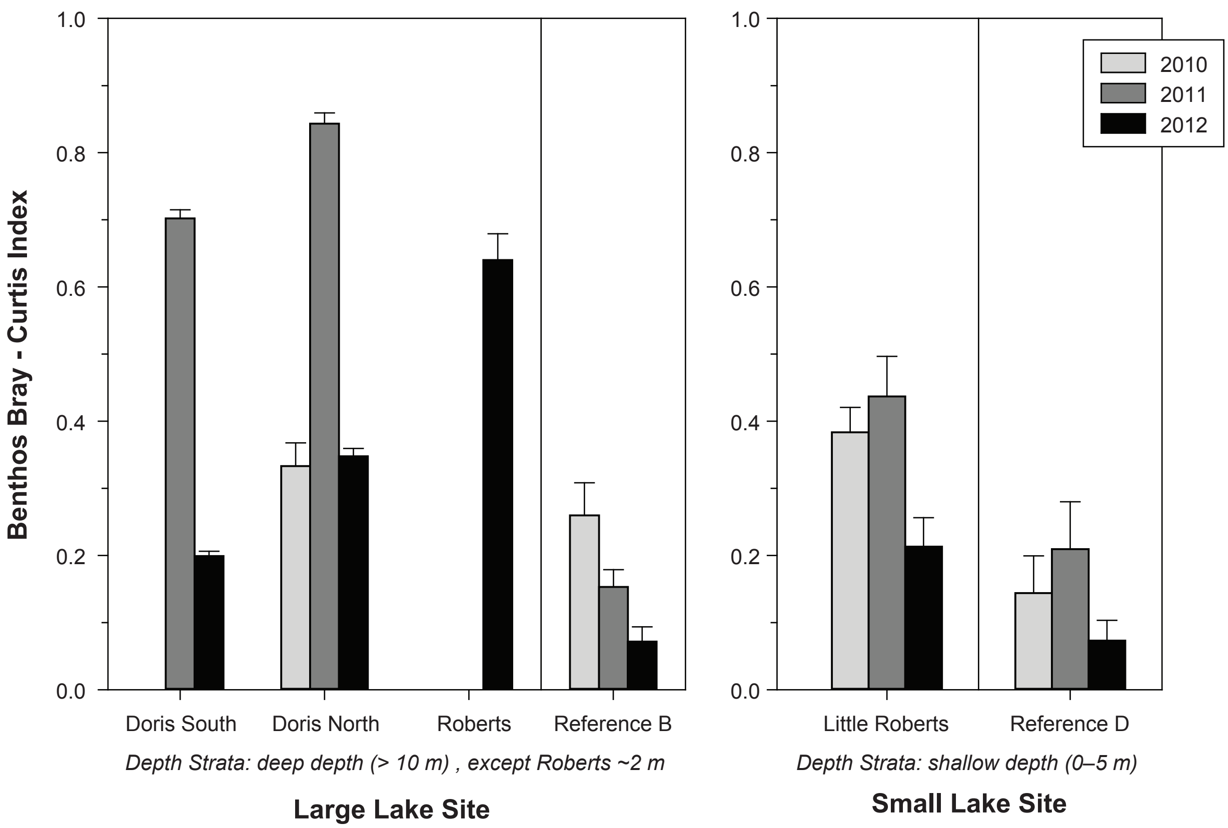

Note: Error bars represent the standard error of the mean.

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Benthos Bray-Curtis Index for AEMP Lake Sites, Doris North Project, 2010 to 2012

Figure 3.6-6

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3.6.2.3 Bray-Curtis Index

In both Little Roberts Lake and Reference Lake D, the mean Bray-Curtis Index decreased slightly from 2010 to 2012 (Figure 3.6-6). These trends were parallel ($p = 0.26$), suggesting the decrease was due to natural annual variability. In Doris Lake North, the mean 2012 Bray-Curtis Index was similar to the 2010 index, but it was more than two-fold lower than the 2011 Bray-Curtis Index (Figure 3.6-6), suggesting that the benthos community sampled in Doris Lake North was more divergent from the median reference community in 2011 than in either 2012 or 2010. A different trend was observed at Reference Lake B, where the Bray-Curtis Index has steady decreased since 2010 (Figure 3.6-6). As a result, there was evidence of non-parallelism in the 2010 to 2012 Bray-Curtis Index trends between Doris Lake North and Reference Lake B ($p = 0.007$). Because only three years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability or patchiness in the benthos community in lakes. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass in Doris Lake North that could have affected the community composition of benthic invertebrates; therefore, it is unlikely that the increase the Bray-Curtis Index in Doris Lake North was related to Project activities.

3.6.3 Marine Benthos

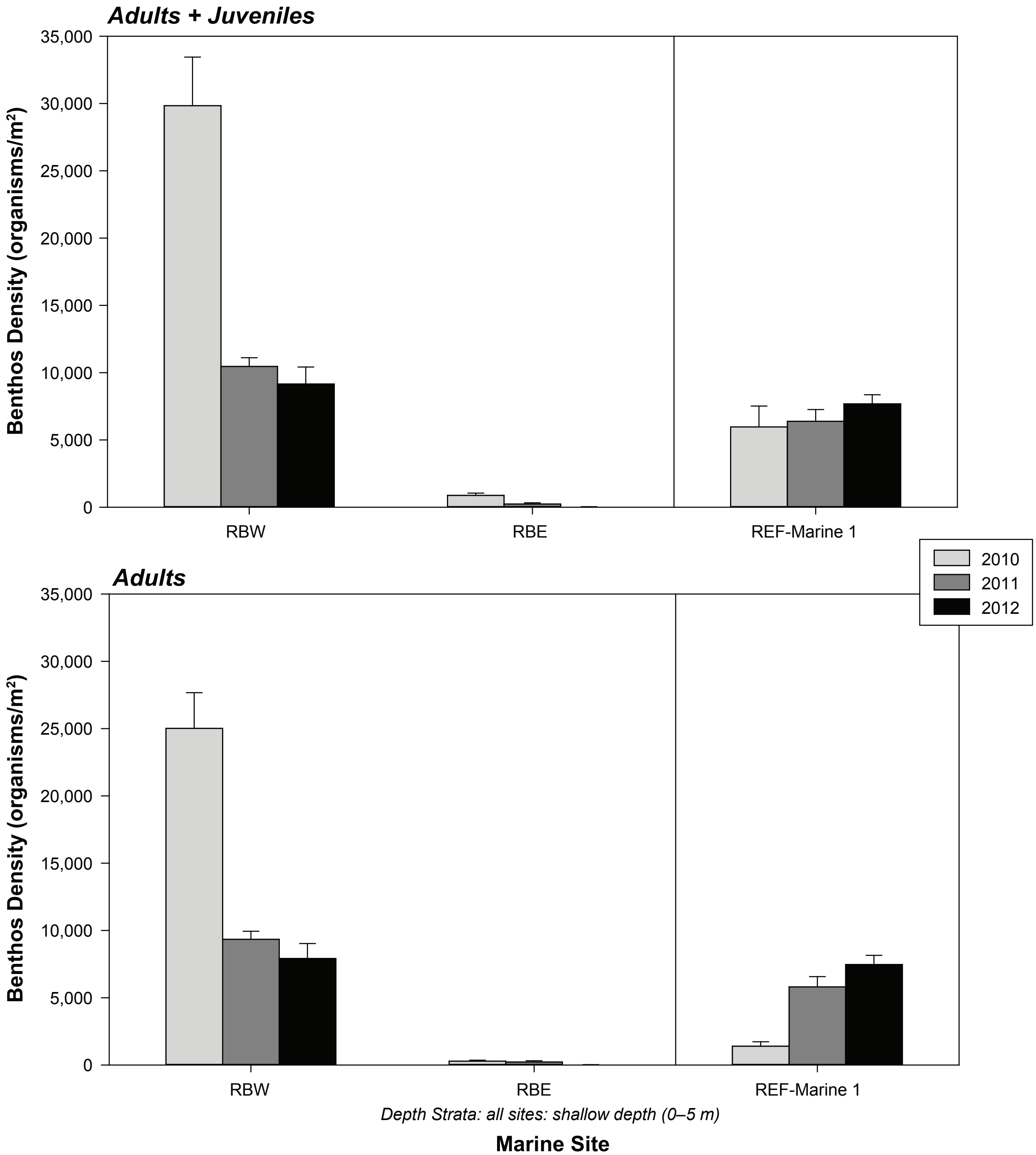
As recommended in the EEM guidance document (Environment Canada 2011), the marine benthos community was analyzed for the whole community (adults and juveniles) as well as for the adult community in isolation because juvenile benthos can respond differently to environmental disturbances than adult benthos.

3.6.3.1 Density

In 2010, 2011 and 2012, whole community as well as adult benthos densities were highest at marine site RBW and lowest at RBE, except the mean 2012 density was slightly higher at REF-Marine 1 than RBW (Figure 3.6-7). In the whole community, there was evidence of non-parallelism in the 2010 to 2012 benthos density trends between RBW and REF-Marine 1 ($p = 0.0001$), but 2010 to 2012 trends between RBE and REF-Marine 1 were parallel ($p = 0.18$). In the adult dataset, there was evidence of non-parallelism in 2010 to 2012 density trends at both RBW and RBE compared to REF-Marine 1 (both $p < 0.0001$). These non-parallel results were largely driven by the large density observed in 2010 at the exposure sites and the corresponding low density at the reference site. As only three years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the benthos density at marine exposure sites. Furthermore, there were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass at RBW or RBE that could have affected benthos density; therefore, it is unlikely that the differences in densities from 2010 to 2012 at the marine exposure sites were related to Project activities.

3.6.3.2 Community Richness, Evenness, and Diversity

In both the whole community and the adult only datasets, family richness increased between 2010 and 2012 at the exposure site RBW and the reference site REF-Marine 1 (Figure 3.6-8a and 3.6-8b). However, the magnitude of the increase was higher at REF-Marine 1 than at RBW. Accordingly, there was evidence of non-parallelism in 2010 to 2012 benthos family richness between REF-Marine 1 and RBW (whole community: $p = 0.0017$ and adults: $p = 0.0004$). In both the whole community and the adult only datasets, family richness decreased between 2010 and 2012 at the exposure site RBE, resulting in non-parallelism between this site and the reference site ($p < 0.00001$ for both the whole community and adult only dataset).



Note: Error bars represent the standard error of the mean.

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Benthos Density in AEMP Marine Sites, Doris North Project, 2010 to 2012

Figure 3.6-7

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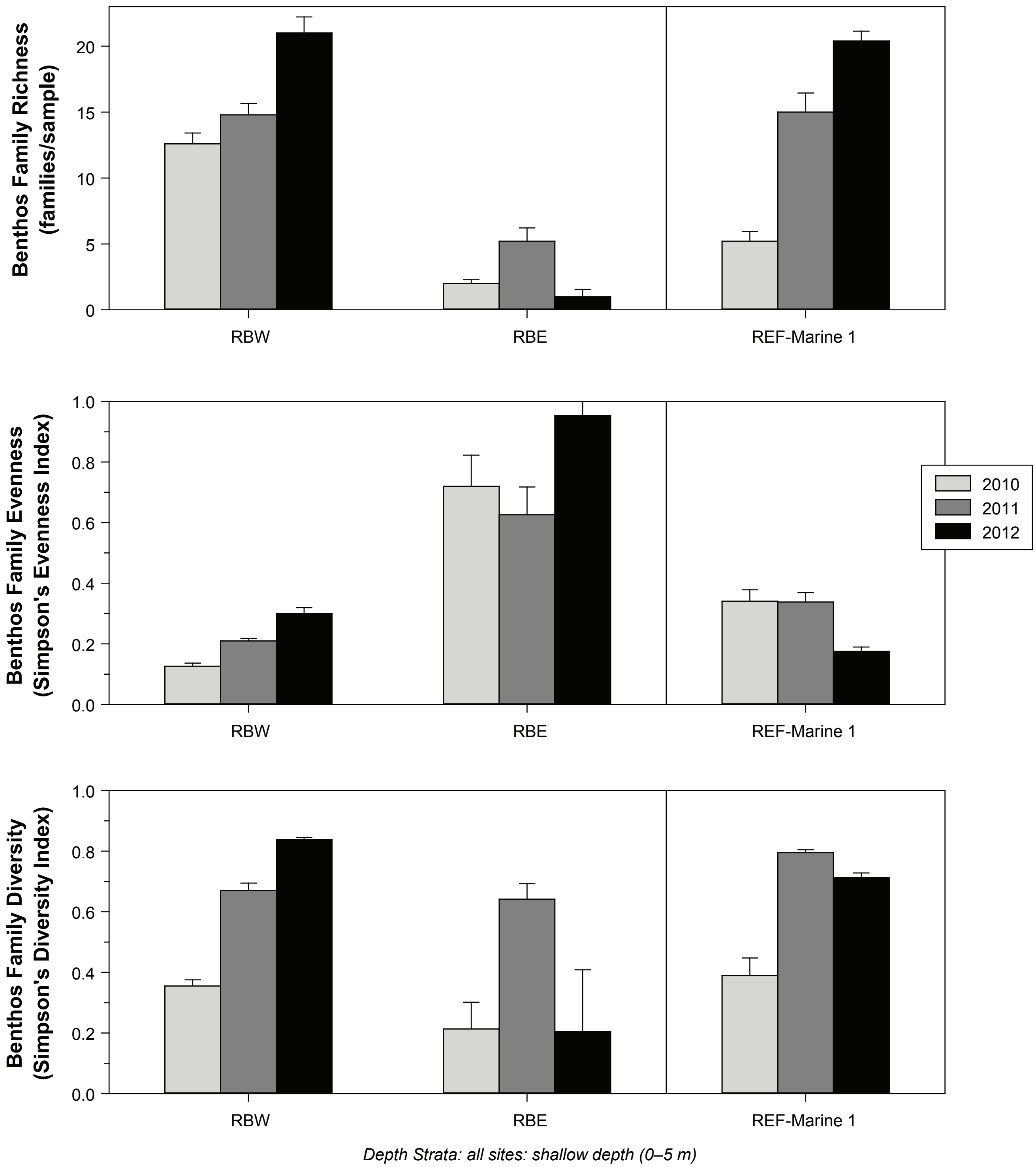

Note: Error bars represent the standard error of the mean.

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Benthos Richness, Evenness, and Diversity for Adults and Juveniles in AEMP Marine Sites, Doris North Project, 2010 to 2012

Figure 3.6-8a

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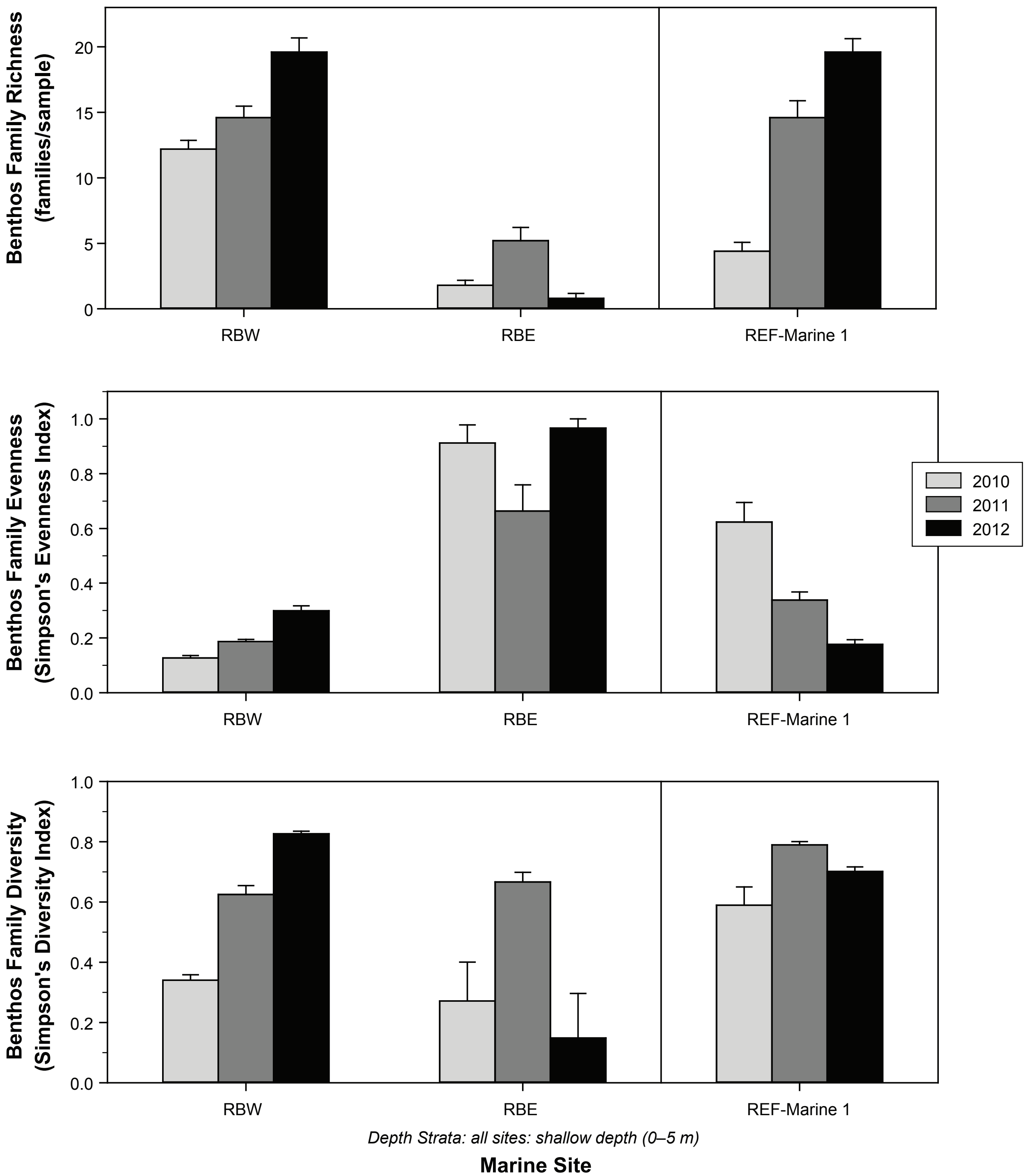

Note: Error bars represent the standard error of the mean.

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Benthos Richness, Evenness, and Diversity for Adults in AEMP Marine Sites, Doris North Project, 2010 to 2012

Figure 3.6-8b

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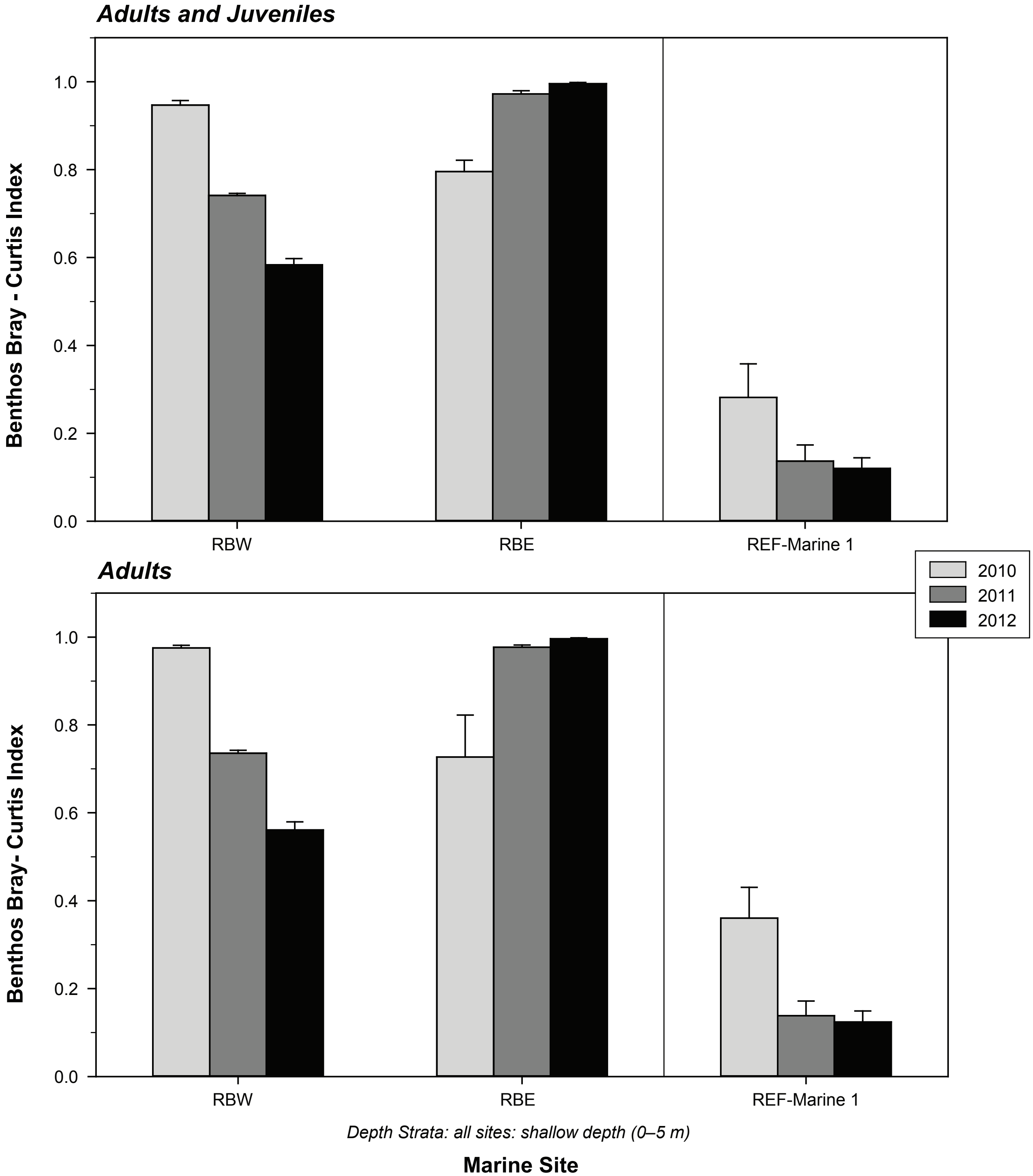
In the whole community dataset, family evenness decreased between 2010 and 2012 at REF-Marine 1 (Figure 3.6-8a), while mean evenness increased between 2010 and 2012 at both RBW and RBE. The impact level-by-time analysis showed that there was evidence of non-parallelism in the 2010 to 2012 evenness trends between the exposure sites and the reference site ($p < 0.00001$ for RBW and $p = 0.0089$ for RBE). The adult-only benthos dataset mirrored the whole community dataset. Family evenness decreased from 2010 to 2012 at REF-Marine 1, while evenness increased from 2010 to 2012 at RBW and RBE (Figure 3.6-8b). Accordingly, there was evidence of non-parallelism in the 2010 to 2012 trends between RBW and REF-Marine 1 ($p < 0.00001$) and between RBE and REF-Marine 1 ($p = 0.0007$).

In both the whole community and the adult only datasets, the 2010 to 2012 Simpson's diversity index at RBE and REF-Marine 1 followed similar trends (Figure 3.6-8a and 3.6-8b). The changes that occurred at the exposure site RBE from 2010 to 2012 paralleled the changes that occurred at REF-Marine 1 (whole community: $p = 0.08$; adults: $p = 0.24$). The Simpson's diversity index increased from 2010 to 2012 at the exposed site RBW (Figure 3.6-8a and 3.6-8b). The increased diversity in the whole benthos community paralleled the changes in the reference community ($p = 0.025$), but was non-parallel in the adult only dataset ($p < 0.00001$). This significant result was likely being driven by the large proportion of juvenile benthos in the REF-Marine 1 2010 dataset. As such, these results should be interpreted carefully.

As only three years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the benthos family richness, evenness and diversity at marine exposure sites. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass at RBW or RBE that could have affected benthos richness, evenness or adult diversity in 2012; therefore, it is unlikely that the changes in richness, evenness and diversity from 2010 to 2012 at the marine exposure sites were related to Project activities.

3.6.3.3 Bray-Curtis Index

In both the whole community and the adult only datasets, the Bray-Curtis Index decreased between 2010 and 2012 at RBW and REF-Marine 1, and increased between 2010 and 2012 at RBE (Figure 3.6-9). The impact level-by-time analysis showed that 2010 to 2012 trends between RBW and REF-Marine 1 were parallel (whole community: $p = 0.03$; adults: $p = 0.03$), while the 2010 to 2012 trends between RBE and REF-Marine 1 were non-parallel (whole community: $p = 0.0006$; adults: $p = 0.0007$). Together, these results (along with the other parameters) suggest that the benthic community at RBW were more similar to those at the reference site, while the communities at RBE continued to be unlike the reference communities, which is likely due to substantial differences in sediment substrate and the influence of freshwater from Little Roberts Outflow. Furthermore, because only three years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the Bray-Curtis Index. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass at RBE that could have affected the community composition of benthic invertebrates; therefore, it is unlikely that the increase the Bray-Curtis Index at RBE was related to Project activities.



Note: Error bars represent the standard error of the mean.

Figure 3.6-9

Benthos Bray - Curtis Index for AEMP Marine Sites, Doris North Project, 2010 to 2012

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4. Summary of Evaluation of Effects

4. Summary of Evaluation of Effects

The evaluation of effects employed graphical and statistical methods to identify potential effects to the aquatic environment that may have resulted from Project activities in 2012. When historical information was available, before (baseline, pre-2010) and after (evaluation year, 2012) data for specific parameters were first compared at each of the exposure sites to determine whether there was a discernible change in evaluated parameters in 2012. 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 to aid in the interpretation of temporal trends. Professional judgment was always employed when statistical or graphical methods indicated potential 2012 construction year effects for specific parameters to determine if the effect was likely naturally occurring or Project related.

4.1 STREAMS

Table 4.1-1 provides a summary of the 2012 evaluation of effects for the AEMP exposure streams. There was sufficient historical information to evaluate potential Project-related effects on water and sediment quality, periphyton biomass, and the benthic invertebrate community. Overall, there were no apparent Project-related effects on any of the evaluated parameters in the AEMP exposure streams.

Mean 2012 water quality parameter concentrations in AEMP exposure streams were generally below CCME guidelines, except total aluminum which was naturally elevated in Roberts Outflow.

There was evidence of an increase in alkalinity, hardness, and concentrations of total molybdenum in Doris Outflow and total arsenic in Roberts Outflow in 2012 compared to baseline concentrations. However in these instances, the BACI analysis showed that parallel increases from baseline means also occurred in the reference streams. Thus, there was no evidence that these increases were due to Project activities in 2012. There was evidence of a slight increase in the 2012 concentrations of radium-226 in Roberts Outflow compared to available baseline concentrations. However, this result must be interpreted carefully because a high proportion of the data were below analytical detection limits. Furthermore, the radium-226 concentrations were within the range observed in the reference stream, therefore the increase in this stream was due to natural variability and did not influence the exposure streams.

Mean nitrate concentrations in Roberts Outflow and Little Roberts Outflow increased in 2012 compared to pre-2010 baseline levels and these changes were non-parallel to the increase observed in Reference B Outflow according to the BACI analysis. The BACI interaction was significant because the increase that occurred in Reference B Outflow was greater than the increase in that occurred in Roberts or Little Roberts Outflows. Furthermore, a large proportion of nitrate data for the exposure streams were below the analytical detection limit (80% of Doris Outflow, 67% of Roberts Outflow and 82% of Little Roberts Outflow) and thus any statistical results are considered unreliable. It is therefore highly unlikely that there was a Project cause for the elevated nitrate concentrations measured in 2012. Nitrate concentrations will continue to be closely monitored in all exposure and reference streams.

Mean 2012 sediment quality parameter concentrations were all below CCME ISQGs and PELs.

At Doris Outflow, there were some differences in the particle size composition of sediment samples collected in 2012 compared to the particle size composition of baseline samples. Variation in sediment particle size composition was unlikely related to 2012 Project activities, and probably reflected natural spatial heterogeneity in stream sediments.

There was no significant difference between the TOC content or metal concentrations in the sediments collected in 2012 compared to the available baseline concentrations. Therefore, there were no apparent adverse effect of 2012 Project activities on the evaluated sediment quality parameters in the Doris North region.

There was no indication of a Project-related effect on periphyton biomass in the exposure streams.

Stream benthos trends in density, family richness, and Simpson's evenness, Simpson's diversity, and Bray-Curtis indices at exposure streams paralleled the trends observed in the reference streams, indicating that there were no effects of 2012 Project activities on these benthos community descriptors.

4.2 LAKES

Table 4.2-1 presents the summary of the 2012 evaluation of effects for the AEMP exposure lakes. There was sufficient historical information to evaluate potential Project-related effects on under-ice dissolved oxygen concentrations, Secchi depth, water and sediment quality, phytoplankton biomass, and the benthic invertebrate community. Overall, there were no apparent Project-related effects on any of the evaluated parameters in the AEMP exposure lakes.

There was no evidence of an effect of 2012 Project activities on either under-ice dissolved oxygen concentrations or Secchi depths in the AEMP exposure lakes.

Mean 2012 water quality parameter concentrations in AEMP exposure lakes were generally below CCME guidelines, except total aluminum and lead in Doris Lake South, total aluminum and copper in Doris Lake North, total copper in Roberts Lake and total aluminum, chromium, copper, iron and lead in Little Roberts Lake. Total aluminum and iron also exceeded CCME guidelines in Reference Lake D.

There was evidence of an increase in 2012 total aluminum and total molybdenum concentrations in Doris Lake North compared to baseline concentrations. However, in these instances, the BACI analysis showed that parallel increases from baseline means also occurred at the reference lake (Reference Lake B). Thus, there was no evidence that these increases were due to Project activities. There was also evidence of a slight increase in mean pH levels and total molybdenum concentrations in Little Roberts Lake in 2012 compared to baseline concentrations. No BACI was possible because of a lack of reference data. However, the temporal patterns of pH and total molybdenum in Little Roberts Lake mirrored those in Doris Lake North where statistical analyses proved that the observed changes were unrelated to Project activities. Therefore, it was concluded that there was no apparent effect of 2012 Project activities on either pH levels or total molybdenum concentrations in Little Roberts Lake.

Mean 2012 sediment quality parameter concentrations were generally below CCME ISQGs, except total arsenic, chromium and copper, which were higher than ISQGs at several lake sites. The mean total arsenic concentration at Doris Lake South was also higher than the PEL guideline.

At Doris Lake South, Doris Lake North and Little Roberts Lake, there were some differences in the particle size composition in the sediment samples collected in 2012 compared to the particle size composition of baseline samples. Variation in sediment particle size composition was unlikely related to 2012 Project activities, and probably reflected natural spatial heterogeneity in lake sediments.

Total arsenic concentrations in the sediments from Little Roberts Lake increased in 2012 compared to baseline concentrations. No BACI was possible due a lack to reference data. However, there was a generally increasing trend in the concentration of total arsenic in the sediments collected from Reference Lake D. Therefore, there was no evidence that 2012 Project activities increased total arsenic concentrations.

Table 4.1-1. Summary of Evaluation of Effects for the AEMP Streams, Doris North Project, 2012

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]					Before-After Trend Relative to Reference Sites (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
<u>Water Quality</u>												
pH	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Alkalinity, Total	GA, BA, BACI	**Increase**	No difference	No difference	No difference	-	Parallel	☐	☐	No effect	No effect	No effect
Hardness	GA, BA, BACI	**Increase**	No difference	No difference	No difference	-	Parallel	☐	☐	No effect	No effect	No effect
Total Suspended Solids	GA, BA	No difference	No difference	No difference	**Decrease**	-	☐	☐	☐	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, BACI	**Decrease**	**Increase**	**Increase**	**Increase**	-	☐	**Non-parallel**	**Non-parallel**	No effect	No effect[d]	No effect[d]
Cyanide, Total	GA, BA	No difference	No difference	No difference	-		-	-	-	No effect	No effect	No effect
Radium-226	GA, BA	No difference	**Increase**	No difference	-	-	-	-	-	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	**Increase**	No difference	**Increase**	-	☐	Parallel	☐	No effect	No effect	No effect
Cadmium, Total	GA, BA	No difference	No difference	No difference	**Increase**	-	☐	☐	☐	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 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, BA	No difference	No difference	No difference	**Decrease**	-	☐	☐	☐	No effect	No effect	No effect
Molybdenum, Total	GA, BA, BACI	**Increase**	No difference	No difference	No difference	-	Parallel	☐	☐	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 difference	-	☐	☐	☐	No effect	No effect	No effect
<u>Sediment Quality</u>												
% Gravel (>2 mm)	GA, BA	**Decrease**	-	No difference	No difference		☐	-	☐	No effect	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA, BACI	**Increase**	-	No difference	No difference		**Non-parallel**	-	☐	No effect[d]	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 difference	-	No difference	No difference	-	☐	-	☐	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 difference	-	☐	-	☐	No effect	No effect	No effect
Zinc	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
<u>Periphyton</u>												
Biomass	GA, BA	No difference	-	No difference	-	-	☐	-	☐	No effect	No effect	No effect
							2010 to 2012 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]					
<u>Benthic Invertebrates</u>												
Total Density	GA, ILBT	-	-	-	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect
Family Richness	GA, ILBT	-	-	-	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect
Simpson's Evenness Index	GA, ILBT	-	-	-	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect
Simpson's Diversity Index	GA, ILBT	-	-	-	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect
Bray-Curtis Index	GA, ILBT	-	-	-	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis; ILBT - Impact Level-by-Time 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, periphyton biomass, and benthos community descriptors, 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 a significant difference, this change cannot be attributed to Project activities.*

For both the BACI and the ILBT analyses, a differential increase or decrease in exposure site parameters over time relative to the reference sites (i.e., a non-parallel effect) may indicate a Project-related effect.

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 baseline and 2012 means.

Table 4.2-1. Summary of Evaluation of Effects for the AEMP Lakes, Doris North Project, 2012

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]					Before-After Trend Relative to Reference Site (BACI analysis)[a]			Conclusion of Effect[b, c]		
		Doris South	Doris North	Reference B	Little Roberts	Reference D	Doris South	Doris North	Little Roberts	Doris South	Doris North	Little Roberts
Physical Limnology												
Winter Dissolved Oxygen	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Secchi Depth	GA, BA	No difference	No difference	-	-	-	□	□	-	No effect	No effect	No effect
Water Quality												
pH	GA, BA	No difference	No difference	No difference	**Increase**	-	□	□	-	No effect	No effect	No effect
Alkalinity, Total	GA, BA	No difference	No difference	**Increase**	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 difference	-	□	□	-	No effect	No effect	No effect
Ammonia (as N)	GA, BA	No difference	No difference	**Decrease**	No difference	-	□	□	-	No effect	No effect	No effect
Nitrate (as N)	GA, BA	No difference	No difference	**Increase**	No difference	-	□	□	-	No effect	No effect	No effect
Cyanide, Total	GA, BA, BACI	**Decrease**	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Radium-226	GA,BA	-	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Aluminum, Total	GA, BA, BACI	No difference	**Increase**	No difference	No difference	-	□	Parallel	-	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	**Decrease**	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	No difference	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, BACI	**Decrease**	No difference	**Decrease**	No difference	-	Parallel	□	-	No effect	No effect	No effect
Molybdenum, Total	GA, BA, BACI	No difference	**Increase**	**Increase**	**Increase**	-	□	Parallel	-	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	**Increase**	No difference	-	□	□	-	No effect	No effect	No effect
Sediment Quality												
% Gravel (>2 mm)	GA	**Decrease**	No difference	-	**Decrease**	-	□	□	-	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	**Increase**	-	No difference	-	□	□	-	No effect	No effect[d]	No effect
% Clay (<4 µm)	GA, BA	No difference	**Decrease**	-	**Decrease**	-	□	□	-	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	-	**Increase**	-	□	□	-	No effect	No effect	No effect[d]
Cadmium	GA, BA	No difference	No difference	-	No difference	-	□	□	-	No effect	No effect	No effect
Chromium	GA, BA	No difference	No difference	-	No difference	-	□	□	-	No effect	No effect	No effect
Copper	GA, BA	**Decrease**	**Decrease**	-	No difference	-	□	□	-	No effect	No effect	No effect
Lead	GA, BA	No difference	**Decrease**	-	**Decrease**	-	□	□	-	No effect	No effect	No effect
Mercury	GA, BA	No difference	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
Phytoplankton												
Biomass	GA, BA	No difference	No difference	-	No difference	-	□	□	-	No effect	No effect	No effect
							2010 to 2012 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]					
Benthic Invertebrates												
Total Density	GA, ILBT	-	-	-	-	-	-	Parallel	Parallel	No effect	No effect	No effect
Family Richness	GA, ILBT	-	-	-	-	-	-	Parallel	Parallel	No effect	No effect	No effect
Simpson's Evenness Index	GA, ILBT	-	-	-	-	-	-	Parallel	Parallel	No effect	No effect	No effect
Simpson's Diversity Index	GA, ILBT	-	-	-	-	-	-	Parallel	Parallel	No effect	No effect	No effect
Bray-Curtis Index	GA, ILBT	-	-	-	-	-	-	**Non-parallel**	Parallel	No effect[d]	No effect	No effect

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis; ILBT - Impact Level-by-Time 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, phytoplankton biomass, and benthos community descriptors, a change in any direction is considered to be an effect.*
For Secchi depth and 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 a significant difference, this change cannot be attributed to Project activities.*

For both the BACI and the ILBT analyses, a differential increase or decrease in exposure site parameters over time relative to the reference sites (i.e., a non-parallel effect) may indicate a Project-related effect.

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 baseline and 2012 means.

Total copper in Doris Lake South sediments, total copper and lead concentrations in sediments from Doris Lake North, and total lead concentrations in Little Roberts Lake sediments decreased in 2012 compared to baseline levels, but decreases in concentrations of these metals are not of environmental concern. Therefore, there were no apparent adverse effects of 2012 Project activities on the evaluated sediment quality parameters.

There was no indication of a Project-related effect on phytoplankton biomass in the exposure lakes.

There was evidence of non-parallelism in the 2010 to 2012 benthos Bray-Curtis Index trends between Doris Lake North and Reference Lake B. This difference in trends was unlikely Project-related and probably reflected natural annual variability or patchiness in the composition of the benthos community within lakes. 2010 to 2012 trends in total density, family richness, and Simpson's evenness and Simpson's diversity indices at exposure lakes paralleled the trends observed for the reference lakes, indicating that there were no effects of 2012 Project activities on these benthos community descriptors.

4.3 MARINE

Table 4.3-1 presents the summary of the 2012 evaluation of effects for the AEMP marine exposure sites. There was sufficient historical information to evaluate potential Project-related effects on under-ice dissolved oxygen concentrations, water and sediment quality, phytoplankton biomass, and the benthic invertebrate community. Overall, there were no apparent Project-related effects on any of the evaluated parameters in the marine exposure sites.

All dissolved oxygen concentrations and water quality parameters measured at the marine exposure sites during 2012 remained similar to baseline conditions, indicating that 2012 Project activities had no effects on the water chemistry in the surrounding marine habitat. The dissolved oxygen concentrations in Roberts Bay were above the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L), and all water quality parameters were below applicable CCME guidelines for the protection of aquatic life.

At site RBW near the jetty and the reference site REF-Marine 1, there were some differences in the particle size composition of the sediment samples collected in 2012 compared to the particle size composition of samples collected in 2002 or 2009, including a higher proportion of the fine sediment silt. Variation in sediment particle size composition was unlikely related to 2012 Project activities, and probably reflected natural spatial heterogeneity in marine sediments. Several metals increased in RBW sediments between 2002 and 2012. However, the increase in metal concentrations was related to the significant increase in fine sediments in the samples which has a higher affinity for metals. Increases in metal concentrations were also observed in the sediments from the reference site. This suggests that the increase in metal concentrations that occurred in sediments from RBW in 2012 was unrelated to 2012 Project activities. All measured sediment quality parameters in marine exposure sites were below CCME ISQGs and PELs, except total copper concentrations at RBW which were above the ISQG but well below the PEL. Copper concentrations will continue to be closely monitored at RBW.

There was no indication of a Project-related effect on phytoplankton biomass at the marine exposure sites.

In the whole benthos community (adults and juveniles), there was evidence of non-parallelism in the 2010 to 2012 benthos total density, family richness and Simpson's evenness index between RBW and REF-Marine 1. There was also evidence of non-parallelism in the 2010 to 2012 family richness, Simpson's evenness and Bray-Curtis indices between RBE and REF-Marine 1. In the adult benthos community, there was non-parallelism in the 2010 to 2012 total density, family richness, and Simpson's evenness and Simpson's diversity indices between RBW and REF-Marine 1 and the total density, family richness, and Simpson's evenness and Bray-Curtis indices trends between RBE and REF-Marine 1. These differences in trends were unlikely Project-related, and probably reflected natural annual variability or patchiness in the composition of the benthos community within marine sites.

Table 4.3-1. Summary of Evaluation of Effects for the AEMP Marine Sites, Doris North Project, 2012

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]			Before-After Trend Relative to Reference Site (BACI analysis)[a]		Conclusion of Effect[b, c]	
		Roberts Bay West (RBW)	Roberts Bay East (RBE)	Ida Bay (REF-Marine 1)	Roberts Bay West (RBW)	Roberts Bay East (RBE)	Roberts Bay West (RBW)	Roberts Bay East (RBE)
Physical Oceanography								
Winter Dissolved Oxygen	GA	-	-	-	-	-	No effect	No effect
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, BACI	**Decrease**	No difference	No difference	□	□	No effect	No effect
Ammonia (as N)	GA, BA	No difference	No difference	No difference	-	□	No effect	No effect
Nitrate (as N)	GA, BA	No difference	No difference	No difference	-	□	No effect	No effect
Cyanide, Total	GA, BA	-	No difference	-	-	-	No effect	No effect
Radium-226	GA, BA	-	No difference	-	-	-	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	No difference	No difference	No difference	□	□	No effect	No effect
Mercury, Total	GA, BA, BACI	**Decrease**	No difference	**Decrease**	□	□	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 difference	□	□	No effect	No effect
Sediment Quality								
% Gravel (>2 mm)	GA, BA	No difference	-	No difference	-	-	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA	**Decrease**	-	**Decrease**	-	-	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	**Increase**	-	**Increase**	-	-	No effect[d]	No effect
% Clay (<4 µm)	GA, BA	No difference	-	**Increase**	-	-	No effect	No effect
Total Organic Carbon	GA, BA	**Increase**	-	**Increase**	-	-	No effect[d]	No effect
Arsenic	GA, BA	**Increase**	-	**Increase**	-	-	No effect[d]	No effect
Cadmium	GA, BA	**Decrease**	-	**Decrease**	-	-	No effect	No effect
Chromium	GA, BA	**Increase**	-	**Increase**	-	-	No effect[d]	No effect
Copper	GA, BA	**Increase**	-	**Increase**	-	-	No effect[d]	No effect
Lead	GA, BA	**Increase**	-	**Increase**	-	-	No effect[d]	No effect
Mercury	GA, BA	No difference	-	**Increase**	-	-	No effect	No effect
Zinc	GA, BA	**Increase**	-	**Increase**	-	-	No effect[d]	No effect
Phytoplankton								
Biomass	GA, BACI	-	-	-	Parallel	Parallel	No effect	No effect
					2010 to 2012 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]			
Benthic Invertebrates (Adults + Juveniles)								
Total Density	GA, ILBT	-	-	-	**Non-parallel**	Parallel	No effect[d]	No effect
Family Richness	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect
Simpson's Evenness Index	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
Simpson's Diversity Index	GA, ILBT	-	-	-	Parallel	Parallel	No effect	No effect
Bray-Curtis Index	GA, ILBT	-	-	-	Parallel	**Non-parallel**	No effect	No effect[d]
Benthic Invertebrates (Adults)								
Total Density	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
Family Richness	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
Simpson's Evenness Index	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
Simpson's Diversity Index	GA, ILBT	-	-	-	**Non-parallel**	Parallel	No effect[d]	No effect
Bray-Curtis Index	GA, ILBT	-	-	-	Parallel	**Non-parallel**	No effect	No effect[d]

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis; ILBT - Impact Level-by-Time 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, phytoplankton biomass, and benthos community descriptors, 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 a significant difference, this change cannot be attributed to Project activities.*

For both the BACI and the ILBT analyses, a differential increase or decrease in exposure site parameters over time relative to the reference sites (i.e., a non-parallel effect) may indicate a Project-related effect.

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 baseline and 2012 means.

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Appendix A
2012 Data Report

Appendix A. 2012 Data Report

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Appendix A. Appendix A. 2012 Data Report

A.1 OVERVIEW OF REPORT

This report presents the raw data as well as graphs and tables of the results of the 2012 Aquatic Effects Monitoring Program (AEMP) for the Doris North Gold Mine Project. The 2012 AEMP included: physical profiles of temperature, dissolved oxygen, and salinity (marine sites only); Secchi depth; water quality; sediment quality; primary producer biomass; and benthic invertebrate taxonomy and density. All details of the sampling methodology and data analysis are provided in the main body of the 2012 AEMP report. Figure A.1-1 shows an overview map of all the sampling sites included in the 2012 program and Figures A.1-2 to A.1-8 show detailed maps of each AEMP lake and marine sampling site, and includes sampling details and bathymetric contours (if available).

Because there has been historical mining activity (an abandoned silver mine)and current non-HBML exploration activity (North Arrow Minerals Inc.) occurring in the Roberts watershed and lake area, an additional site in Roberts Lake was added in 2011 (Figure A.1-3). The sampling site in Roberts Lake was in the northwestern end of Roberts Lake adjacent to the North Arrow Minerals Inc. exploration camp (Figure A.1-1). The purpose of adding this Roberts Lake site was to help identify any potential confounding influence of activities unrelated to the Doris North Gold Mine Project. The Roberts Lake site was not part of the approved AEMP program, but was added to the 2011 and 2012 sampling design to track potential environmental concerns.

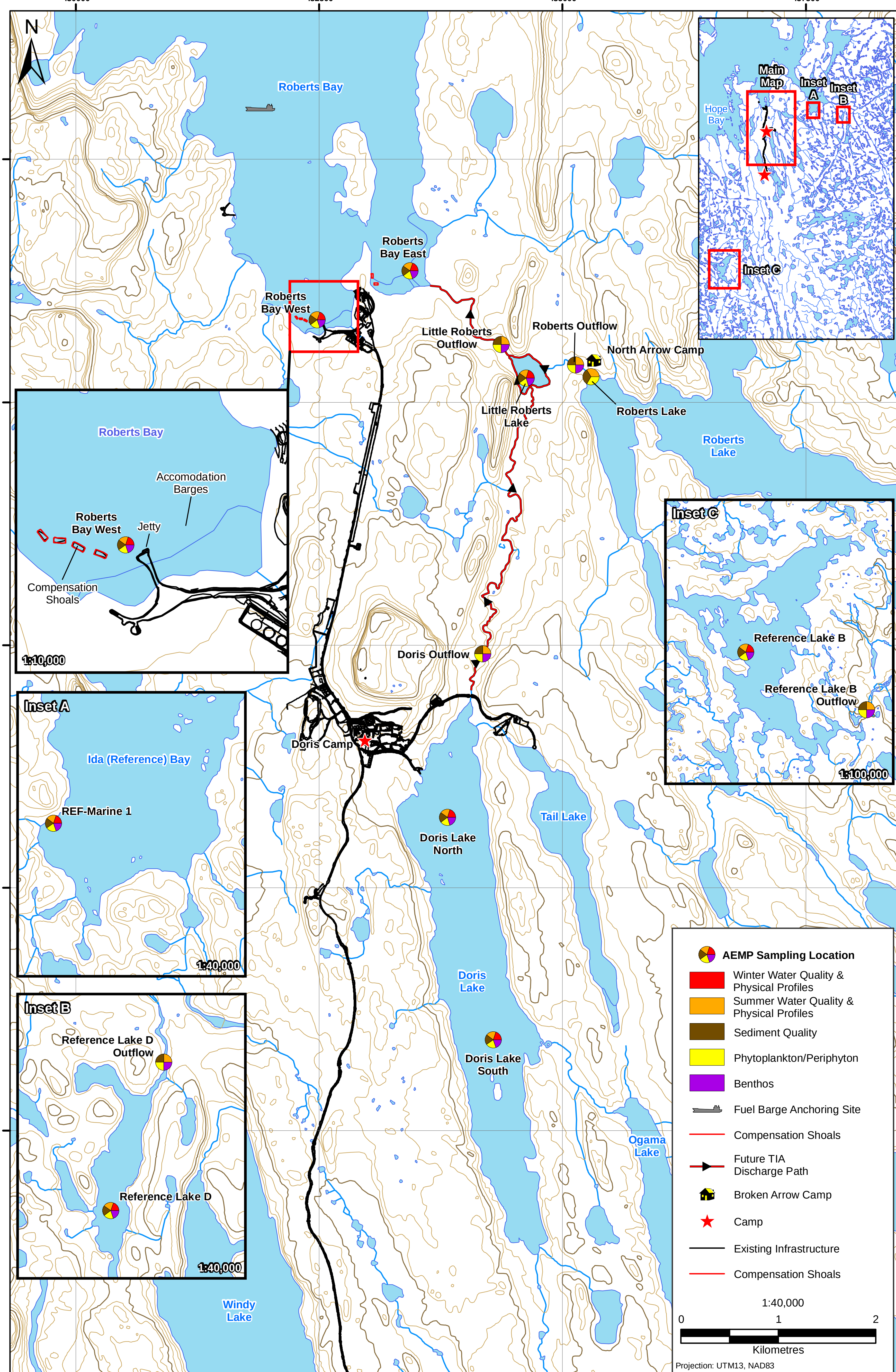

Figure A.1-1

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Sampling Locations, Doris North Project, 2012

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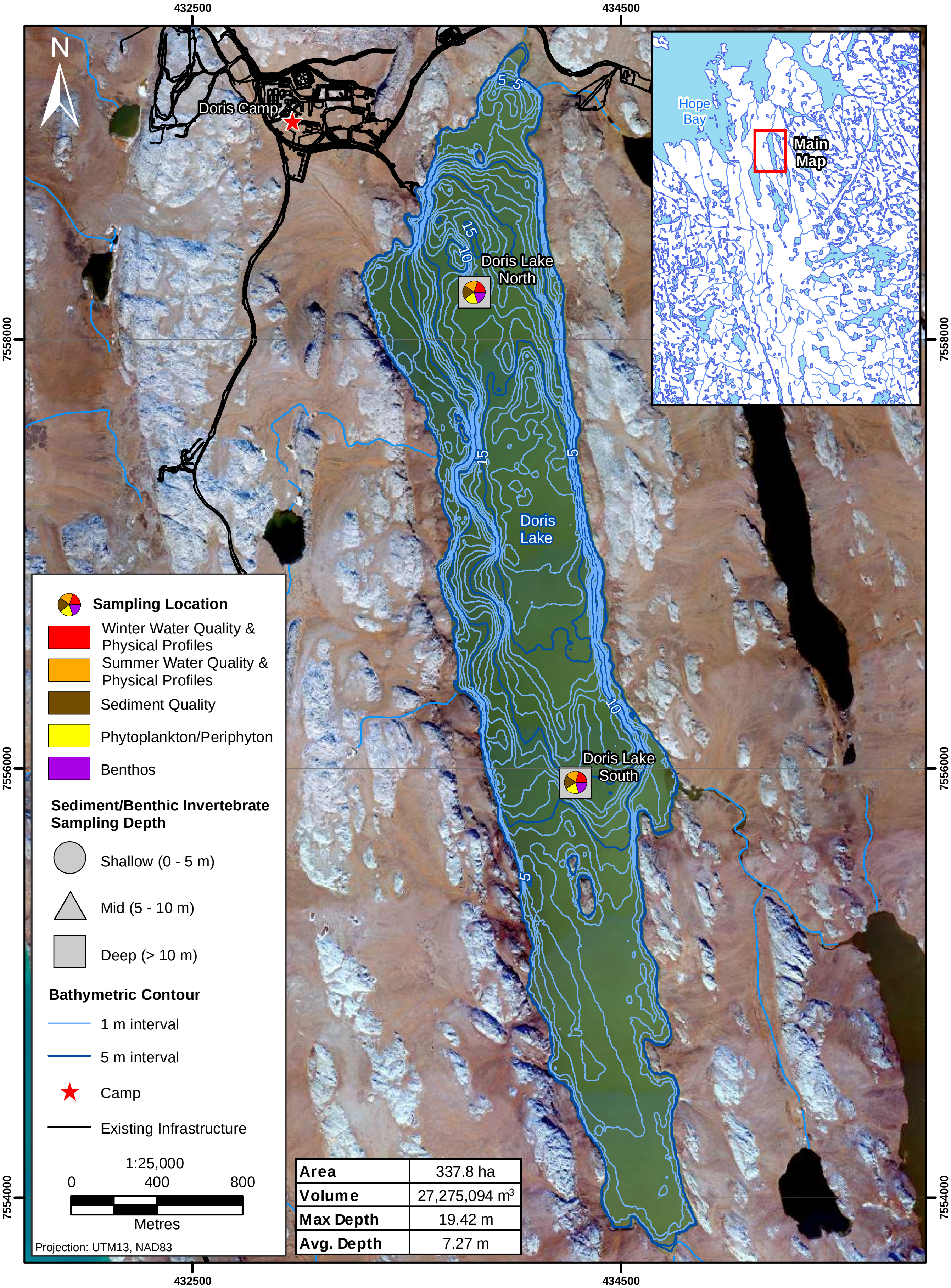
Figure A.1-1



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

Figure A.1-2

Sampling Locations in Doris Lake, Doris North Project, 2012

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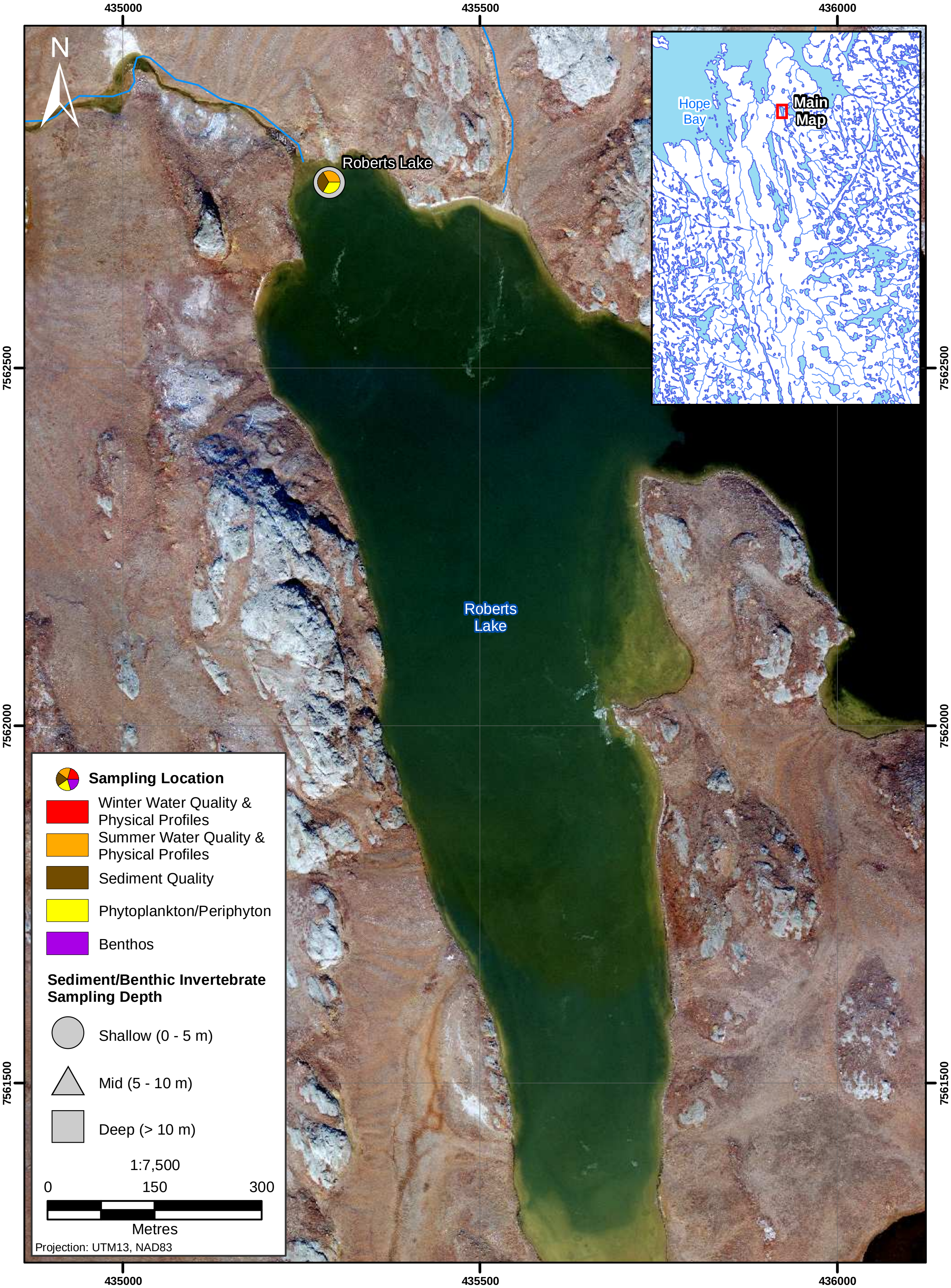

Figure A.1-3

Sampling Location in Roberts Lake, Doris North Project, 2012

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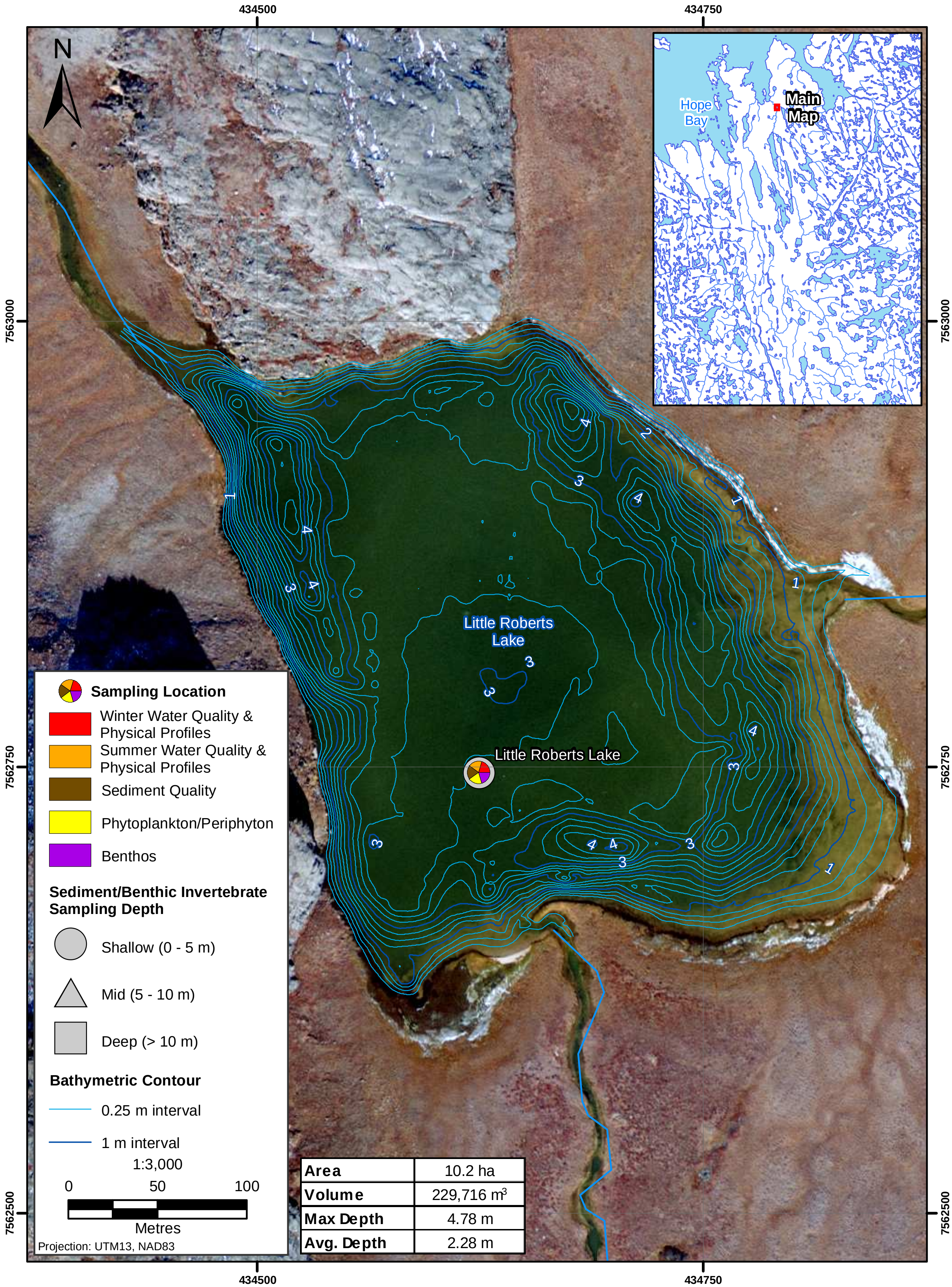

Area	10.2 ha
Volume	229,716 m^3
Max Depth	4.78 m
Avg. Depth	2.28 m

Figure A.1-4

Sampling Location in Little Roberts Lake, Doris North Project, 2012

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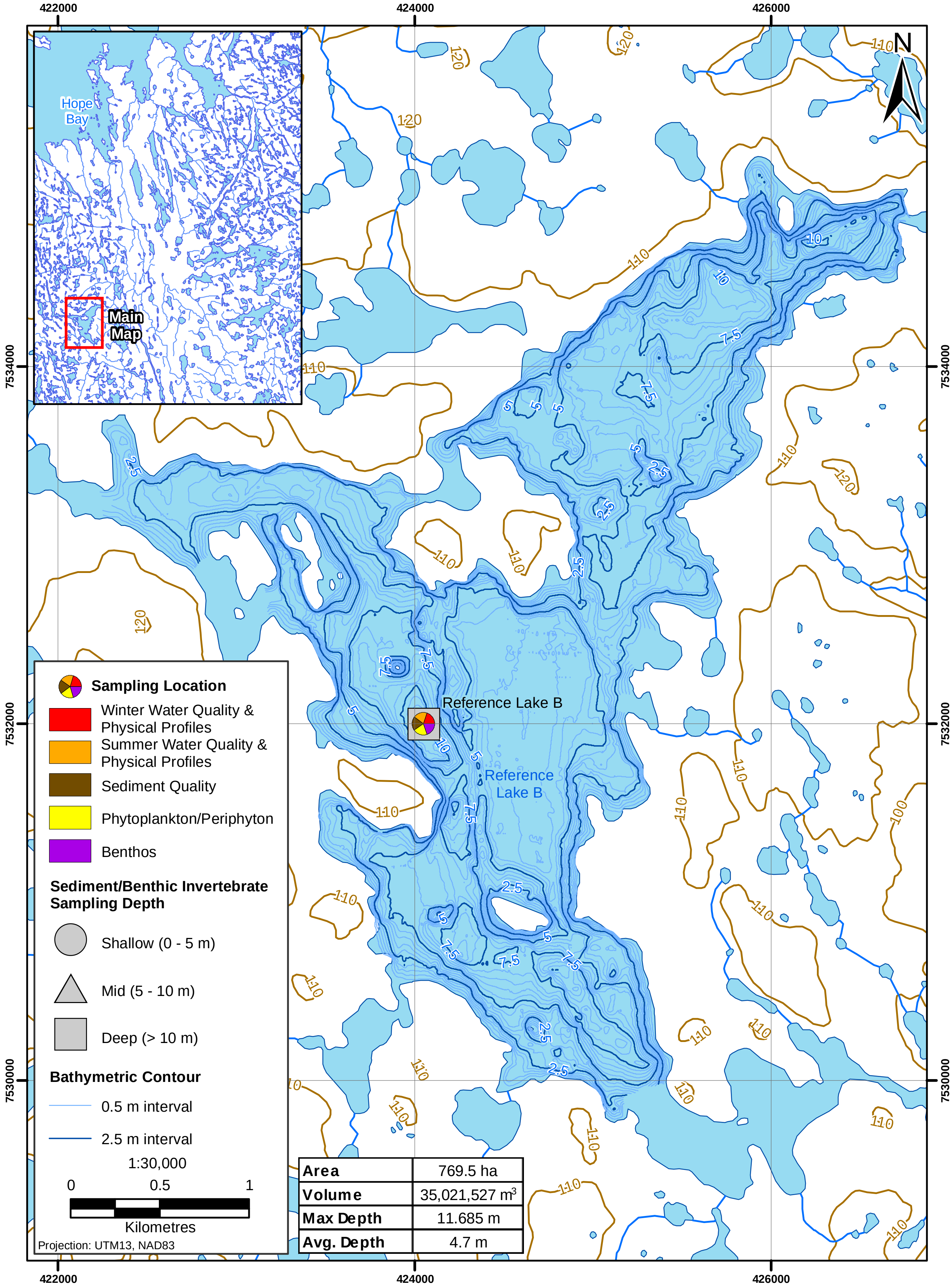
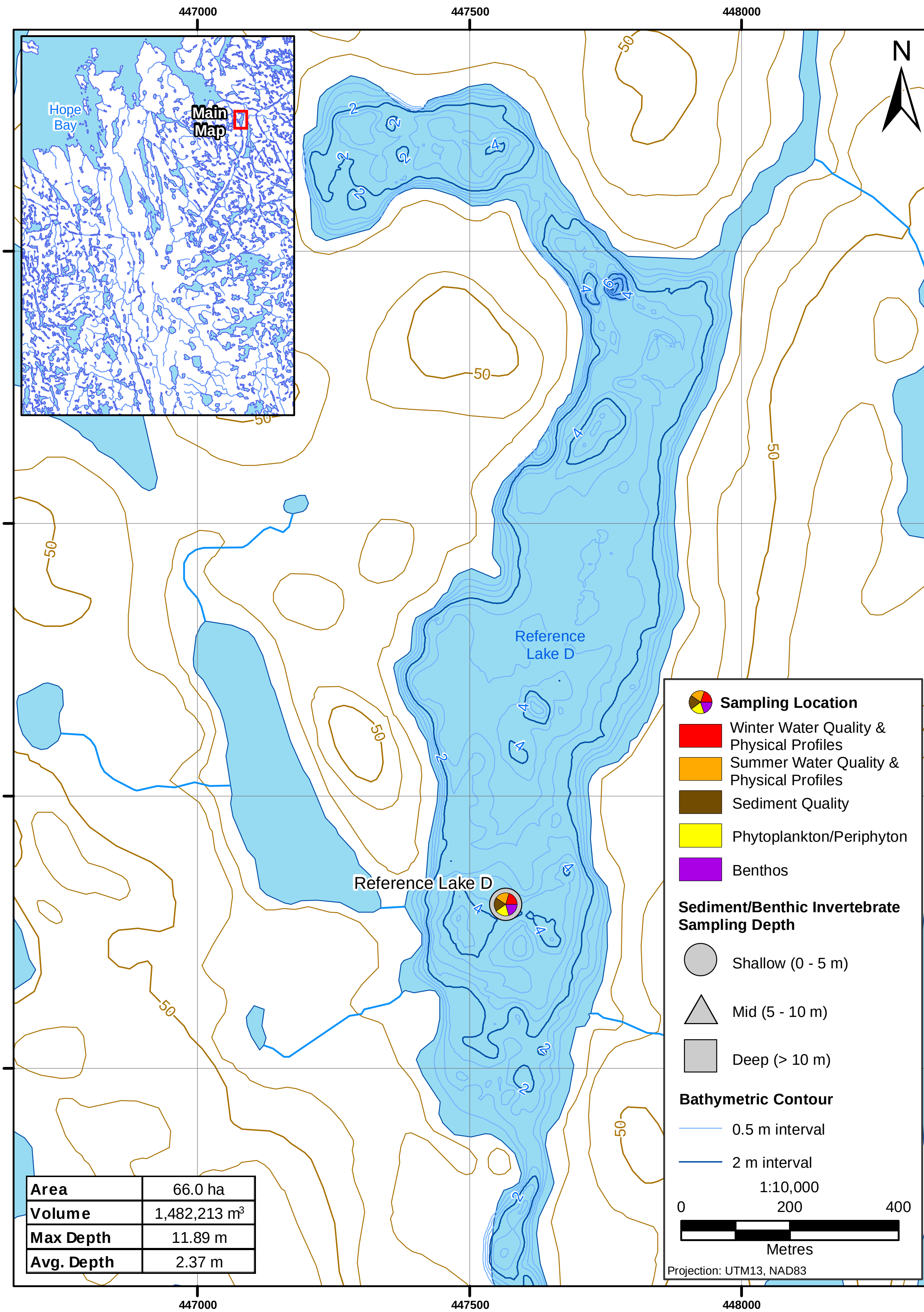


Area	769.5 ha
Volume	35,021,527 m^3
Max Depth	11.685 m
Avg. Depth	4.7 m

Figure A.1-5

Sampling Location in Reference Lake B, Doris North Project, 2012



Area	66.0 ha
Volume	1,482,213 m^3
Max Depth	11.89 m
Avg. Depth	2.37 m

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Sampling Location in Reference Lake D, Doris North Project, 2012

Figure A.1-6

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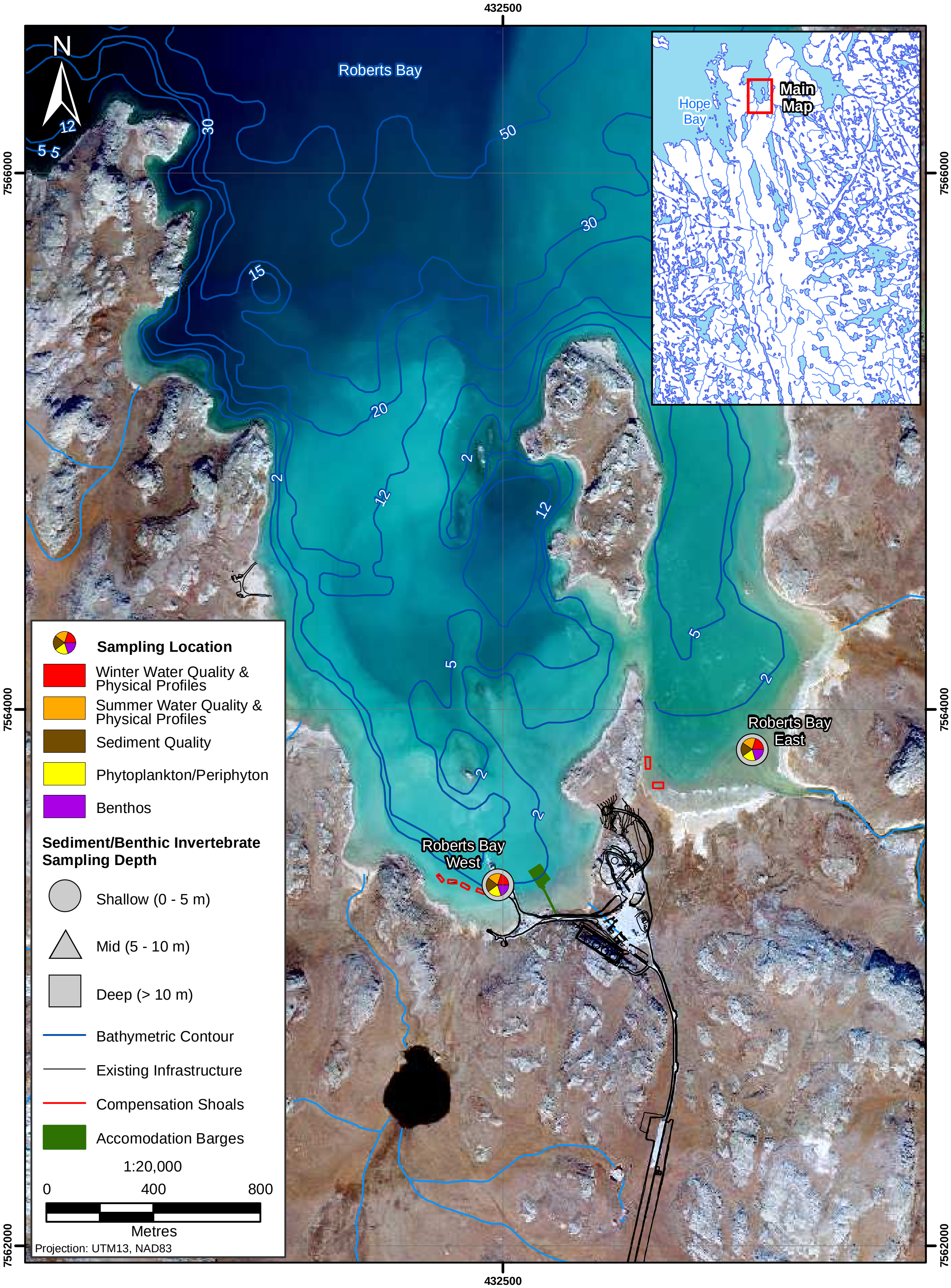

Figure A.1-7

Sampling Locations in Roberts Bay, Doris North Project, 2012

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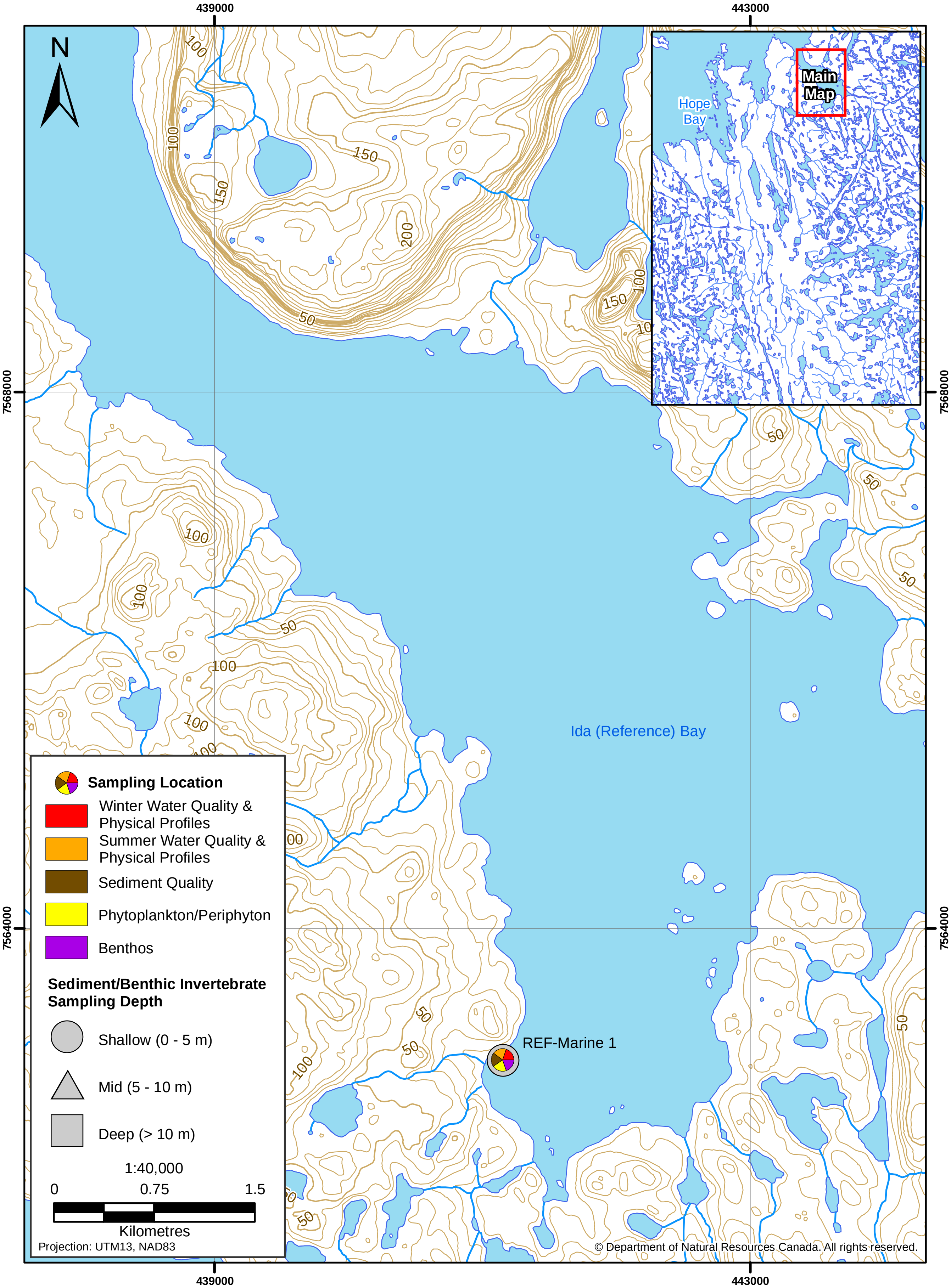

Figure A.1-8

Sampling Location in Ida (Reference) Bay, Doris North Project, 2012

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A.2 2012 PHYSICAL PROFILES AND SECCHI DEPTH

The following sections present the Secchi depth data and the physical profiles collected between April and September 2012 in stream, lake, and marine sites.

A.2.1 Stream Data

Stream water temperatures measured between June 16 and September 20, 2012 are shown in Table A.2-1.

Table A.2-1 Stream Water Temperature, Doris North Project, 2012

Stream	Date			
	June 16	July 21	August 21-25	September20
Doris Outflow	7.3°C	16.7°C	10.2°C	5.3°C
Roberts Outflow	6.5°C	18.3°C	14.1°C	5.6°C
Little Roberts Outflow	7.1°C	17.5°C	14.6°C	4.0°C
Reference B Outflow	4.7°C	20.6°C	15.6°C	2.8°C
Reference D Outflow	5.5°C	21.0°C	14.1°C	4.2°C

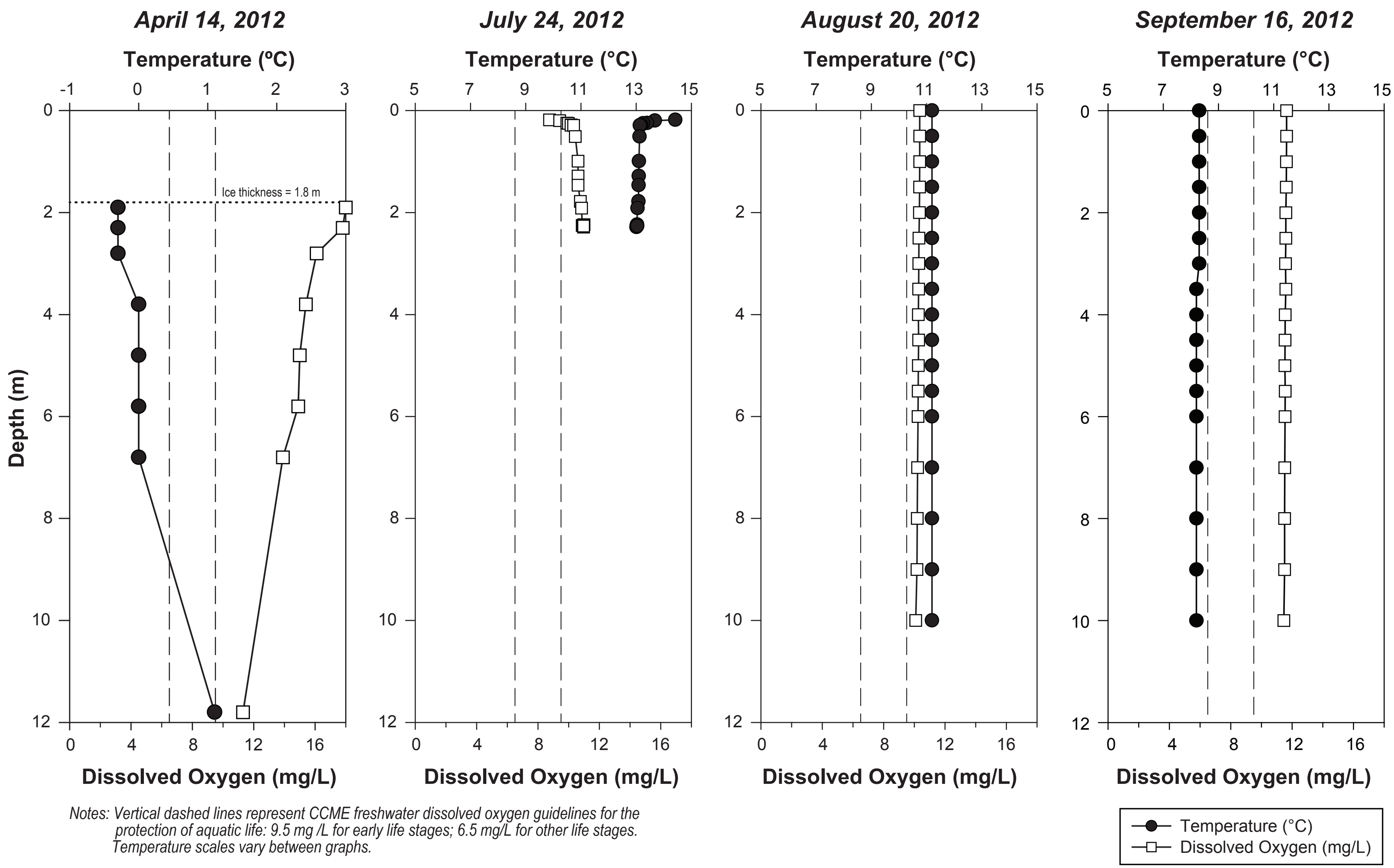
A.2.2 Lake Data

Lake Secchi depths and calculated euphotic zone depths (1% light level) are shown in Table A.2-2. Figures A.2-1 to A.2-6 show the temperature and dissolved oxygen profiles collected at lake sites between April and September 2012, and Annex A.2-1 provides the raw physical profile data.

TableA.2-2. Lake Secchi Depths and Euphotic Zone Depths, Doris North Project, 2012

Lake Site	Sampling Date	Secchi Depth (Ds) (m)	Euphotic Zone Depth 1% Light Level (m)
Large Lake Site			
Doris Lake South	July 19	1.5	4.1*
	August 15	2.0	5.4
	September 19	1.0	2.7
Doris Lake North	July 19	1.6	4.3
	August 15	1.75	4.7
	September 19	NC	-
Roberts Lake	July 23	1.9	5.1*
	August 14	1.95	5.3*
	September 24	1.5	4.1*
Reference Lake B	July 18	4.0	10.8
	August 20	8.0	21.6*
	September 18	8.4	22.7*
Small Lake Site			
Little Roberts Lake	July 20	1.4	3.8*
	August 28	1.4	3.8*
	September 24	1.5	4.1*
Reference Lake D	July 20	2.5	6.8*
	August 16	3.2	8.7*
	September 26	2.1	5.7*

*Note: * indicates that the euphotic zone extended to the bottom of the water column.*
NC = not collected



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

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Doris Lake South, Doris North Project, 2012

Figure A2-1

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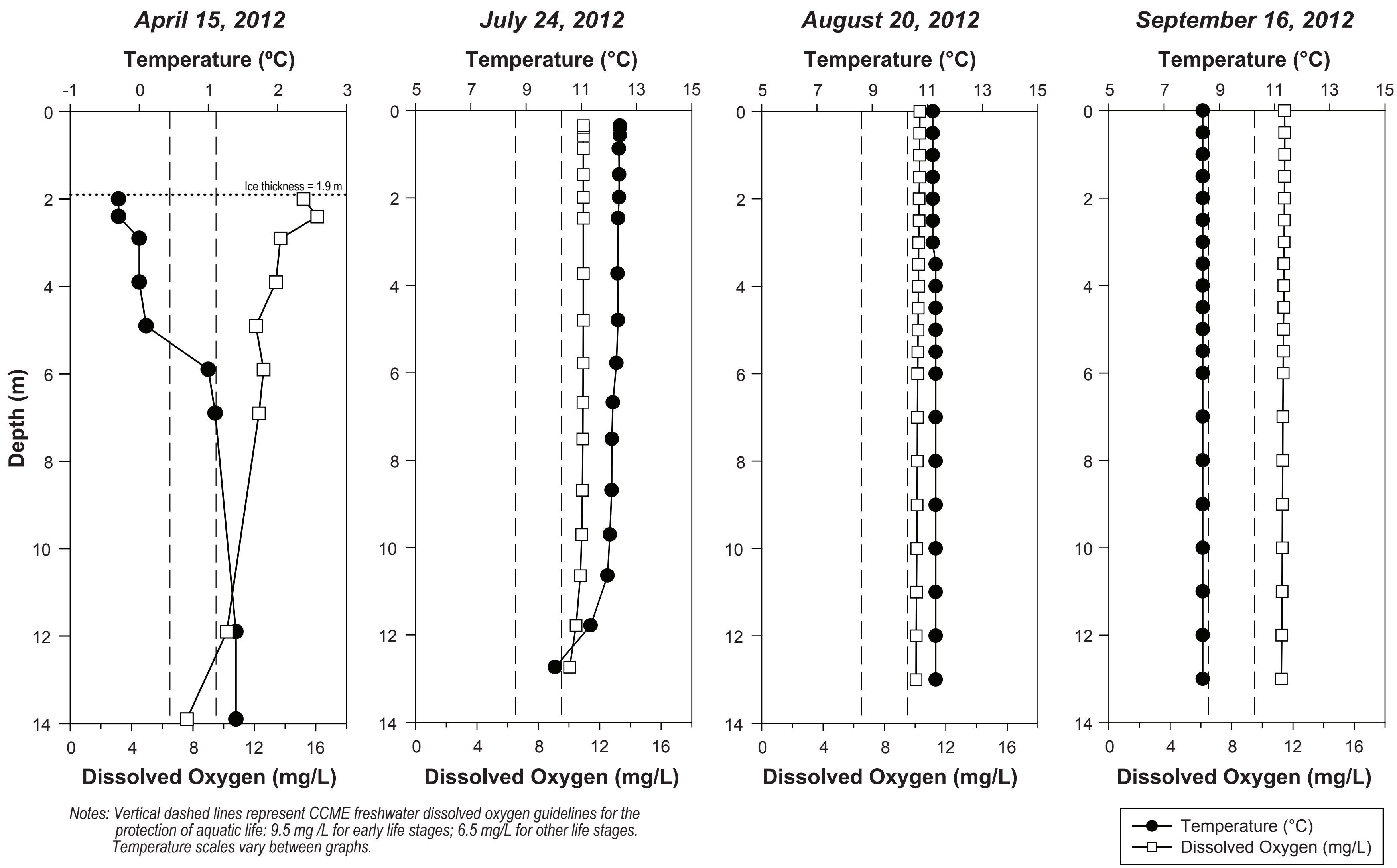


Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

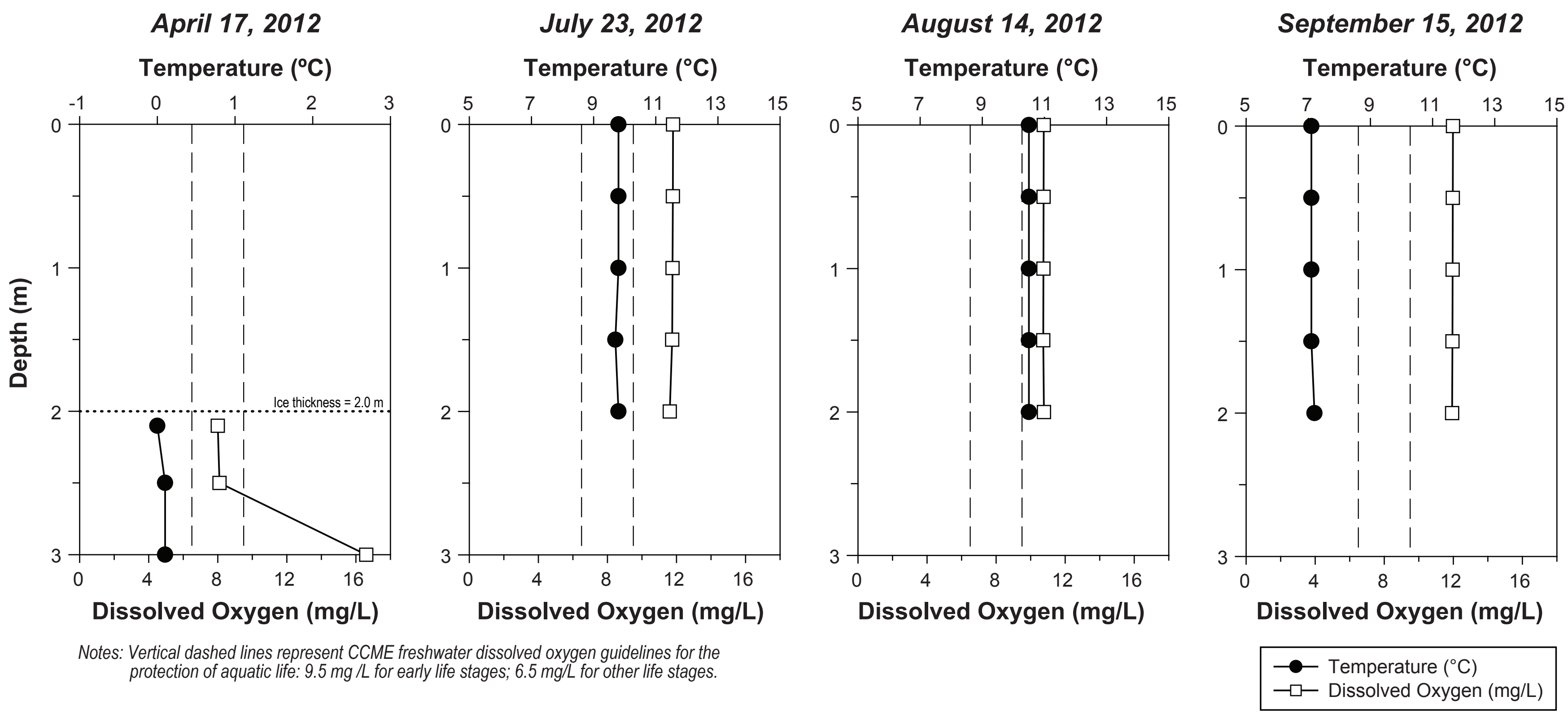
Figure A2-2

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Doris Lake North, Doris North Project, 2012

Figure A2-2

Rescan Engineers & Scientists



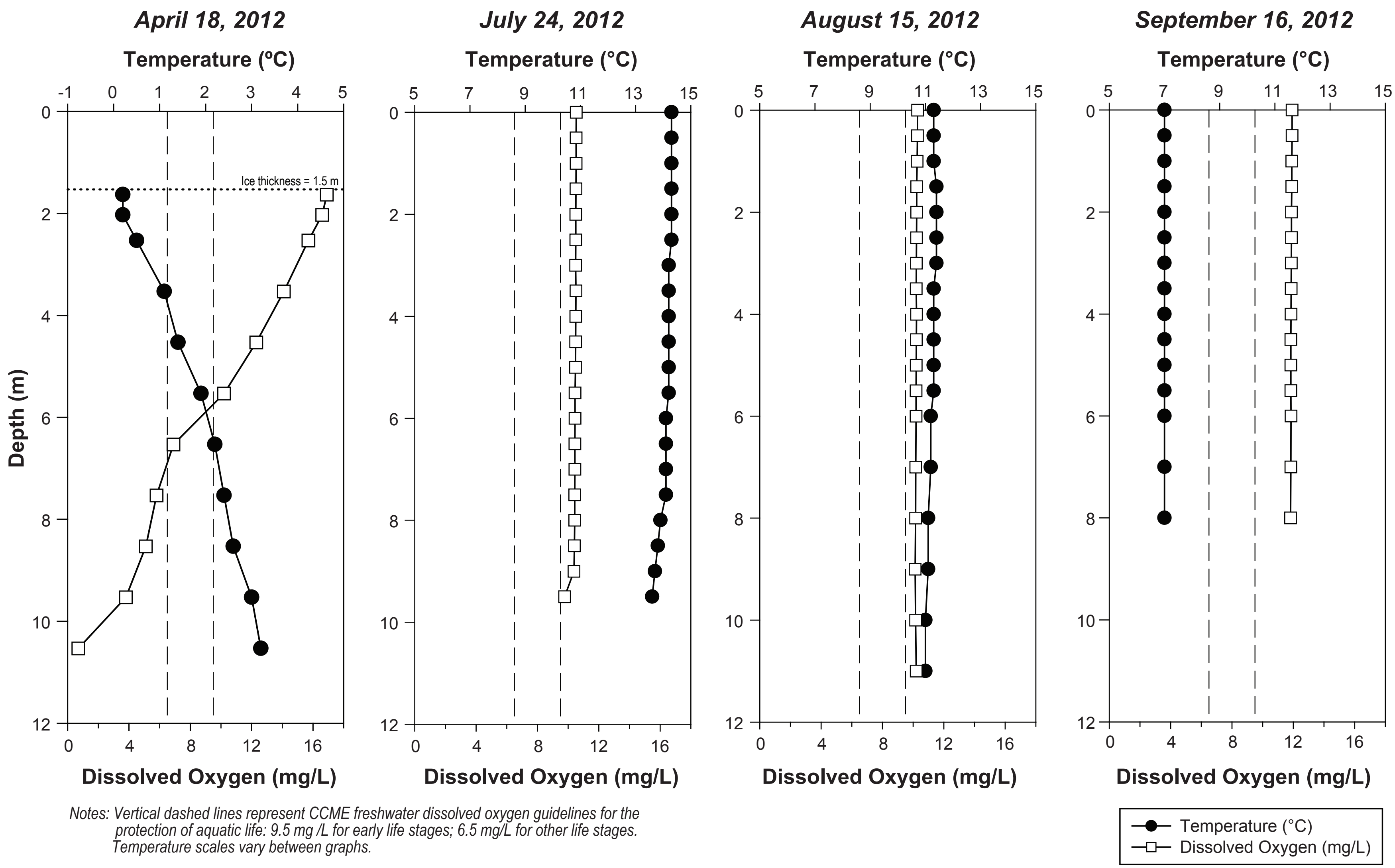
Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages.

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Roberts Lake, Doris North Project, 2012

Figure A2-3

Rescan Engineers & Scientists



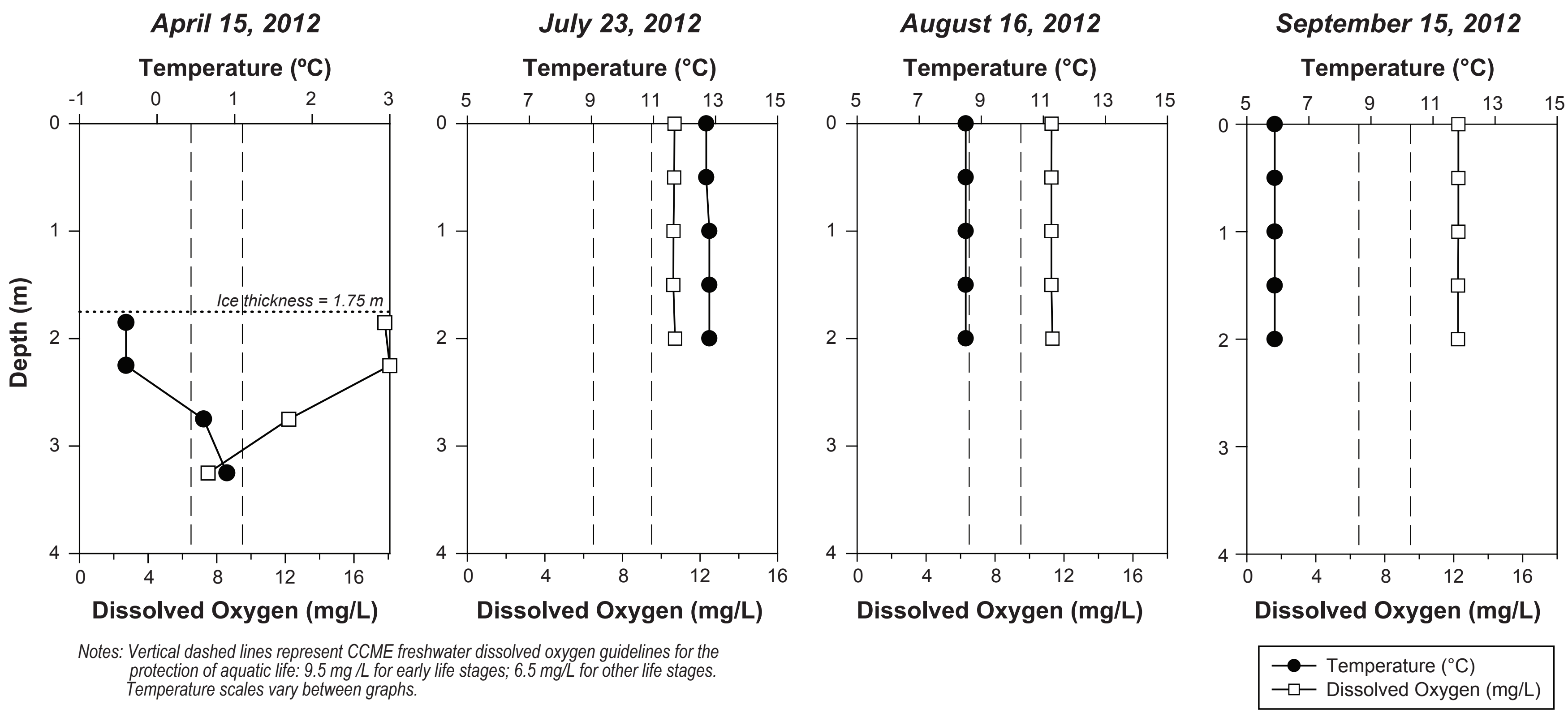
Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Reference Lake B, Doris North Project, 2012

Figure A2-4

Rescan Engineers & Scientists



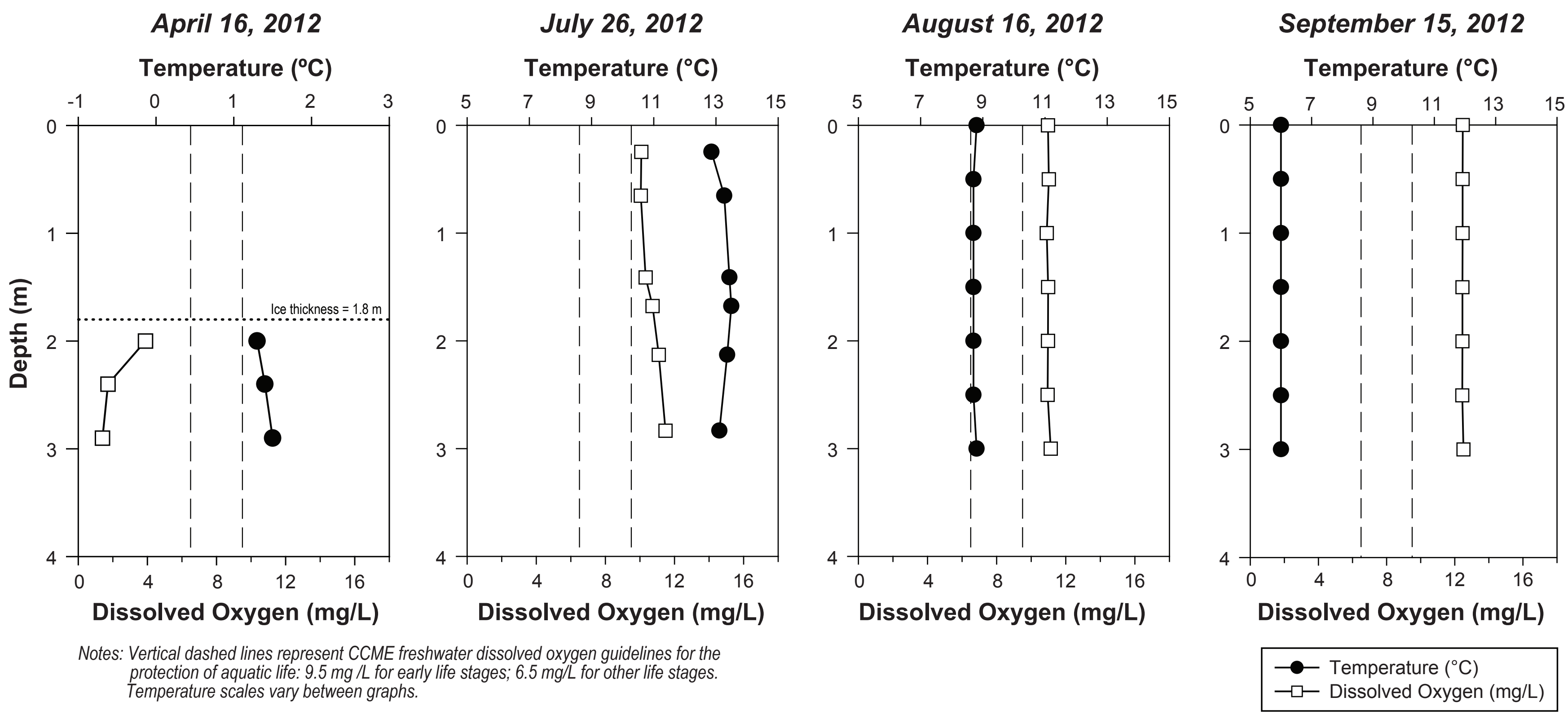
Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

Figure A2-5

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Little Roberts Lake, Doris North Project, 2012

Rescan Engineers & Scientists



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

Figure A2-6

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Reference Lake D, Doris North Project, 2012

Figure A2-6

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Annex A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2012

Doris Lake South — 14-Apr-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
1.9	-0.3	18	110.1
2.3	-0.3	17.8	112.2
2.8	-0.3	16.1	107.7
3.8	0	15.4	105
4.8	0	15	99.6
5.8	0	14.9	95.1
6.8	0	13.9	94.5
11.8	1.1	11.3	80.1

Doris Lake South — 24-Jul-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.183	14.414	8.7488	
0.1974	13.6753	9.4071	
0.2433	13.3944	9.8746	
0.2516	13.2497	9.9795	
0.2803	13.1788	10.1677	
0.2851	13.14	10.1405	
0.2909	13.1314	10.3139	
0.5093	13.1202	10.4214	
0.9929	13.0985	10.6006	
1.2828	13.0928	10.6089	
1.463	13.0884	10.6064	
1.7795	13.08	10.7571	
1.9113	13.05	10.8342	
2.2523	13.02	10.8739	
2.2853	13.0107	10.9641	
2.2574	13.0226	10.9097	
2.2362	13.0292	10.9926	
2.2433	13.0309	10.9597	
2.264	13.0369	10.9661	

Doris Lake South — 20-Aug-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	11.2	10.36	94.4
0.5	11.2	10.35	94.3
1	11.2	10.35	94.3
1.5	11.2	10.34	94.2
2	11.2	10.33	94.1
2.5	11.2	10.3	93.8
3	11.2	10.29	93.7
3.5	11.2	10.28	93.6
4	11.2	10.27	93.5
4.5	11.2	10.28	93.7
5	11.2	10.26	93.4
5.5	11.2	10.25	93.3
6	11.2	10.24	93.3
7	11.2	10.21	93
8	11.2	10.19	92.8
9	11.2	10.17	92.7
10	11.2	10.09	91.9

Doris Lake South — 16-Sep-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	8.3	11.64	99
0.5	8.3	11.64	99
1	8.3	11.63	98.9
1.5	8.3	11.62	98.8
2	8.3	11.59	98.6
2.5	8.3	11.59	98.5
3	8.3	11.57	98.5
3.5	8.2	11.59	98.4
4	8.2	11.55	98.3
4.5	8.2	11.54	98.2
5	8.2	11.53	98.1
5.5	8.2	11.55	98
6	8.2	11.54	97.9
7	8.2	11.52	97.8
8	8.2	11.51	97.7
9	8.2	11.51	97.4
10	8.2	11.46	97.2

Doris Lake North — 15-Apr-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2.0	-0.3	15.20	102.1
2.4	-0.3	16.10	103.0
2.9	0.0	13.70	94.0
3.9	0.0	13.40	89.4
4.9	0.1	12.10	86.2
5.9	1.0	12.60	88.4
6.9	1.1	12.30	86.8
11.9	1.4	10.20	72.6
13.9	1.4	7.60	52.6

Doris Lake North — 24-Jul-12

Depth (m)	Temperature (°C)	Oxygen (mg/L)	Oxygen (%)
0.3446	12.394	10.9238	
0.3959	12.3932	10.9238	
0.5693	12.3894	10.9261	
0.8724	12.358	10.9273	
1.4642	12.3677	10.9245	
1.9861	12.3645	10.9219	
2.4631	12.3294	10.9257	
3.7297	12.3164	10.9273	
4.7969	12.3263	10.9219	
5.7759	12.269	10.92	
6.6758	12.1394	10.9091	
7.5133	12.1021	10.8976	
8.6861	12.0962	10.8601	
9.6989	12.0326	10.8269	
10.6418	11.9476	10.7315	
11.7833	11.3349	10.4541	
12.7347	10.0469	10.0368	

Doris Lake North — 20-Aug-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	11.2	10.31	93.9
0.5	11.2	10.3	93.8
1	11.2	10.29	93.8
1.5	11.2	10.29	93.7
2	11.2	10.27	93.6
2.5	11.2	10.26	93.5
3	11.2	10.23	93.4
3.5	11.3	10.22	93.4
4	11.3	10.22	93.3
4.5	11.3	10.2	93.2
5	11.3	10.19	93.1
5.5	11.3	10.18	93
6	11.3	10.17	92.9
7	11.3	10.15	92.7
8	11.3	10.14	92.6
9	11.3	10.13	92.5
10	11.3	10.11	92.3
11	11.3	10.09	92.1
12	11.3	10.07	92
13	11.3	10.06	91.1

Doris Lake North — 16-Sep-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	8.4	11.45	97.6
0.5	8.4	11.46	97.6
1	8.4	11.46	97.7
1.5	8.4	11.45	97.6
2	8.4	11.44	97.6
2.5	8.4	11.43	97.4
3	8.4	11.42	97.4
3.5	8.4	11.4	97.2
4	8.4	11.4	97.2
4.5	8.4	11.4	97.2
5	8.4	11.37	97
5.5	8.4	11.37	96.9
6	8.4	11.36	96.8
7	8.4	11.34	96.7
8	8.4	11.33	96.6
9	8.4	11.31	96.5
10	8.4	11.3	96.3
11	8.4	11.29	96.2
12	8.4	11.27	96
13	8.4	11.24	95.8

Little Roberts Lake — 15-Apr-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
1.85	-0.4	17.8	112
2.25	-0.4	18.1	114.6
2.75	0.6	12.2	92.3
3.25	0.9	7.5	60.4

Little Roberts Lake — 23-Jul-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	12.7	10.68	100.6
0.5	12.7	10.66	100.5
1	12.8	10.63	100.5
1.5	12.8	10.62	100.3
2	12.8	10.71	100.8

Little Roberts Lake — 16-Aug-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	8.5	11.29	96.5
0.5	8.5	11.28	96.4
1	8.5	11.27	96.3
1.5	8.5	11.27	96.3
2	8.5	11.33	96.8

Annex A2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2012

Station
Date
Parameter

Little Roberts Lake — 15-Sep-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	5.9	12.27	98.3
0.5	5.9	12.27	98.3
1	5.9	12.27	98.3
1.5	5.9	12.25	98.2
2	5.9	12.25	98.1

Roberts Lake — 17-Apr-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2.1	0.0	8.00	54.5
2.5	0.1	8.10	55.7
3.0	0.1	16.60	114.0
4.0	1.5	15.40	109.5
5	1.5	6.3	44.9

Roberts Lake — 23-Jul-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Disolved Oxygen %
0	9.8	11.8	104
0.5	9.8	11.79	103.9
1	9.8	11.77	103.7
1.5	9.7	11.75	103.5
2	9.8	11.61	103.7

Roberts Lake — 14-Aug-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	10.5	10.76	96.4
0.5	10.5	10.75	96.4
1	10.5	10.74	96.3
1.5	10.5	10.73	96.2
2	10.5	10.78	96.6

Roberts Lake — 15-Sep-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	7.1	11.98	98.9
0.5	7.1	11.97	98.8
1	7.1	11.96	98.7
1.5	7.1	11.95	98.6
2	7.2	11.93	98.8

Note:
No salinity was collected fromm Mar-REF1 in July because of a probe malfunction

Reference Lake B — 18-Apr-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
1.6	0.2	16.90	116.0
2.0	0.2	16.60	114.0
2.5	0.5	15.70	109.0
3.5	1.1	14.10	99.0
4.5	1.4	12.30	88.0
5.5	1.9	10.20	74.0
6.5	2.2	6.90	50.0
7.5	2.4	5.80	43.0
8.5	2.6	5.10	37.0
9.5	3.0	3.80	28.0
10.5	3.2	0.70	5.0

Reference Lake B — 24-Jul-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	14.3	10.53	102.8
0.5	14.3	10.52	102.8
1	14.3	10.52	102.8
1.5	14.3	10.51	102.7
2	14.3	10.5	102.6
2.5	14.3	10.5	102.5
3	14.2	10.49	102.4
3.5	14.2	10.51	102.4
4	14.2	10.5	102.3
4.5	14.2	10.49	102.2
5	14.2	10.48	102.1
5.5	14.2	10.45	101.9
6	14.1	10.45	101.7
6.5	14.1	10.44	101.6
7	14.1	10.44	101.5
7.5	14.1	10.43	101.4
8	13.9	10.43	101
8.5	13.8	10.41	100.6
9	13.7	10.38	100.3
9.5	13.6	9.77	93.2

Reference Lake B — 15-Aug-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	11.3	10.29	94
0.5	11.3	10.28	93.8
1	11.3	10.27	93.7
1.5	11.4	10.23	93.7
2	11.4	10.23	93.6
2.5	11.4	10.22	93.5
3	11.4	10.21	93.4
3.5	11.3	10.2	93.4
4	11.3	10.22	93.3
4.5	11.3	10.21	93.2
5	11.3	10.2	93.1
5.5	11.3	10.19	93
6	11.2	10.19	92.8
7	11.2	10.17	92.7
8	11.1	10.16	92.3
9	11.1	10.13	92.1
10	11	10.16	92.1
11	11	10.2	92.8

Reference Lake B — 16-Sep-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	7	11.92	98.2
0.5	7	11.92	98.1
1	7	11.9	98.1
1.5	7	11.9	98
2	7	11.88	97.9
2.5	7	11.88	97.8
3	7	11.87	97.8
3.5	7	11.86	97.7
4	7	11.85	97.6
4.5	7	11.84	97.6
5	7	11.84	97.5
5.5	7	11.84	97.5
6	7	11.85	97.4
7	7	11.84	97.3
8	7	11.82	97.1

16-Apr-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2	1.3	3.89	27.3
2.4	1.4	1.72	12.2
2.9	1.5	1.4	10.2

Reference Lake D — 26-Jul-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.2459	12.8555	10.071	
0.6517	13.2637	10.0429	
1.4099	13.4331	10.3238	
1.6757	13.4908	10.7225	
2.1284	13.3608	11.0845	
2.8331	13.1078	11.4726	

Reference Lake D — 16-Aug-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	8.8	10.97	94.4
0.5	8.7	11.02	94.6
1	8.7	10.9	94.3
1.5	8.7	10.98	94.3
2	8.7	10.97	94.2
2.5	8.7	10.95	94
3	8.8	11.13	95.6

Reference Lake D — 15-Sep-12

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0	6	12.47	100.2
0.5	6	12.46	110.1
1	6	12.46	100.1
1.5	6	12.45	100
2	6	12.45	100
2.5	6	12.44	100
3	6	12.51	100.4

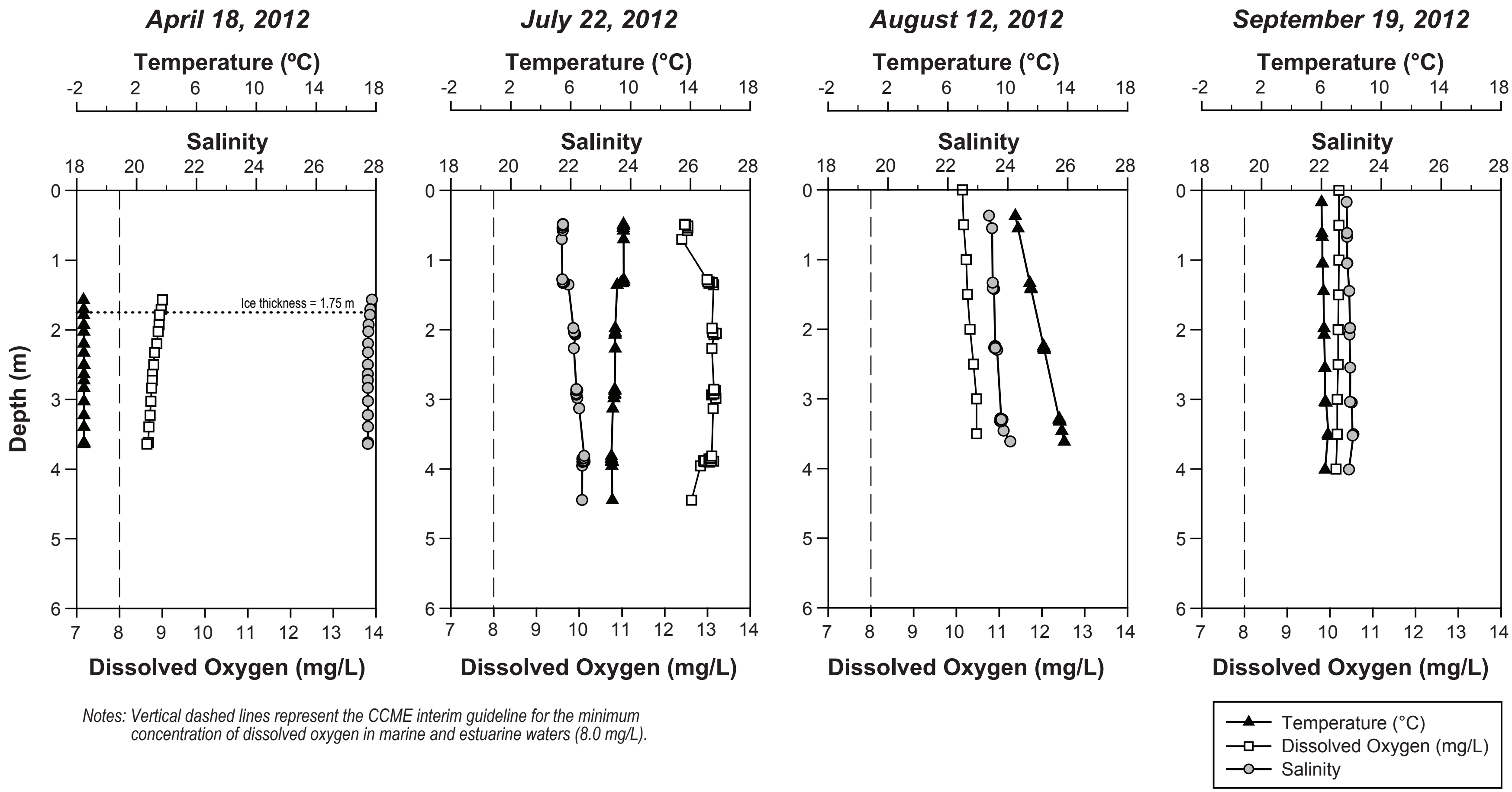
A.2.3 Marine Data

Marine Secchi depths and calculated euphotic zone depths (1% light level) are shown in Table A.2-3. Figures A.2-7 to A.2-9 show the temperature, dissolved oxygen, and salinity profiles collected at marine sites between April and September 2012, and Annexes A.2-2 and A.2-3 provide the raw physical profile data.

Table A.2-3. Marine Secchi Depths and Euphotic Zone Depths, Doris North Project, 2012

Marine Site	Sampling Date	Secchi Depth (D_s) (m)	Euphotic Zone Depth 1% Light Level (m)
RBW	July 22	5.2	14.0*
	August 18	4.7	12.7*
	September 19	1.9	5.1*
RBE	July 22	0.8	2.2*
	August 18	0.7	1.9*
	September 19	0.6	1.6*
REF-Marine 1	July 26	4.5	12.2*
	August 17	4.2	11.3*
	September 17	4.2	11.3*

*Note: * indicates that the euphotic zone extended to the bottom of the water column.*



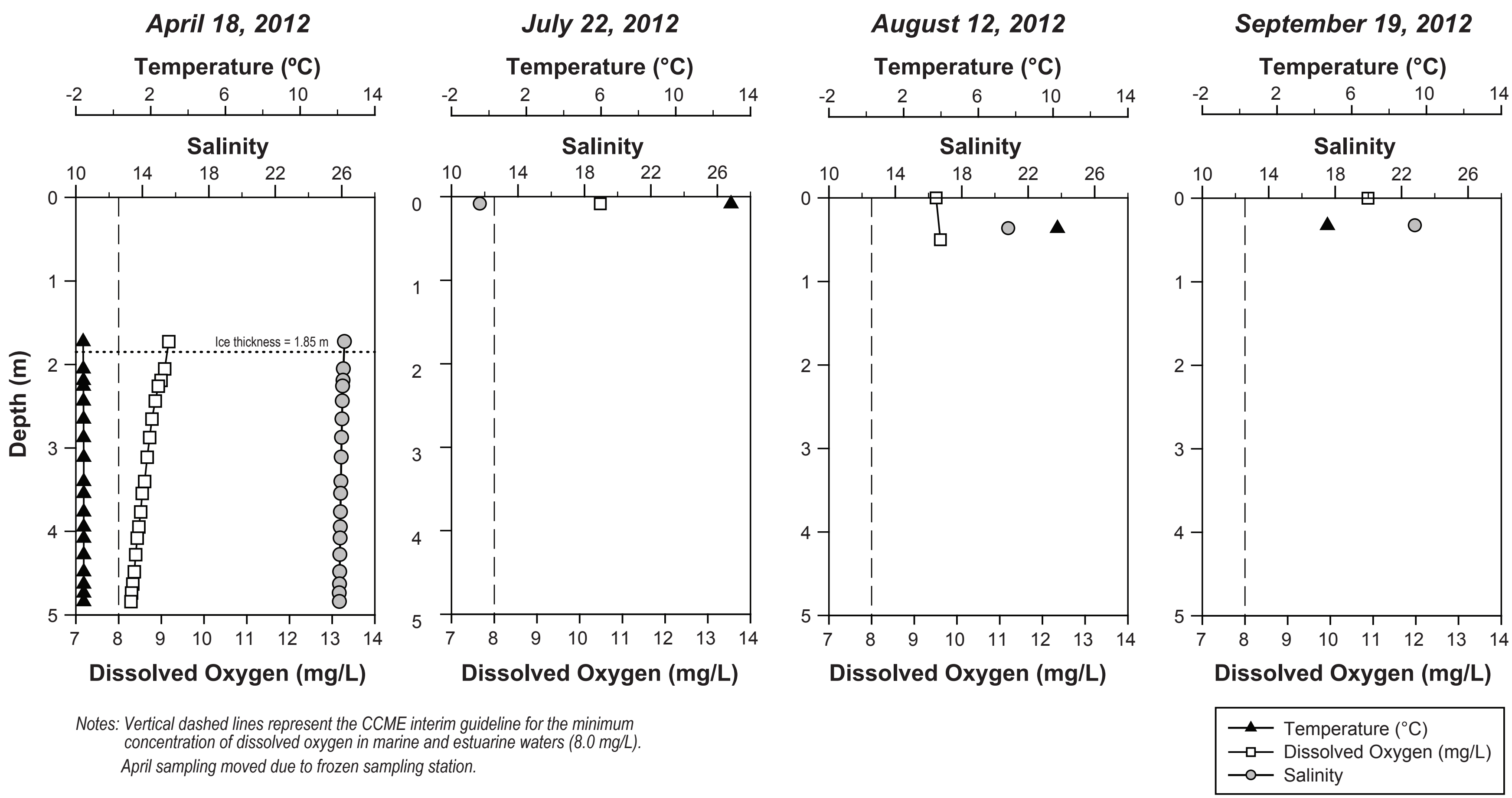
Notes: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site RBW, Doris North Project, 2012

Figure A2-7

NEWMONT NORTH AMERICA

Rescan Engineers & Scientists



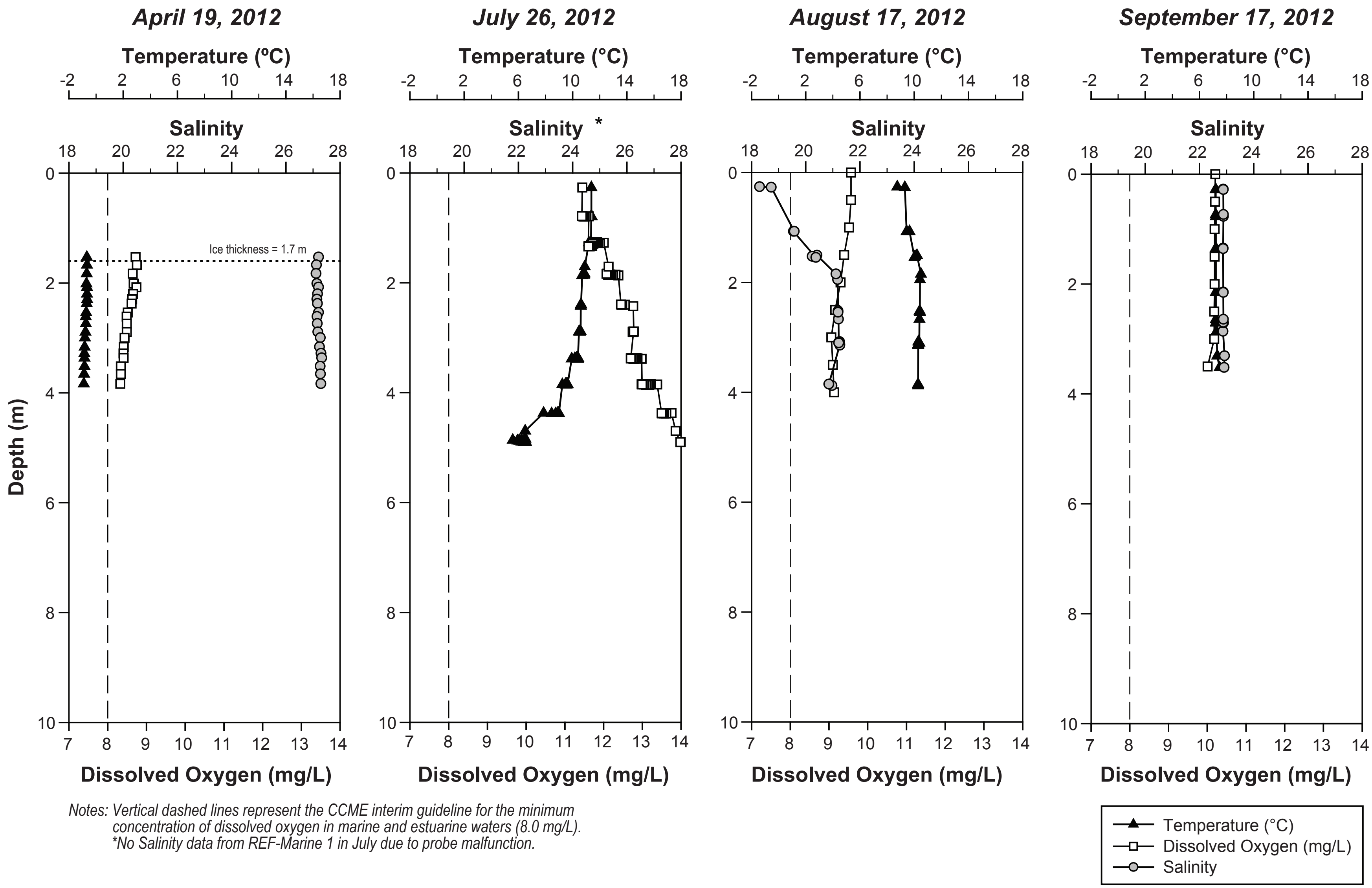
Notes: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).
April sampling moved due to frozen sampling station.

NEWMONT NORTH AMERICA

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site RBE, Doris North Project, 2012

Figure A2-8

Rescan Engineers & Scientists



Notes: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).
**No Salinity data from REF-Marine 1 in July due to probe malfunction.*

Figure A2-9

NEWMONT NORTH AMERICA

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site REF-Marine 1, Doris North Project, 2012

Figure A2-9

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Annex A2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2012

Station	RBW		
Date	19-Apr-12		
Parameter	Depth (m)	Temperature (°C)	Salinity
	1.57	-1.54	27.86
	1.70	-1.54	27.81
	1.79	-1.54	27.79
	1.93	-1.53	27.75
	2.03	-1.53	27.74
	2.20	-1.53	27.73
	2.33	-1.52	27.73
	2.50	-1.52	27.73
	2.64	-1.52	27.73
	2.72	-1.52	27.72
	2.83	-1.52	27.72
	3.03	-1.52	27.73
	3.23	-1.52	27.73
	3.39	-1.52	27.73
	3.62	-1.52	27.73
	3.64	-1.52	27.72

RBW		
22-Jul-12		
Depth (m)	Temperature (°C)	Salinity
0.486	9.5373	21.7353
0.4874	9.5277	21.7427
0.491	9.5273	21.7409
0.5105	9.5296	21.7368
0.5395	9.5167	21.731
0.576	9.5188	21.7329
0.7015	9.5324	21.7015
1.2795	9.5401	21.7178
1.3095	9.5294	21.7301
1.3144	9.5067	21.7376
1.3233	9.3759	21.7789
1.3306	9.465	21.7404
1.3547	9.1089	21.9258
1.9783	8.9747	22.0922
2.0373	8.9744	22.1119
2.052	8.9712	22.1274
2.0707	8.9641	22.1523
2.2691	8.9732	22.1082
2.8552	8.9466	22.1908
2.8703	8.9611	22.2184
2.8725	8.9415	22.1852
2.9159	8.9363	22.185
2.9224	8.9338	22.1856
2.9364	8.9326	22.1909
2.9836	8.8896	22.2251
3.132	8.8126	22.2852
3.8128	8.7253	22.4498
3.8458	8.7116	22.4436
3.8539	8.725	22.3923
3.8791	8.7493	22.459
3.8826	8.7537	22.4249
3.8853	8.7175	22.4151
3.8864	8.7383	22.4502
3.8933	8.767	22.4686
3.894	8.7465	22.4524
3.8994	8.7493	22.3895
3.9542	8.7551	22.3872
4.4467	8.7867	22.3794
4.6589	8.7681	20.5842

RBW		
18-Aug-12		
Depth (m)	Temperature (°C)	Salinity
0.37	10.51	23.38
0.55	10.69	23.48
1.33	11.48	23.50
1.41	11.55	23.52
1.41	11.56	23.50
1.43	11.57	23.54
2.24	12.39	23.57
2.25	12.40	23.58
2.26	12.41	23.56
2.27	12.42	23.55
2.27	12.42	23.61
2.27	12.42	23.58
2.28	12.43	23.57
2.30	12.45	23.65
3.28	13.44	23.76
3.29	13.45	23.81
3.30	13.46	23.83
3.30	13.46	23.76
3.30	13.46	23.79
3.32	13.48	23.77
3.32	13.48	23.80
3.32	13.48	23.74
3.33	13.49	23.78
3.46	13.62	23.86
3.61	13.78	24.09
4.51	14.68	22.27
4.54	14.71	19.94

RBW		
19-Sep-12		
Depth (m)	Temperature (°C)	Salinity
0.17	6.01	22.84
0.62	6.02	22.86
0.67	6.06	22.86
1.05	6.08	22.87
1.05	6.06	22.86
1.45	6.15	22.93
1.98	6.17	22.95
2.07	6.18	22.94
2.55	6.23	22.97
3.04	6.23	22.96
3.05	6.31	23.01
3.50	6.43	23.07
3.52	6.48	23.04
4.01	6.24	22.92

RBE		
19-Apr-12		
Depth (m)	Temperature (°C)	Salinity
1.73	-1.62	26.17
2.05	-1.61	26.11
2.19	-1.60	26.08
2.26	-1.60	26.05
2.44	-1.60	26.03
2.65	-1.59	26.02
2.87	-1.59	25.99
3.11	-1.58	25.97
3.40	-1.58	25.96
3.54	-1.58	25.94
3.77	-1.58	25.93
3.95	-1.58	25.92
4.08	-1.58	25.91
4.28	-1.58	25.89
4.48	-1.58	25.88
4.63	-1.58	25.87
4.74	-1.58	25.86
4.84	-1.58	25.87

RBE		
22-Jul-12		
Depth (m)	Temperature (°C)	Salinity
0.08	12.97	11.70

RBE		
18-Aug-12		
Depth (m)	Temperature (°C)	Salinity
0.36	10.23	20.80

RBE		
19-Sep-12		
Depth (m)	Temperature (°C)	Salinity
0.32	4.70	22.80

Annex A2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2012

Station	REF-Marine 1		
Date	19-Apr-12		
Parameter	Depth (m)	Temperature (°C)	Salinity
	1.53	-0.68	27.21
	1.67	-0.67	27.13
	1.83	-0.70	27.12
	2.01	-0.72	27.15
	2.08	-0.67	27.21
	2.20	-0.67	27.17
	2.30	-0.66	27.14
	2.37	-0.69	27.16
	2.54	-0.74	27.21
	2.61	-0.76	27.15
	2.74	-0.75	27.16
	2.89	-0.79	27.18
	3.00	-0.83	27.27
	3.16	-0.85	27.24
	3.28	-0.86	27.30
	3.36	-0.86	27.32
	3.52	-0.86	27.26
	3.66	-0.89	27.27
	3.83	-0.91	27.29

REF-Marine 1			REF-Marine 1			REF-Marine 1		
26-Jul-12			26-Jul-12..continued			26-Jul-12..completed		
Depth (m)	Temperature (°C)	Salinity	Depth (m)	Temperature (°C)	Salinity	Depth (m)	Temperature (°C)	Salinity
0.26	11.38		2.39	10.62		3.85	9.64	
0.78	11.38		2.40	10.61		3.85	9.55	
0.78	11.38		2.40	10.62		3.86	9.50	
0.79	11.38		2.42	10.60		4.37	8.92	
0.79	11.37		2.88	10.59		4.37	7.86	
0.79	11.38		2.88	10.57		4.37	8.99	
0.79	11.38		2.89	10.52		4.38	8.95	
0.79	11.38		2.89	10.53		4.38	8.88	
1.26	11.35		2.89	10.47		4.38	8.45	
1.27	11.36		2.89	10.51		4.38	8.75	
1.27	11.36		2.90	10.52		4.69	6.50	
1.27	11.20		3.37	10.37		4.84	6.52	
1.27	11.35		3.37	10.31		4.86	6.45	
1.27	11.34		3.37	10.38		4.86	5.58	
1.28	11.27		3.37	10.40		4.87	6.51	
1.28	11.36		3.37	10.27		4.87	6.24	
1.29	11.35		3.37	10.41		4.87	5.93	
1.33	11.35		3.37	10.37		4.88	6.48	
1.33	11.34		3.37	10.38		4.88	6.03	
1.33	11.33		3.37	10.16		4.88	6.26	
1.33	11.34		3.37	10.34		4.88	6.10	
1.33	11.34		3.38	10.39		4.89	6.42	
1.33	11.33		3.38	10.38		4.89	6.23	
1.34	11.35		3.38	10.40		4.90	6.53	
1.34	11.35		3.38	9.93		4.90	6.50	
1.70	10.89		3.39	10.38		4.90	6.54	
1.83	10.87		3.84	9.56		4.90	6.52	
1.83	10.88		3.84	9.48		4.90	6.52	
1.85	10.83		3.85	9.59		4.90	6.40	
1.85	10.82		3.85	9.56		5.42	5.59	
1.85	10.85		3.85	9.62				
1.85	10.77		3.85	9.52				
1.85	10.82		3.85	9.24				
1.86	10.81		3.85	9.63				
1.86	10.70		3.85	9.50				

REF-Marine 1		
17-Aug-12		
Depth (m)	Temperature (°C)	Salinity
0.26	8.76	18.30
0.27	9.31	18.73
1.07	9.44	19.58
1.07	9.65	19.54
1.51	10.20	20.42
1.53	10.06	20.24
1.55	10.02	20.38
1.85	10.50	21.11
1.95	10.43	21.18
2.52	10.41	21.19
2.54	10.42	21.19
2.67	10.39	21.21
3.08	10.30	21.25
3.09	10.37	21.21
3.10	10.38	21.22
3.13	10.30	21.26
3.14	10.30	21.26
3.85	10.28	20.85
3.88	10.28	20.97

REF-Marine 1		
17-Sep-12		
Depth (m)	Temperature (°C)	Salinity
0.27	7.20	22.88
0.28	7.20	22.88
0.73	7.20	22.88
0.77	7.20	22.88
1.35	7.21	22.87
1.36	7.20	22.87
2.15	7.21	22.88
2.15	7.21	22.88
2.64	7.21	22.88
2.70	7.22	22.88
2.71	7.22	22.89
2.86	7.26	22.87
3.31	7.31	22.93
3.52	7.48	22.91
4.11	7.50	23.08

Note:
No salinity was collected fromm Mar-REF1 in July because of a probe malfunction

Annex A2-3. Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2012

Station	RBW		
Date	19-Apr-12		
Parameter	Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	1.57	9.00	
	1.70	8.98	
	1.79	8.94	
	1.93	8.93	
	2.03	8.90	
	2.20	8.87	
	2.33	8.82	
	2.50	8.80	
	2.64	8.77	
	2.72	8.77	
	2.83	8.75	
	3.03	8.73	
	3.23	8.72	
	3.39	8.69	
	3.62	8.67	
	3.64	8.64	

RBW		
22-Jul-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.486	12.4857	
0.4874	12.4598	
0.491	12.4646	
0.5105	12.5378	
0.5395	12.5391	
0.576	12.5289	
0.7015	12.3974	
1.2795	12.9887	
1.3095	13.0073	
1.3144	13.039	
1.3233	13.1151	
1.3306	13.0354	
1.3547	13.1429	
1.9783	13.1058	
2.0373	13.1247	
2.052	13.205	
2.0707	13.1474	
2.2691	13.1023	
2.8552	13.1493	
2.8703	13.1852	
2.8725	13.134	
2.9159	13.1522	
2.9224	13.1397	
2.9364	13.0969	
2.9836	13.1941	
3.132	13.1292	
3.8128	13.0972	
3.8458	13.0735	
3.8539	13.0345	
3.8791	12.941	
3.8826	12.9065	
3.8853	13.0873	
3.8864	13.1413	
3.8933	12.9266	
3.894	12.9705	
3.8994	13.0383	
3.9542	12.8358	
4.4467	12.6249	
4.6589	12.5119	

RBW		
18-Aug-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.00	10.14	103.4
0.50	10.17	103.5
1.00	10.23	103.6
1.50	10.26	103.9
2.00	10.32	104
2.50	10.40	104.6
3.00	10.47	105.1
3.50	10.47	105.1
4.00	10.52	104.8
4.50	10.65	104.7

RBW		
17-Sep-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.00	10.21	98.1
0.50	10.21	98.1
1.00	10.21	98.1
1.50	10.20	98.2
2.00	10.19	98.1
2.50	10.19	97.6
3.00	10.17	98.7
3.50	10.17	98.6
4.00	10.14	98
4.50	10.01	96.1

RBE		
19-Apr-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
1.73	9.18	
2.05	9.08	
2.19	8.99	
2.26	8.93	
2.44	8.86	
2.65	8.78	
2.87	8.73	
3.11	8.67	
3.40	8.61	
3.54	8.55	
3.77	8.52	
3.95	8.47	
4.08	8.43	
4.28	8.40	
4.48	8.37	
4.63	8.33	
4.74	8.30	
4.84	8.29	

RBE		
22-Jul-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.08	10.48	

RBE		
18-Aug-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.00	9.51	101.8
0.50	9.61	101.7

RBE		
19-Sep-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
22.80	10.88	

Annex A2-3. Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2012

Station	REF-Marine		
Date	19-Apr-12		
Parameter	Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	1.53	8.72	
	1.67	8.75	
	1.83	8.64	
	2.01	8.67	
	2.08	8.74	
	2.20	8.66	
	2.30	8.63	
	2.37	8.62	
	2.54	8.52	
	2.61	8.49	
	2.74	8.49	
	2.89	8.49	
	3.00	8.44	
	3.16	8.41	
	3.28	8.40	
	3.36	8.41	
	3.52	8.34	
	3.66	8.34	
	3.83	8.32	

REF-Marine		
26-Jul-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.26	11.45	
0.78	11.44	
0.78	11.45	
0.79	11.55	
0.79	11.62	
0.79	11.46	
0.79	11.51	
0.79	11.48	
1.26	11.84	
1.27	11.80	
1.27	11.75	
1.27	12.00	
1.27	11.78	
1.27	11.86	
1.28	11.91	
1.28	11.74	
1.29	11.72	
1.33	11.63	
1.33	11.68	
1.33	11.67	
1.33	11.71	
1.33	11.64	
1.33	11.65	
1.34	11.61	
1.34	11.61	
1.70	12.13	
1.83	12.09	
1.83	12.07	
1.85	12.17	
1.85	12.20	
1.85	12.11	
1.85	12.31	
1.85	12.14	
1.86	12.25	
1.86	12.38	
2.39	12.45	

REF-Marine		
26-Jul-12...continued		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2.40	12.55	
2.40	12.48	
2.42	12.77	
2.88	12.78	
2.88	12.78	
2.89	12.75	
2.89	12.77	
2.89	12.77	
2.89	12.75	
2.90	12.76	
3.37	12.72	
3.37	12.83	
3.37	12.73	
3.37	12.76	
3.37	12.85	
3.37	12.80	
3.37	12.72	
3.37	12.70	
3.37	12.88	
3.37	12.81	
3.38	12.77	
3.38	12.71	
3.38	12.76	
3.38	12.98	
3.39	12.78	
3.84	13.20	
3.84	13.22	
3.85	12.98	
3.85	13.01	
3.85	12.98	
3.85	13.05	
3.85	13.38	
3.85	12.99	
3.85	13.14	
3.85	13.18	
3.85	13.17	

REF-Marine		
26-Jul-12...completed		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
3.86	13.10	
4.37	13.52	
4.37	13.75	
4.37	13.50	
4.38	13.51	
4.38	13.53	
4.38	13.62	
4.38	13.56	
4.69	13.86	
4.84	14.07	
4.86	14.09	
4.86	14.74	
4.87	14.10	
4.87	14.16	
4.87	14.36	
4.88	14.07	
4.88	14.23	
4.88	14.22	
4.88	14.21	
4.89	14.02	
4.89	14.19	
4.90	13.99	
4.90	14.04	
4.90	14.01	
4.90	13.98	
4.90	14.03	
4.90	14.01	
5.42	14.52	

REF-Marine		
17-Aug-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.00	9.57	97
0.50	9.57	97
1.00	9.52	98.4
1.50	9.39	98.4
2.00	9.30	99.9
2.50	9.16	98.1
3.00	9.06	96.9
3.50	9.10	97.1
4.00	9.13	97.3
4.50	9.12	97.3

REF-Marine		
17-Sep-12		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.00	10.21	101.1
0.50	10.20	101.1
1.00	10.19	100.9
1.50	10.19	100.9
2.00	10.19	100.9
2.50	10.18	100.8
3.00	10.18	100.8
3.50	10.01	99.3

Note:
No salinity was collected fromm Mar-REF1 in July because of a probe malfunction

A.3 2012 WATER QUALITY

The following sections present the water quality data collected between April and September 2012 from stream, lake, and marine sites, as well as the blank QA/QC water quality data. Only the parameters that were subjected to an evaluation of effects (see main body of AEMP report) are shown graphically. All water quality parameters were screened against CCME water quality guidelines for the protection of aquatic life (CCME 2012b). CCME guidelines are included in all graphs, tables, and annexes.

A.3.1 Stream Data

Stream water quality data were collected monthly from June to September 2012. Figures A.3-1 to A.3-9 show monthly trends of select water quality parameters. Table A.3-1 presents the percentage of stream water quality samples in which parameter concentrations were higher than CCME guidelines, and Table A.3-2 provides the factor by which average 2012 concentrations were higher than CCME guidelines. Annex A.3-1 presents the raw stream water quality data.

A.3.2 Lake Data

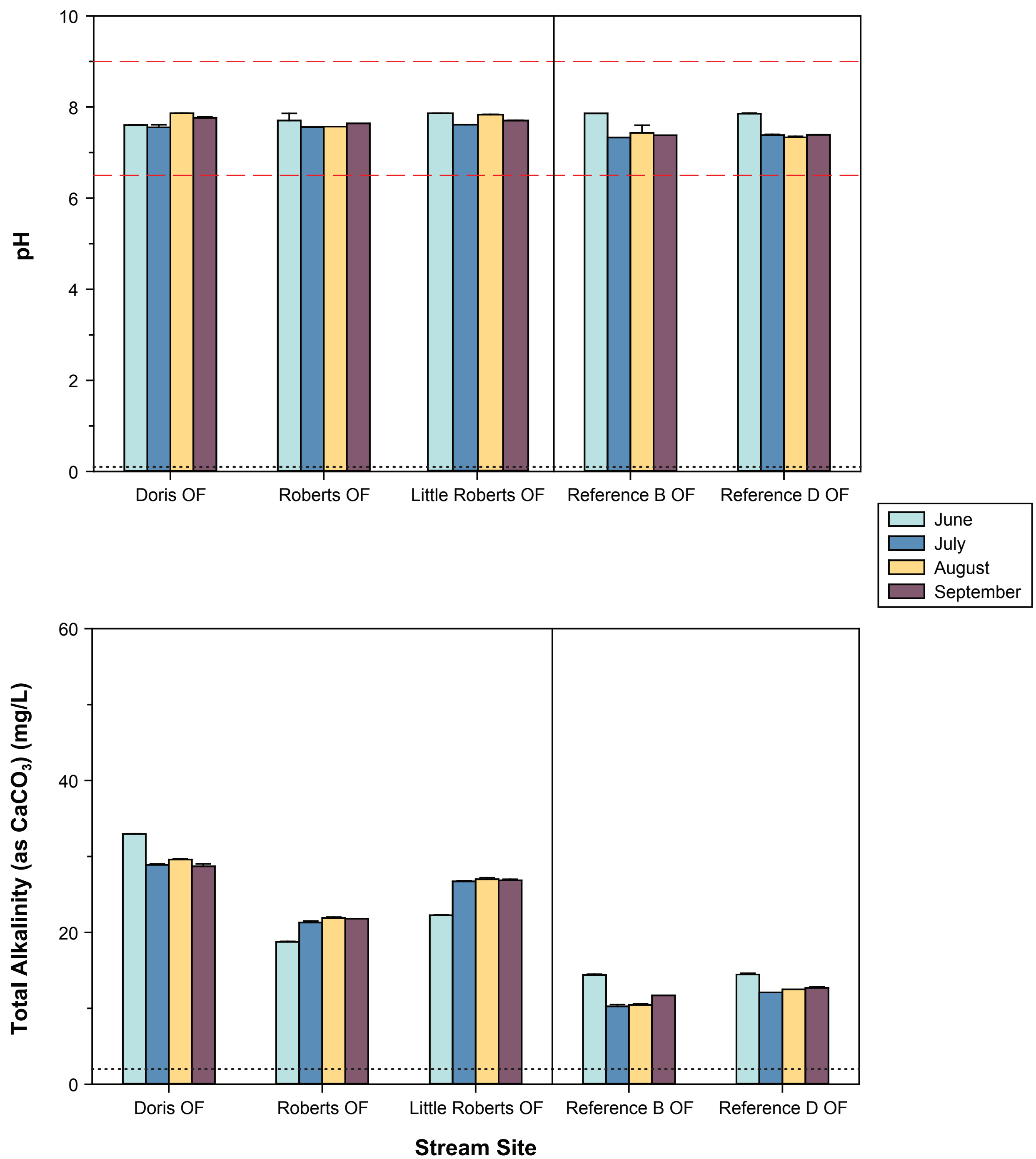
Lake water quality data were collected in April (under-ice sampling) and monthly from July to September 2012. Figures A.3-10 to A.3-18 show seasonal trends of select water quality parameters. Table A.3-3 presents the percentage of lake water quality samples in which parameter concentrations were higher than CCME guidelines, and Table A.3-4 provides the factor by which average 2012 concentrations were higher than CCME guidelines. Annex A.3-2 presents the raw lake water quality data.

A.3.3 Marine Data

Marine water quality data were collected in April (under-ice sampling) and monthly from July to September 2012. Figures A.3-19 to A.3-27 show seasonal trends of select water quality parameters. Annex A.3-3 presents the raw marine water quality data. Marine water quality data were screened against CCME guidelines for the protection of marine and estuarine aquatic life (CCME 2012b), and all measured parameters were below recommended CCME guidelines.

A.3.4 Quality Assurance/Quality Control (QA/QC) Data

Annex A.3-4 presents the results of the QA/QC blank data (equipment, fild, and travel blanks) collected to identify possible sources of contamination to water quality samples. There is no evidence of contamination based upon the equipment, field or travel blanks.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits.
Red dashed lines represent the CCME freshwater 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.

NEWMONT NORTH AMERICA

pH and Total Alkalinity in Stream Sites, Doris North Project, 2012

Figure A3-1

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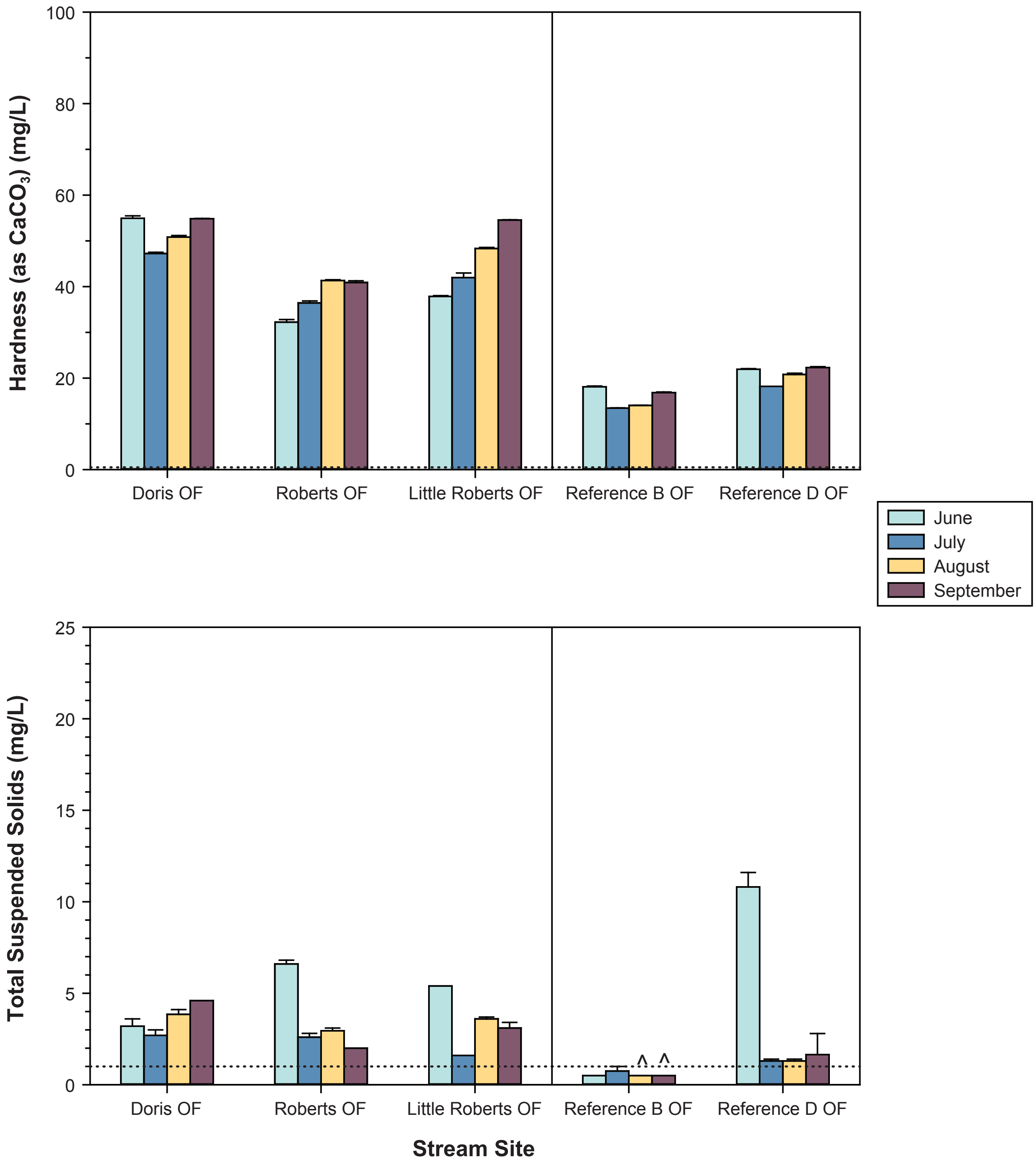


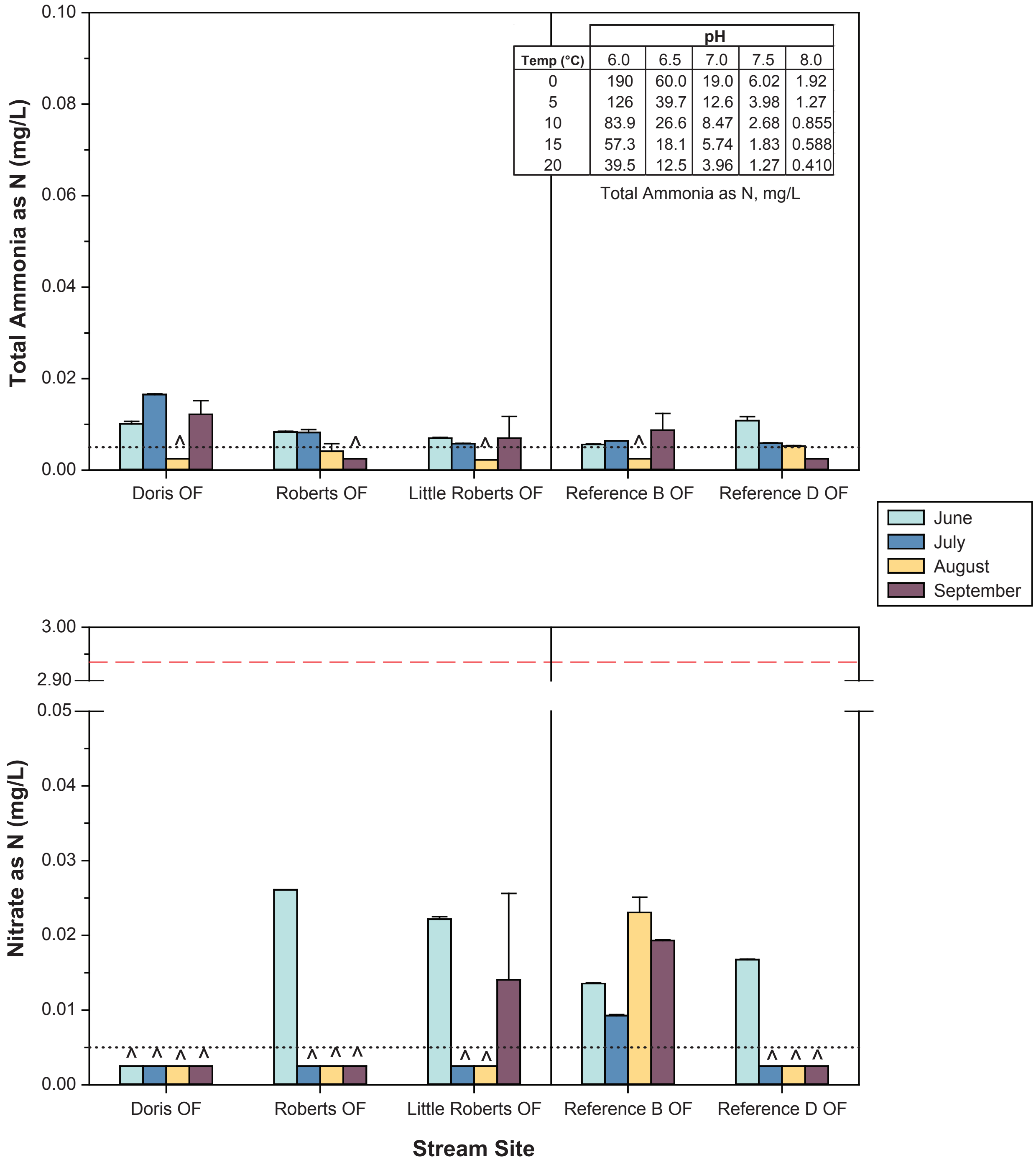
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for total suspended solids is dependent upon background levels.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

NEWMONT NORTH AMERICA

Hardness and Total Suspended Solids in Stream Sites, Doris North Project, 2012

Figure A3-2

Rescan Engineers & Scientists



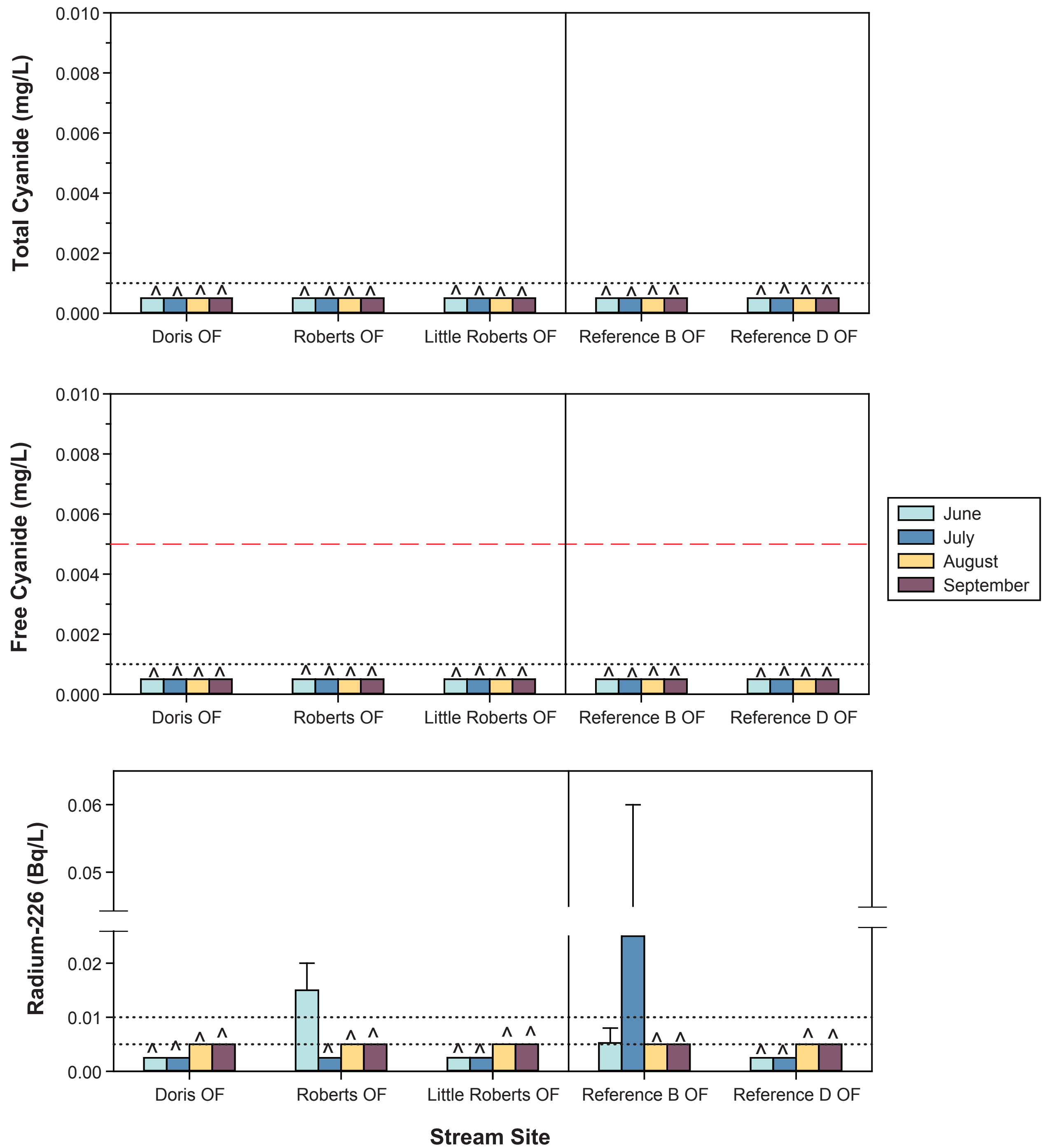
Temp (°C)	pH 6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Total Ammonia as N, mg/L

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that concentrations in all samples were below detection limits.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Red dashed line represents the interim CCME freshwater 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.

Figure A3-3

Total Ammonia and Nitrate Concentrations in Stream Sites, Doris North Project, 2012



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 applicable detection limit.
^ Indicates that total cyanide or free cyanide concentrations in all samples were below the detection limits.
Red dashed line represents the CCME freshwater guideline for free cyanide (0.005 mg/L).
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Stream Sites, Doris North Project, 2012

Figure A3-4

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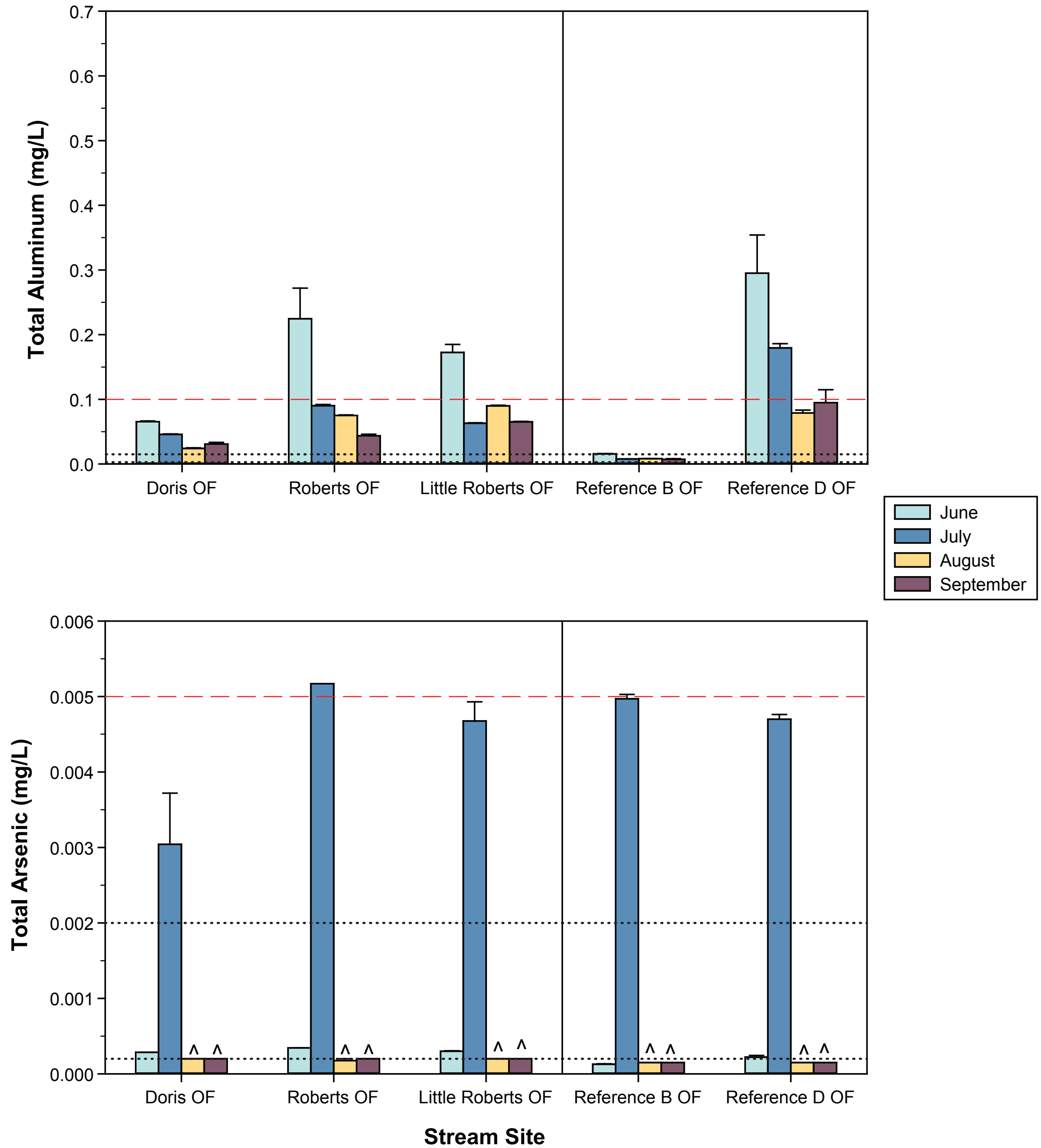

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5).
and the CCME freshwater guideline for arsenic (0.005 mg/L).
pH was greater than 6.5 in all stream samples.
^ Indicates that total arsenic concentrations in all sample were below the detection limit.
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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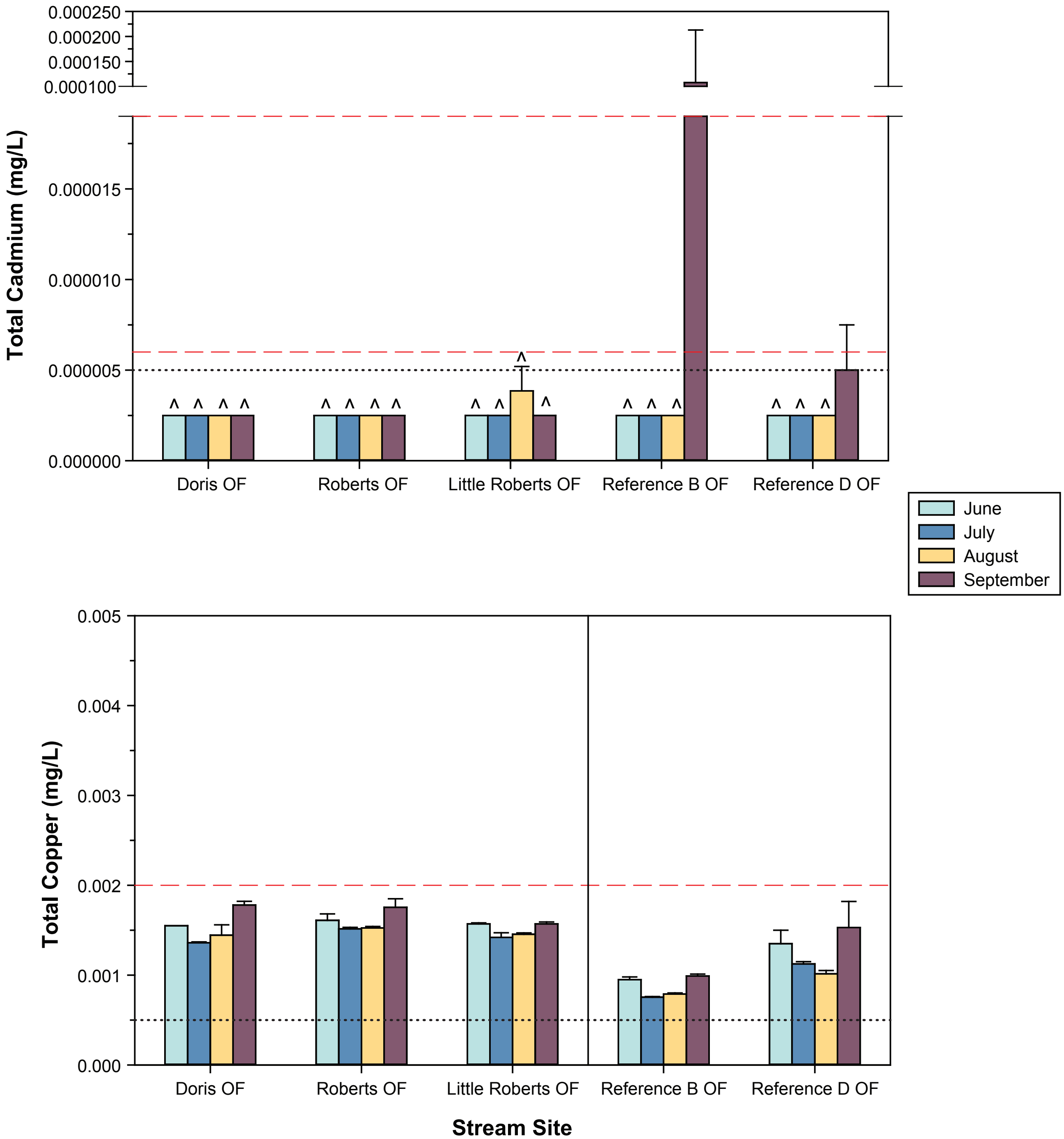
Total Aluminum and Total Arsenic Concentrations in Stream Sites, Doris North Project, 2012

Figure A3-5

Rescan Engineers & Scientists



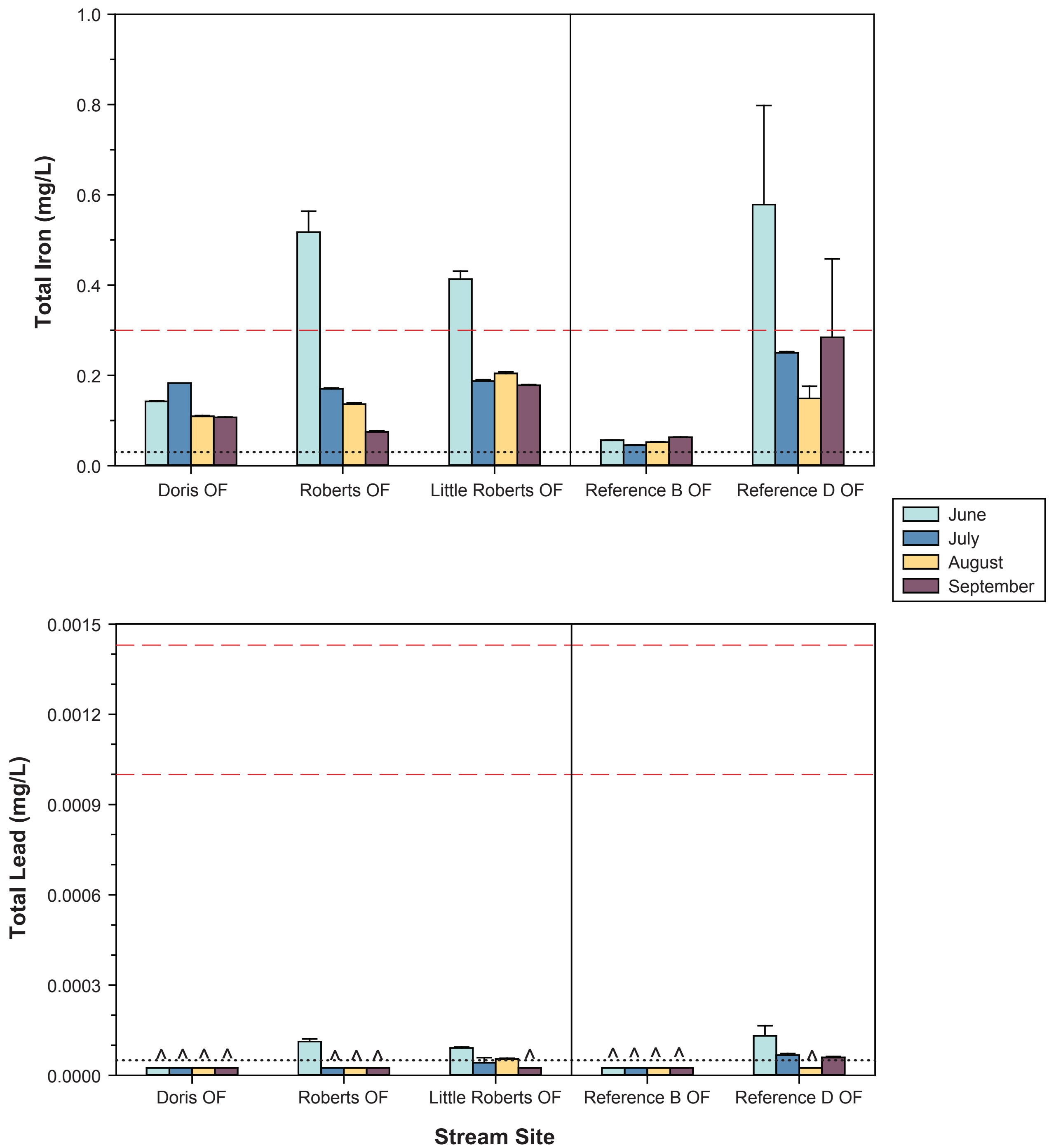
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum site-specific CCME freshwater guidelines for cadmium (0.000006 and 0.000019 mg/L) and for copper (0.002 mg/L) based on the hardness (as $CaCO_3$) range in streams of 13.2 to 53.4 mg/L.
^ Indicates that cadmium concentrations in all samples were below the dectection limit.
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.

NEWMONT NORTH AMERICA

Total Cadmium and Total Copper Concentrations in Stream Sites, Doris North Project, 2012

Figure A3-6

Rescan Engineers & Scientists



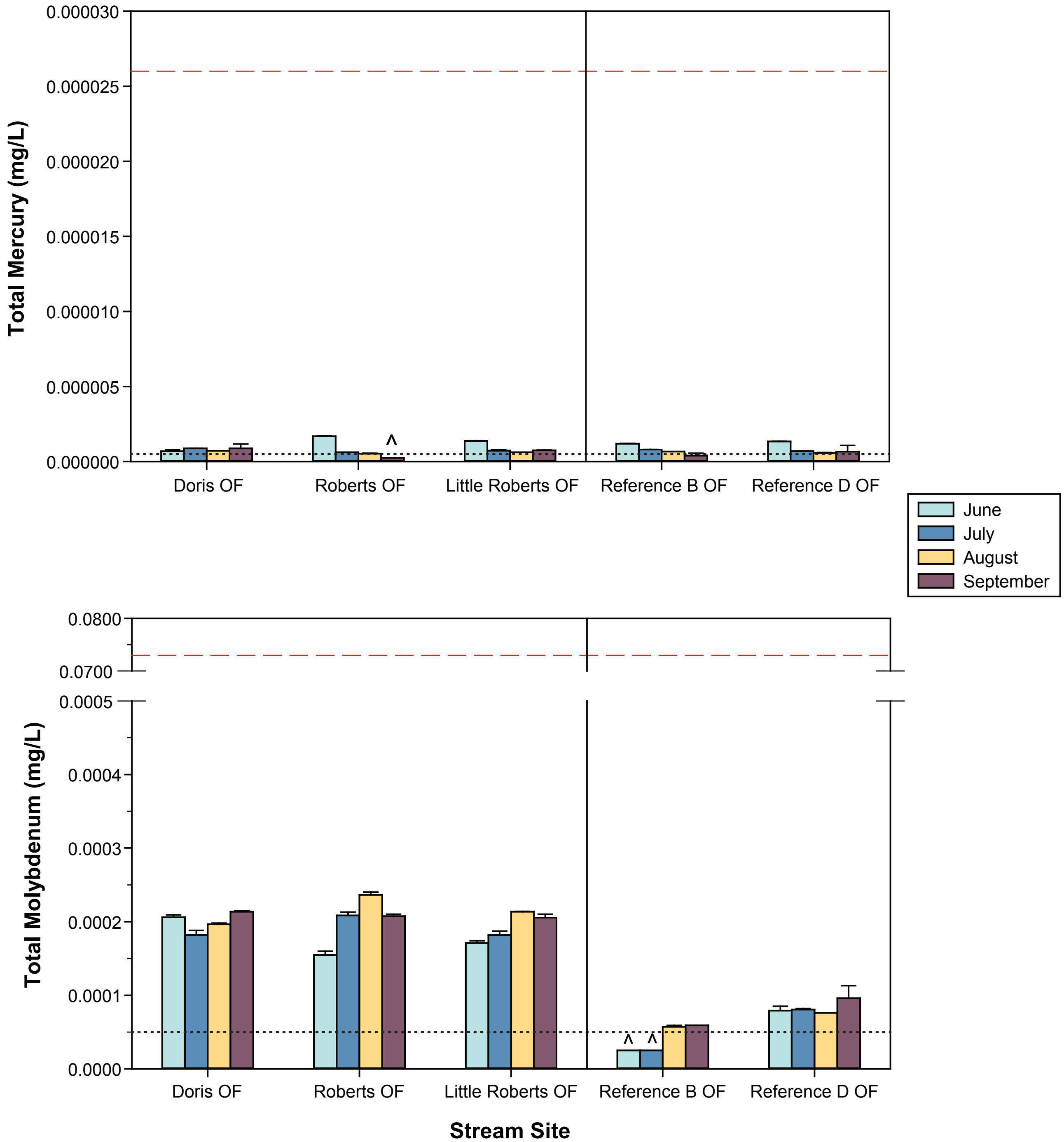
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L) and the minimum and maximum site-specific CCME freshwater guideline for lead (0.001 and 0.00143 mg/L) based on the hardness (as $CaCO_3$) range in streams of 13.2 to 53.4 mg/L.
^ Indicates that lead concentrations in all sample were below detection limits.
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.

NEWMONT NORTH AMERICA

Total Iron and Total Lead Concentrations in Stream Sites, Doris North Project, 2012

Figure A3-7

Rescan Engineers & Scientists



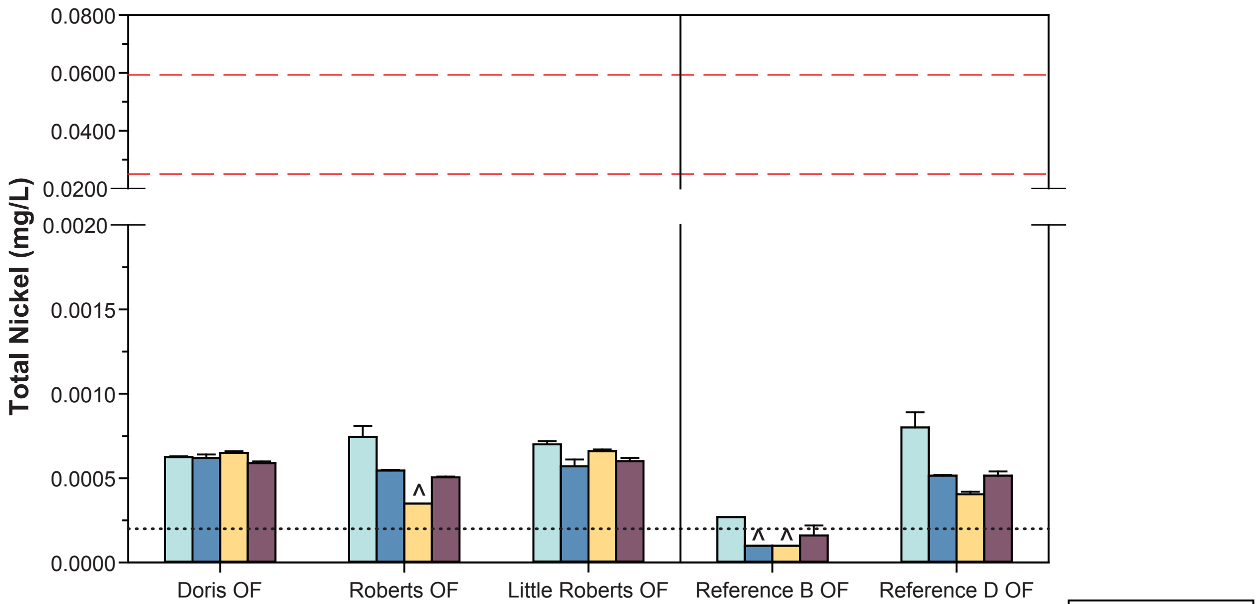
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater guidelines for inorganic mercury (0.000026 mg/L) 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.
^ indicates that concentrations in all samples were below detection limits.

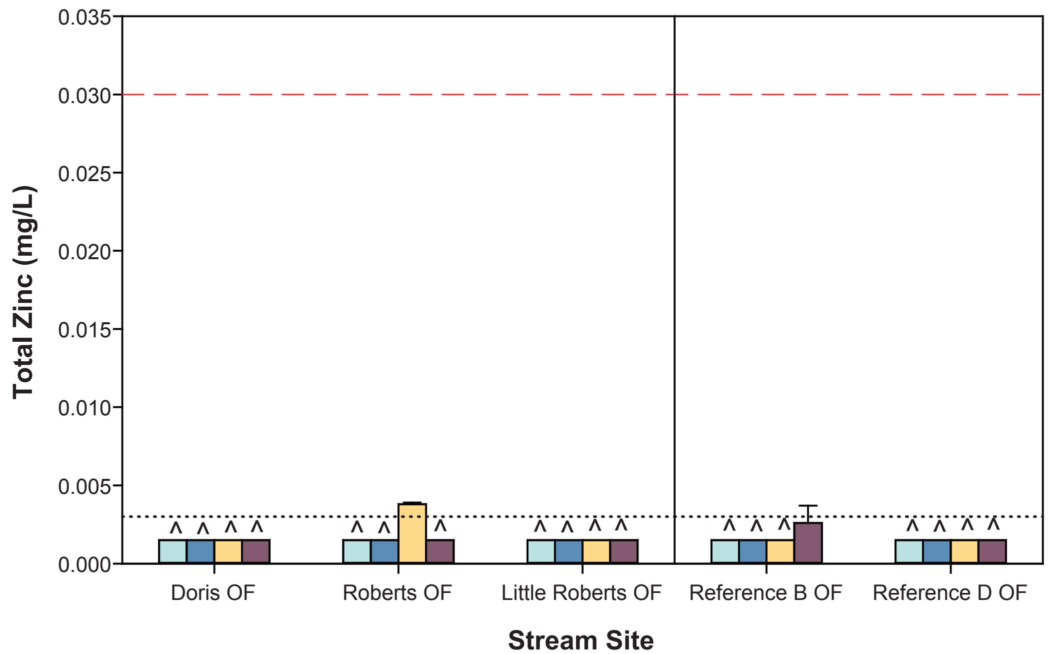
NEWMONT NORTH AMERICA

Total Mercury and Total Molybdenum Concentrations in Stream Sites, Doris North Project, 2012

Figure A3-8

Rescan Engineers & Scientists





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 applicable detection limit.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for zinc (0.03 mg/L) and the minimum and maximum site-specific CCME guideline for nickel (0.025 and 0.059 mg/L) based on the hardness (as CaCO3) range in streams of 13.2 to 53.4 mg/L.
^ indicates that values in all samples are below detection limits.
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 Stream Sites, Doris North Project, 2012

Figure A3-9

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Table A.3-1. Water Quality in Stream Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

			pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)	Arsenic (As)	Boron (B)	Cadmium (Cd)
Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	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]
Doris Outflow	8		0	0	0	0	0	0	Oligotrophic to Mesotrophic	0	0	0	0	0
Roberts Outflow	8		0	0	0	0	0	0	Oligotrophic to Mesotrophic	0	25	25	0	0
Little Roberts Outflow	8		0	0	0	0	0	0	Oligotrophic to Mesotrophic	0	25	0	0	0
Reference B Outflow	8		0	0	0	0	0	0	Ultra-oligotrophic	0	0	12.5	0	0
Reference D Outflow	8		0	0	0	0	0	0	Ultra-oligotrophic to Oligotrophic	0	62.5	0	0	0

			Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Zinc (Zn)
Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥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		0	0	0	0	0	0	0	25	0	0	0	0
Roberts Outflow	8		0	0	25	0	0	0	0	0	0	0	0	0
Little Roberts Outflow	8		0	0	25	0	0	0	0	12.5	0	0	0	0
Reference B Outflow	8		0	0	0	0	0	0	0	0	0	0	0	0
Reference D Outflow	8		0	0	37.5	0	0	0	0	0	0	0	0	0

Values represent the percentages of 2012 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) =* $10^{\{0.86[\log(hardness)]-3.2\}}$ */ 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.*

Table A.3-2. Water Quality in Stream Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)	Arsenic (As)	Boron (B)	Cadmium (Cd)
			6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	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]
Doris Outflow	8		-	-	-	-	-	-	Oligotrophic to Mesotrophic	-	-	-	-	-
Roberts Outflow	8		-	-	-	-	-	-	Oligotrophic to Mesotrophic	-	2.245	1.034	-	-
Little Roberts Outflow	8		-	-	-	-	-	-	Oligotrophic to Mesotrophic	-	1.725	-	-	-
Reference B Outflow	8		-	-	-	-	-	-	Ultra-oligotrophic	-	-	1.006	-	-
Reference D Outflow	8		-	-	-	-	-	-	Ultra-oligotrophic to Oligotrophic	-	2.070	-	-	-

Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Zinc (Zn)
			Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥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		-	-	-	-	-	-	-	1.185	-	-	-	-
Roberts Outflow	8		-	-	1.725	-	-	-	-	-	-	-	-	-
Little Roberts Outflow	8		-	-	1.378	-	-	-	-	1.14	-	-	-	-
Reference B Outflow	8		-	-	-	-	-	-	-	-	-	-	-	-
Reference D Outflow	8		-	-	1.794	-	-	-	-	-	-	-	-	-

Values represent the factor by which average 2012 concentrations are higher than CCME guidelines; dashes represent average 2012 concentrations that are below CCME guidelines.

The average 2012 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.

For hardness-dependent guidelines, the average hardness over all sampling periods was used to determine the site-specific CCME guideline.

[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.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2012

Site ID				Doris OF	Doris OF	Little Roberts OF	Little Roberts OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Doris OF	Doris OF	Little Roberts OF	Little Roberts OF
Depth Zone:				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
Date Sampled		CCME guideline for the	Realized Detection	16-JUN-12	16-JUN-12	16-JUN-12	16-JUN-12	16-JUN-12	16-JUN-12	16-JUN-12	16-JUN-12	16-JUN-12	16-JUN-12	21-JUL-12	21-JUL-12	21-JUL-12	21-JUL-12
ALS Sample ID	Units	Protection of Aquatic life[a]	Limit	L1164238-1	L1164238-2	L1164238-5	L1164238-6	L1164238-3	L1164238-4	L1164238-9	L1164238-10	L1164238-7	L1164238-8	L1182753-1	L1182753-2	L1182753-3	L1182753-4
Physical Tests																	
Conductivity	uS/cm		2.0	280	288	215	209	195	195	59.2	59.2	109	109	248	248	243	243
Hardness (as $CaCO_3$)	mg/L		0.50	54.4	55.5	37.7	38.1	32.8	31.7	17.9	18.3	21.8	22.1	47.5	47.0	41.0	43.0
pH	pH	6.5-9.0	0.10	7.87	7.88	7.85	7.86	7.55	7.86	7.86	7.86	7.87	7.84	7.61	7.50	7.60	7.61
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.8	3.6	5.4	5.4	6.4	6.8	<1.0	<1.0	10.0	11.6	3.0	2.4	1.6	1.6
Turbidity	NTU	dependent on background levels	0.10	4.16	4.80	7.97	7.73	9.32	9.28	0.44	0.71	12.7	13.1	3.35	3.17	2.50	2.84
Anions and Nutrients																	
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	32.9	33.0	22.3	22.2	18.7	18.8	14.5	14.3	14.6	14.3	28.8	29.0	26.6	26.8
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0107	0.0096	0.0074	0.0071	0.0082	0.0085	0.0057	0.0055	0.0100	0.0117	0.0167	0.0164	0.0061	0.0060
Bromide (Br)	mg/L		0.050	0.229	0.236	0.175	0.178	0.165	0.169	<0.050	<0.050	0.075	0.078	0.189	0.189	0.189	0.191
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	66.0	66.9	49.8	49.8	45.2	45.1	7.69	7.69	22.3	22.3	57.5	57.6	56.8	56.8
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.059	0.059	0.046	0.046	0.044	0.043	0.023	0.023	0.037	0.038	0.056	0.055	0.052	0.052
Nitrate (as N)	mg/L	2.935[b]	0.0050	<0.0050	<0.0050	0.0218	0.0225	0.0261	0.0261	0.0135	0.0136	0.0168	0.0167	<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
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0214	0.0333	0.0247	0.0252	0.0271	0.0276	0.0070	0.0068	0.0191	0.0201	0.0200	0.0185	0.0157	0.0156
Sulfate (SO_4)	mg/L		0.50	3.17	3.19	3.14	3.12	3.11	3.12	2.02	2.02	2.18	2.18	2.69	2.68	3.31	3.32
Cyanides																	
Cyanide, Total	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
Cyanide, Free	mg/L	0.005	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	6.36	6.78	6.12	6.04	5.89	5.87	3.93	4.05	7.90	5.15	5.08	5.07	4.98	4.92
Total Metals																	
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.003 to 0.021	0.0667	0.0643	0.185	0.160	0.272	0.177	0.0163	0.0152	0.236	0.354	0.0465	0.0452	0.0625	0.0637
Antimony (Sb)	mg/L		0.00001 to 0.00003	<0.000030	<0.000030	<0.000020	<0.000030	<0.000020	<0.000020	<0.000020	<0.000010	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Arsenic (As)	mg/L	0.005	0.00005 to 0.002	0.000284	0.000285	0.000305	0.000293	0.000345	0.000343	0.000134	0.000120	0.000199	0.000244	0.00236	0.00372	0.00442	0.00493
Barium (Ba)	mg/L		0.00010	0.00302	0.00302	0.00373	0.00359	0.00446	0.00362	0.00234	0.00239	0.00370	0.00495	0.00283	0.00283	0.00279	0.00300
Beryllium (Be)	mg/L		0.000005 or 0.00001	<0.0000050	0.0000084	0.0000080	0.0000074	0.0000136	0.0000119	<0.0000050	<0.0000050	0.0000128	0.0000164	<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
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005 to 0.035	0.0262	0.0277	0.0244	0.0241	0.0237	0.0218	0.0105	0.0074	0.0165	0.0170	0.0235	0.0229	0.0228	0.0246
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	10.3	10.5	6.02	6.15	4.63	4.47	4.39	4.47	3.42	3.47	8.83	8.73	7.07	7.43
Cesium (Cs)	mg/L		0.000005 or 0.00001	<0.0000050	<0.0000050	0.0000134	0.0000119	0.0000183	0.0000129	<0.0000050	<0.0000050	0.0000158	0.0000266	<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	0.00059	<0.00050	<0.00050	<0.00050	0.00055	0.00076	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000067	0.000070	0.000134	0.000121	0.000181	0.000146	<0.000050	<0.000050	0.000100	0.000238	0.000050	0.000054	0.000057	0.000057
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00155	0.00155	0.00156	0.00158	0.00168	0.00154	0.00092	0.00098	0.00120	0.00150	0.00135	0.00137	0.00137	0.00147
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	0.000058	<0.000050	0.000082	0.000052	<0.000050	<0.000050	0.000073	0.000121	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.141	0.144	0.431	0.396	0.564	0.471	0.057	0.056	0.359	0.798	0.183	0.183	0.184	0.191
Lead (Pb)	mg/L	≥0.001[f]	0.000050	<0.000050	<0.000050	0.000088	0.000094	0.000121	0.000104	<0.000050	<0.000050	0.000098	0.000165	<0.000050	<0.000050	<0.000050	0.000059
Lithium (Li)	mg/L		0.00020	0.00402	0.00420	0.00283	0.00279	0.00242	0.00227	0.00061	0.00057	0.00166	0.00186	0.00361	0.00377	0.00316	0.00327
Magnesium (Mg)	mg/L		0.10	6.99	7.14	5.50	5.53	5.15	4.98	1.68	1.72	3.23	3.27	6.17	6.13	5.66	5.94
Manganese (Mn)	mg/L		0.00020	0.0126	0.0132	0.0292	0.0286	0.0407	0.0391	0.00575	0.00582	0.00772	0.0273	0.0179	0.0182	0.0128	0.0142
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000209	0.000203	0.000168	0.000174	0.000160	0.000149	<0.000050	<0.000050	0.000073	0.000085	0.000176	0.000188	0.000177	0.000187
Nickel (Ni)	mg/L	≥0.025[g]	0.0002 to 0.0007	0.00063	0.00062	0.00072	0.00068	0.00081	0.00068	0.00027	0.00027	0.00071	0.00089	0.00060	0.00064	0.00053	0.00061
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
Potassium (K)	mg/L		2.0	2.4	2.5	2.1	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.2	2.2	<2.0	2.1
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
Rubidium (Rb)	mg/L		0.0000020	0.00154	0.00152	0.00144	0.00141	0.00161	0.00136	0.000961	0.000961	0.00138	0.00174	0.00132	0.00132	0.00128	0.00132
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	0.00111	0.00126	0.00114	0.00087
Silicon (Si)	mg/L		0.050	1.53	1.55	1.43	1.39	1.56	1.31	0.284	0.295	0.892	1.11	1.26	1.26	0.894	0.914
Silver (Ag)	mg/L	0.0001	0.000005 or 0.00001	<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	33.1	34.0	26.6	26.7	25.0	24.3	4.3	4.5	12.3	12.3	28.8	28.6	27.1	28.6
Strontium (Sr)	mg/L		0.000050	0.0455	0.0454	0.0306	0.0306	0.0264	0.0253	0.0189	0.0191	0.0185	0.0190	0.0355	0.0352	0.0318	0.0331
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
Thallium (Tl)	mg/L	0.0008	0.000002 or 0.00002	0.0000020	<0.0000020	0.0000028	0.0000032	0.0000053	0.0000028	0.0000036	<0.0000020	0.0000036	0.0000067	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.000005 or 0.000035	0.0000247	0.0000265	0.0000838	0.0000765	0.000118	0.0000873	0.0000181	0.0000142	0.000109	0.000175	0.0000204	0.0000210	0.0000275	0.0000294
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
Titanium (Ti)	mg/L		0.00020	0.00226	0.00230	0.00753	0.00622	0.0117	0.00685	0.00039	0.00038	0.0108	0.0173	0.00159	0.00132	0.00213	0.00223

(continued)

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2012 (continued)

Site ID Depth Zone: Replicate Date Sampled ALS Sample ID	Units	CCME guideline for the Protection of Aquatic life[a]	Realized Detection Limit	Doris OF Surface 1 16-JUN-12 L1164238-1	Doris OF Surface 2 16-JUN-12 L1164238-2	Little Roberts OF Surface 1 16-JUN-12 L1164238-5	Little Roberts OF Surface 2 16-JUN-12 L1164238-6	Roberts OF Surface 1 16-JUN-12 L1164238-3	Roberts OF Surface 2 16-JUN-12 L1164238-4	Reference B OF Surface 1 16-JUN-12 L1164238-9	Reference B OF Surface 2 16-JUN-12 L1164238-10	Reference D OF Surface 1 16-JUN-12 L1164238-7	Reference D OF Surface 2 16-JUN-12 L1164238-8	Doris OF Surface 1 21-JUL-12 L1182753-1	Doris OF Surface 2 21-JUL-12 L1182753-2	Little Roberts OF Surface 1 21-JUL-12 L1182753-3	Little Roberts OF Surface 2 21-JUL-12 L1182753-4
Total Metals *(cont'd)*																	
Tungsten (W)	mg/L		0.000010	0.000011	<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	short-term: 0.033; long-term: 0.015	0.0000020	0.0000369	0.0000398	0.0000549	0.0000505	0.0000638	0.0000575	0.0000585	0.0000590	0.0000619	0.0000843	0.0000347	0.0000317	0.0000394	0.0000415
Vanadium (V)	mg/L		0.000050	0.000199	0.000199	0.000469	0.000425	0.000661	0.000489	0.000054	<0.000050	0.000618	0.000927	0.000162	0.000163	0.000196	0.000208
Yttrium (Y)	mg/L		0.0000050	0.0000396	0.0000415	0.000101	0.0000988	0.000128	0.000109	0.0000240	0.0000265	0.000101	0.000193	0.0000340	0.0000320	0.0000384	0.0000378
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
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	0.000094	0.000094	0.000123	0.000094	<0.000050	<0.000050	0.000087	0.000122	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry																	
Radium-226	Bq/L	0.005	0.005														

Notes:

(continued)

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 2012.*

[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) =* $10^{\{0.86[\log(hardness)]-3.2\}}/1000$.

[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 minimum 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.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2012 (continued)

Site ID				Roberts OF	Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Doris OF	Doris OF	Little Roberts OF	Little Roberts OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF
Depth Zone:				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
Date Sampled		CCME guideline for the	Realized Detection	21-JUL-12	21-JUL-12	21-JUL-12	21-JUL-12	21-JUL-12	21-JUL-12	25-AUG-12	25-AUG-12	24-AUG-12	24-AUG-12	22-AUG-12	22-AUG-12	25-AUG-12	25-AUG-12
ALS Sample ID	Units	Protection of Aquatic life[a]	Limit	L1182753-5	L1182753-6	L1182753-9	L1182753-10	L1182753-7	L1182753-8	L1200996-3	L1200996-4	L1200996-1	L1200996-2	L1199725-1	L1199725-2	L1200996-5	L1200996-6
Physical Tests																	
Conductivity	uS/cm		2.0	227	227	44.1	44.0	93.7	94.0	259	259	268	267	237	236	49.8	45.2
Hardness (as $CaCO_3$)	mg/L		0.50	36.0	36.9	13.5	13.4	18.2	18.2	51.2	50.5	48.1	48.6	41.5	41.2	14.0	14.1
pH	pH	6.5-9.0	0.10	7.56	7.56	7.33	7.33	7.40	7.37	7.87	7.86	7.82	7.83	7.57	7.57	7.60	7.27
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.8	2.4	1.0	<1.0	1.4	1.2	4.1	3.6	3.7	3.5	3.1	2.8	<1.0	<1.0
Turbidity	NTU	dependent on background levels	0.10	3.25	3.54	0.34	0.38	4.75	4.68	4.80	5.56	4.66	5.40	2.40	2.11	0.44	0.39
Anions and Nutrients																	
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	21.5	21.1	10.5	10.0	12.1	12.1	29.5	29.7	27.2	26.8	22.0	21.8	10.3	10.6
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0089	0.0076	0.0064	0.0064	0.0060	0.0058	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0058	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.187	0.183	<0.050	<0.050	0.059	0.062	0.192	0.195	0.211	0.209	0.198	0.196	<0.050	<0.050
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	54.2	54.3	6.27	6.28	19.8	19.8	58.8	58.6	62.4	62.3	57.1	57.1	7.02	6.94
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.046	0.047	0.020	0.020	0.035	0.035	0.058	0.057	0.055	0.055	0.048	0.048	0.022	0.022
Nitrate (as N)	mg/L	2.935[b]	0.0050	<0.0050	<0.0050	0.0091	0.0094	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0251	0.0210
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
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0172	0.0151	0.0039	0.0044	0.0082	0.0154	0.0210	0.0215	0.0200	0.0191	0.0181	0.0180	0.0049	0.0057
Sulfate (SO_4)	mg/L		0.50	4.13	4.14	1.65	1.64	1.88	1.87	3.00	2.98	4.06	4.04	4.57	4.61	1.84	1.81
Cyanides																	
Cyanide, Total	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
Cyanide, Free	mg/L	0.005	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	4.58	4.59	2.76	2.67	3.77	3.62	5.79	5.24	5.09	5.44	4.49	4.63	2.78	2.64
Total Metals																	
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.003 to 0.021	0.0920	0.0885	0.0080	0.0078	0.173	0.186	0.0250	0.0234	0.0908	0.0892	0.0742	0.0760	0.0084	0.0082
Antimony (Sb)	mg/L		0.00001 to 0.00003	<0.000020	<0.000020	<0.000010	<0.000010	<0.000020	<0.000020	0.000017	0.000017	0.000019	0.000017	0.000017	0.000016	0.000010	<0.000010
Arsenic (As)	mg/L	0.005	0.00005 to 0.002	0.00517	0.00517	0.00491	0.00503	0.00464	0.00476	<0.00040	<0.00040	<0.00040	<0.00040	<0.00030	<0.00040	<0.00030	<0.00030
Barium (Ba)	mg/L		0.00010	0.00286	0.00285	0.00146	0.00143	0.00299	0.00315	0.00305	0.00303	0.00346	0.00343	0.00303	0.00307	0.00155	0.00148
Beryllium (Be)	mg/L		0.000005 or 0.00001	0.0000057	<0.0000050	<0.0000050	<0.0000050	0.0000051	<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
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005 to 0.035	0.0257	0.0249	0.0065	0.0061	0.0126	0.0127	0.0297	0.0267	0.0309	0.0298	0.0354	0.0342	<0.015	<0.010
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
Calcium (Ca)	mg/L		0.050	5.27	5.35	3.32	3.30	2.85	2.86	9.48	9.38	8.39	8.24	6.08	5.91	3.38	3.39
Cesium (Cs)	mg/L		0.000005 or 0.00001	0.0000055	<0.0000050	<0.0000050	<0.0000050	0.0000108	0.0000112	<0.0000050	<0.0000050	0.0000071	0.0000069	0.0000054	0.0000052	<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	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	0.000053	<0.000050	<0.000050	0.000079	0.000081	<0.000050	<0.000050	0.000066	0.000073	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00150	0.00153	0.00075	0.00076	0.00110	0.00115	0.00133	0.00156	0.00144	0.00147	0.00151	0.00154	0.00078	0.00080
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000058	0.000062	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.169	0.172	0.046	0.045	0.247	0.253	0.111	0.108	0.208	0.201	0.140	0.133	0.053	0.051
Lead (Pb)	mg/L	≥0.001[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000062	0.000073	<0.000050	<0.000050	0.000057	0.000052	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00254	0.00242	0.00056	0.00052	0.00159	0.00155	0.00390	0.00382	0.00358	0.00363	0.00259	0.00254	0.00059	0.00057
Magnesium (Mg)	mg/L		0.10	5.55	5.72	1.26	1.26	2.69	2.69	6.69	6.56	6.60	6.80	6.40	6.42	1.35	1.37
Manganese (Mn)	mg/L		0.00020	0.0112	0.0112	0.00194	0.00205	0.00739	0.00718	0.0178	0.0177	0.0121	0.0120	0.0129	0.0123	0.00309	0.00278
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000204	0.000213	<0.000050	<0.000050	0.000082	0.000079	0.000195	0.000198	0.000214	0.000213	0.000233	0.000240	0.000059	0.000055
Nickel (Ni)	mg/L	≥0.025[g]	0.0002 to 0.0007	0.00055	0.00054	<0.00020	<0.00020	0.00052	0.00051	0.00066	0.00064	0.00067	0.00065	<0.00070	<0.00070	<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
Potassium (K)	mg/L		2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.5	2.5	2.3	2.6	2.1	2.3	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.0000020	0.00127	0.00127	0.000745	0.000723	0.00126	0.00132	0.00143	0.00140	0.00152	0.00155	0.00156	0.00152	0.000801	0.000818
Selenium (Se)	mg/L	0.001	0.00020	0.00079	0.00076	0.00055	0.00049	0.00062	0.00065	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	0.594	0.590	0.132	0.132	0.494	0.534	1.23	1.20	0.987	0.954	0.481	0.470	0.109	0.105
Silver (Ag)	mg/L	0.0001	0.000005 or 0.00001	<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	28.3	29.2	3.4	3.4	10.6	10.7	27.3	29.1	31.0	31.4	32.8	32.0	3.9	3.9
Strontium (Sr)	mg/L		0.000050	0.0285	0.0290	0.0132	0.0129	0.0148	0.0148	0.0415	0.0420	0.0416	0.0406	0.0379	0.0370	0.0153	0.0149
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
Thallium (Tl)	mg/L	0.0008	0.000002 or 0.00002	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000022	0.0000021	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000020	<0.000020	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.000005 or 0.000035	0.0000378	0.0000363	0.0000122	0.0000076	0.0000658	0.0000635	0.0000109	0.0000096	0.0000293	0.0000320	0.0000302	0.0000326	0.0000052	0.0000056
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
Titanium (Ti)	mg/L		0.00020	0.00317	0.00306	<0.00020	<0.00020	0.00710	0.00713	0.00063	0.00061	0.00354	0.00324	0.00274	0.00275	0.00022	<0.00020

(continued)

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2012 (continued)

Site ID				Roberts OF	Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Doris OF	Doris OF	Little Roberts OF	Little Roberts OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF
Depth Zone:				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
Date Sampled		CCME guideline for the	Realized Detection	21-JUL-12	21-JUL-12	21-JUL-12	21-JUL-12	21-JUL-12	21-JUL-12	25-AUG-12	25-AUG-12	24-AUG-12	24-AUG-12	22-AUG-12	22-AUG-12	25-AUG-12	25-AUG-12
ALS Sample ID	Units	Protection of Aquatic life[a]	Limit	L1182753-5	L1182753-6	L1182753-9	L1182753-10	L1182753-7	L1182753-8	L1200996-3	L1200996-4	L1200996-1	L1200996-2	L1199725-1	L1199725-2	L1200996-5	L1200996-6
Total Metals *(cont'd)*																	
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000010	0.000012	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000506	0.0000511	0.0000398	0.0000376	0.0000519	0.0000506	0.0000344	0.0000331	0.0000447	0.0000453	0.0000570	0.0000553	0.0000420	0.0000429
Vanadium (V)	mg/L		0.000050	0.000242	0.000227	<0.000050	<0.000050	0.000398	0.000396	0.000118	0.000126	0.000281	0.000263	0.000181	0.000169	<0.000050	<0.000050
Yttrium (Y)	mg/L		0.0000050	0.0000478	0.0000512	0.0000117	0.0000111	0.0000608	0.0000605	0.0000183	0.0000187	0.0000406	0.0000395	0.0000417	0.0000401	0.0000130	0.0000125
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	0.0039	0.0037	<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	0.000056	0.000053	0.000050	0.000062	<0.000050	<0.000050
Radiochemistry																	
Radium-226	Bq/L	0.005	0.005														

Notes:

(continued)

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 2012.*

[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) =* $10^{\{0.86[\log(hardness)]-3.2\}}$ */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 minimum 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.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2012 (continued)

Site ID				Reference D OF	Reference D OF	Doris OF	Doris OF	Little Roberts OF	Little Roberts OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF
Depth Zone:				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
Date Sampled		CCME guideline for the	Realized Detection	21-AUG-12	21-AUG-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12
ALS Sample ID	Units	Protection of Aquatic life[a]	Limit	L1198204-6	L1198204-7	L1213168-1	L1213168-2	L1213168-5	L1213168-6	L1213168-3	L1213168-4	L1213168-9	L1213168-10	L1213168-7	L1213168-8
Physical Tests															
Conductivity	uS/cm		2.0	109	109	274	273	288	291	242	243	53.9	53.6	116	117
Hardness (as $CaCO_3$)	mg/L		0.50	20.5	21.1	54.9	54.8	54.5	54.6	41.3	40.5	16.7	17.0	22.5	22.1
pH	pH	6.5-9.0	0.10	7.36	7.31	7.79	7.74	7.69	7.70	7.64	7.64	7.38	7.38	7.38	7.40
Total Suspended Solids	mg/L	dependent on background levels	1.0	1.2	1.4	4.6	4.6	2.8	3.4	2.0	2.0	<1.0	<1.0	2.8	<1.0
Turbidity	NTU	dependent on background levels	0.10	1.64	2.18	5.66	5.12	4.55	4.60	1.68	1.68	0.39	0.36	1.48	1.01
Anions and Nutrients															
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	12.5	12.5	29.0	28.4	27.0	26.7	21.8	21.8	11.7	11.7	12.6	12.8
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0051	0.0054	0.0152	0.0092	<0.0050	0.0120	<0.0050	<0.0050	0.0051	0.0124	<0.0050	<0.0050
Bromide (Br)	mg/L		0.050	0.073	0.074	0.217	0.222	0.232	0.231	0.210	0.208	<0.050	<0.050	0.083	0.080
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	24.1	24.0	64.8	64.8	69.4	70.2	59.0	58.7	7.73	7.71	25.8	25.8
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.039	0.038	0.056	0.056	0.054	0.054	0.049	0.048	0.022	0.022	0.039	0.038
Nitrate (as N)	mg/L	2.935[b]	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0256	<0.0050	<0.0050	0.0194	0.0192	<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
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0081	0.0100	0.0282	0.0275	0.0230	0.0294	0.0136	0.0143	0.0057	0.0073	0.0097	0.0078
Sulfate (SO_4)	mg/L		0.50	2.31	2.29	3.49	3.48	5.07	5.20	4.80	4.75	2.16	2.16	2.61	2.60
Cyanides															
Cyanide, Total	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
Cyanide, Free	mg/L	0.005	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	4.18	4.10	7.06	7.17	5.98	6.00	5.24	5.00	3.37	3.49	4.44	4.39
Total Metals															
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.003 to 0.021	0.0745	0.0833	0.0285	0.0335	0.0645	0.0660	0.0412	0.0462	0.0082	0.0066	0.115	0.0486
Antimony (Sb)	mg/L		0.00001 to 0.00003	0.000010	0.000011	0.000020	0.000019	0.000019	0.000018	0.000018	0.000018	<0.000010	0.000010	0.000013	0.000014
Arsenic (As)	mg/L	0.005	0.00005 to 0.002	<0.00030	<0.00030	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00030	<0.00030	<0.00030	<0.00030
Barium (Ba)	mg/L		0.00010	0.00216	0.00235	0.00328	0.00320	0.00361	0.00347	0.00272	0.00274	0.00173	0.00162	0.00279	0.00210
Beryllium (Be)	mg/L		0.000005 or 0.00001	<0.0000050	<0.0000050	<0.000010	<0.000010	<0.000010	<0.0000050	<0.0000050	<0.000010	<0.0000050	<0.0000050	<0.000010	<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
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005 to 0.035	<0.020	<0.020	<0.030	<0.035	<0.035	<0.035	<0.030	<0.030	<0.010	<0.015	<0.020	<0.020
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	0.000213	<0.0000050	<0.0000050	0.0000075
Calcium (Ca)	mg/L		0.050	3.12	3.21	10.2	10.1	9.37	9.37	6.03	5.92	4.10	4.19	3.44	3.37
Cesium (Cs)	mg/L		0.000005 or 0.00001	<0.0000050	0.0000050	<0.0000050	<0.0000050	0.0000058	0.0000054	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000077	<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
Cobalt (Co)	mg/L		0.000050	<0.000050	0.000059	0.000058	0.000058	0.000058	0.000055	<0.000050	<0.000050	<0.000050	<0.000050	0.000213	0.000090
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00098	0.00105	0.00182	0.00174	0.00155	0.00159	0.00166	0.00185	0.00097	0.00101	0.00124	0.00182
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
Iron (Fe)	mg/L	0.3	0.030	0.122	0.176	0.106	0.108	0.180	0.176	0.073	0.077	0.062	0.064	0.458	0.111
Lead (Pb)	mg/L	≥0.001[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000056	0.000063
Lithium (Li)	mg/L		0.00020	0.00141	0.00145	0.00414	0.00424	0.00376	0.00373	0.00270	0.00259	0.00054	0.00060	0.00172	0.00159
Magnesium (Mg)	mg/L		0.10	3.09	3.18	7.18	7.16	7.54	7.58	6.38	6.25	1.56	1.59	3.39	3.31
Manganese (Mn)	mg/L		0.00020	0.00482	0.00623	0.0209	0.0215	0.0104	0.0104	0.00680	0.00686	0.00384	0.00221	0.0124	0.00820
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000076	0.000076	0.000212	0.000215	0.000201	0.000210	0.000205	0.000210	0.000059	0.000059	0.000079	0.000113
Nickel (Ni)	mg/L	≥0.025[g]	0.0002 to 0.0007	0.00039	0.00042	0.00058	0.00060	0.00058	0.00062	0.00050	0.00051	0.00022	<0.00020	0.00054	0.00049
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
Potassium (K)	mg/L		2.0	<2.0	<2.0	2.5	2.4	2.5	2.5	2.2	2.1	<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
Rubidium (Rb)	mg/L		0.000020	0.00110	0.00115	0.00160	0.00160	0.00160	0.00156	0.00138	0.00137	0.000827	0.000861	0.00125	0.00110
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
Silicon (Si)	mg/L		0.050	0.279	0.324	1.43	1.43	1.04	1.04	0.384	0.391	0.110	0.123	0.520	0.280
Silver (Ag)	mg/L	0.0001	0.000005 or 0.00001	<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	13.6	13.7	33.4	33.3	36.2	36.4	32.6	32.0	4.2	4.3	14.0	13.9
Strontium (Sr)	mg/L		0.000050	0.0174	0.0178	0.0460	0.0461	0.0469	0.0473	0.0353	0.0339	0.0164	0.0167	0.0191	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
Thallium (Tl)	mg/L	0.0008	0.000002 or 0.00002	<0.0000020	<0.0000020	0.0000036	0.0000023	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000020	<0.0000020
Thorium (Th)	mg/L		0.000005 or 0.000035	0.0000290	0.0000334	0.0000102	0.0000112	0.0000258	0.0000258	0.0000204	0.0000219	0.0000070	0.0000060	0.0000549	0.0000251
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
Titanium (Ti)	mg/L		0.00020	0.00217	0.00277	0.00092	0.00104	0.00229	0.00210	0.00139	0.00163	0.00025	<0.00020	0.00403	0.00126

(continued)

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2012 (completed)

Site ID				Reference D OF	Reference D OF	Doris OF	Doris OF	Little Roberts OF	Little Roberts OF	Roberts OF	Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF
Depth Zone:				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
Date Sampled		CCME guideline for the	Realized Detection	21-AUG-12	21-AUG-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12	20-SEP-12
ALS Sample ID	Units	Protection of Aquatic life[a]	Limit	L1198204-6	L1198204-7	L1213168-1	L1213168-2	L1213168-5	L1213168-6	L1213168-3	L1213168-4	L1213168-9	L1213168-10	L1213168-7	L1213168-8
Total Metals *(cont'd)*															
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
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000528	0.0000567	0.0000374	0.0000368	0.0000402	0.0000411	0.0000510	0.0000495	0.0000661	0.0000676	0.0000708	0.0000566
Vanadium (V)	mg/L		0.000050	0.000145	0.000200	0.000135	0.000139	0.000169	0.000181	0.000115	0.000120	<0.000050	<0.000050	0.000311	0.000111
Yttrium (Y)	mg/L		0.0000050	0.0000294	0.0000361	0.0000200	0.0000204	0.0000338	0.0000336	0.0000299	0.0000300	0.0000160	0.0000152	0.0000749	0.0000347
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0037	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	0.000055	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000056	<0.000050
Radiochemistry															
Radium-226	Bq/L	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 2012.*

[b] *Interim guideline.*

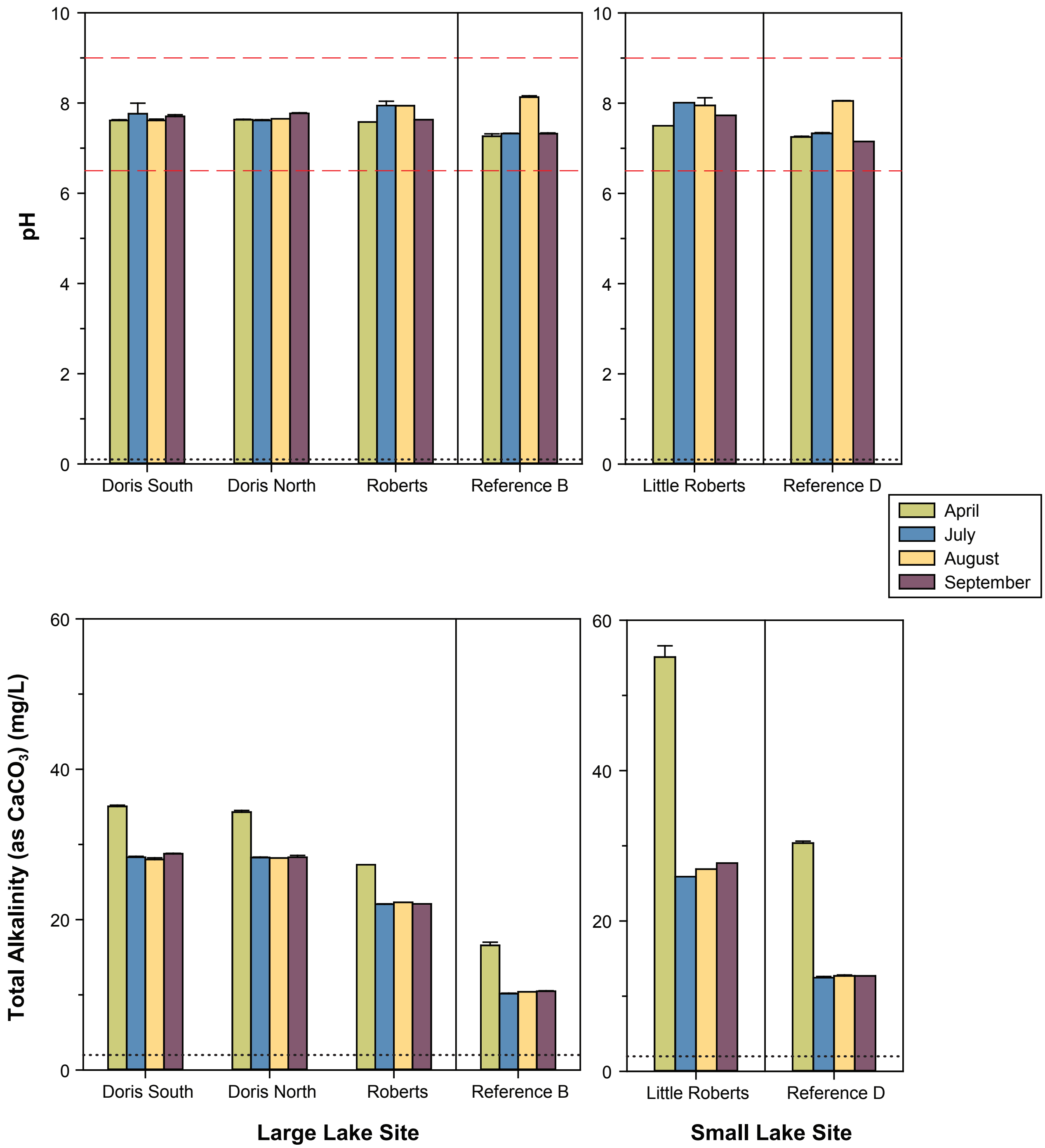
[c] *Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.*

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



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits.
Red dashed lines represent the CCME freshwater 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.

Figure A3-10

pH and Total Alkalinity in Lake Sites, Doris North Project, 2012

NEWMONT NORTH AMERICA

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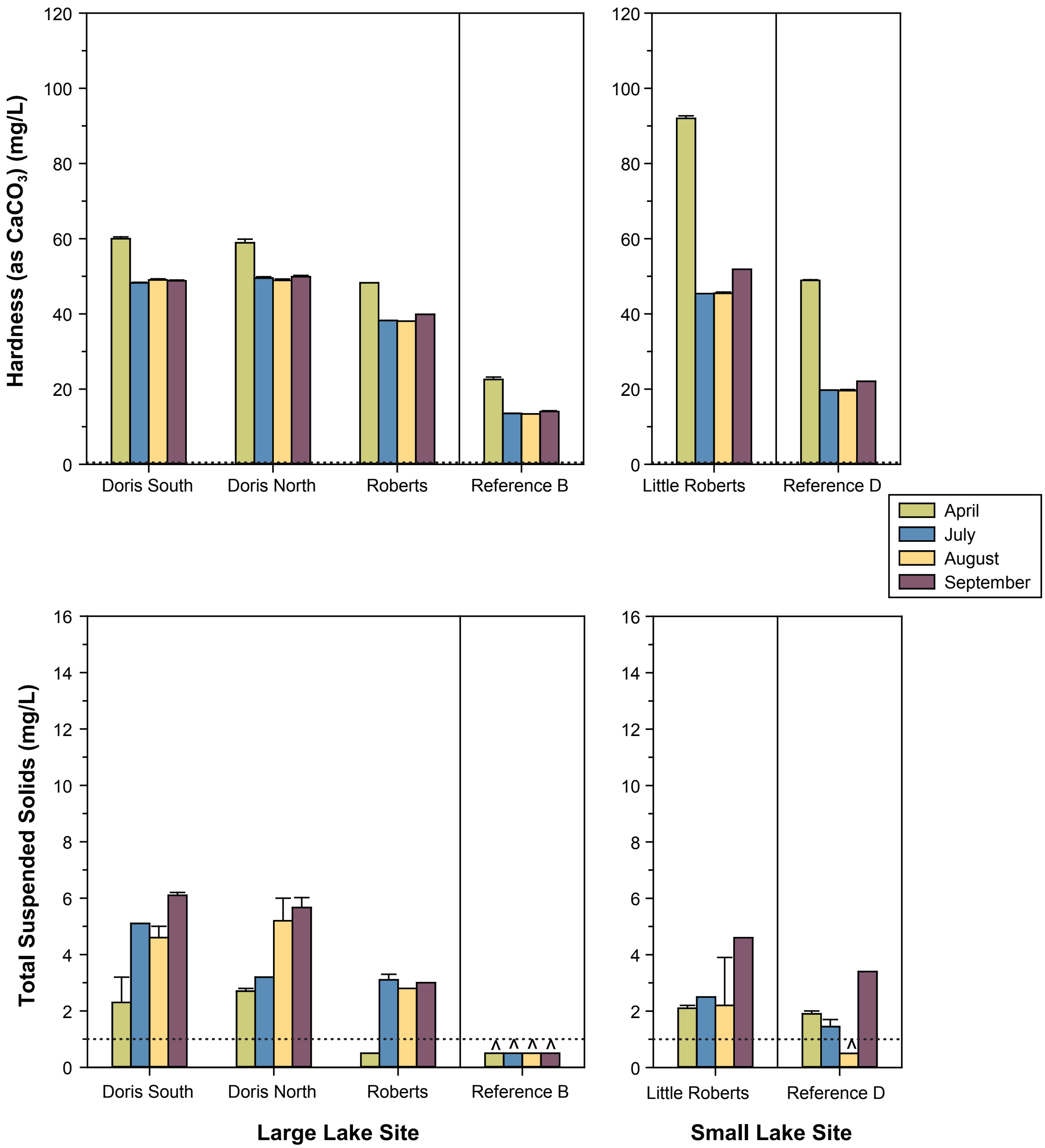


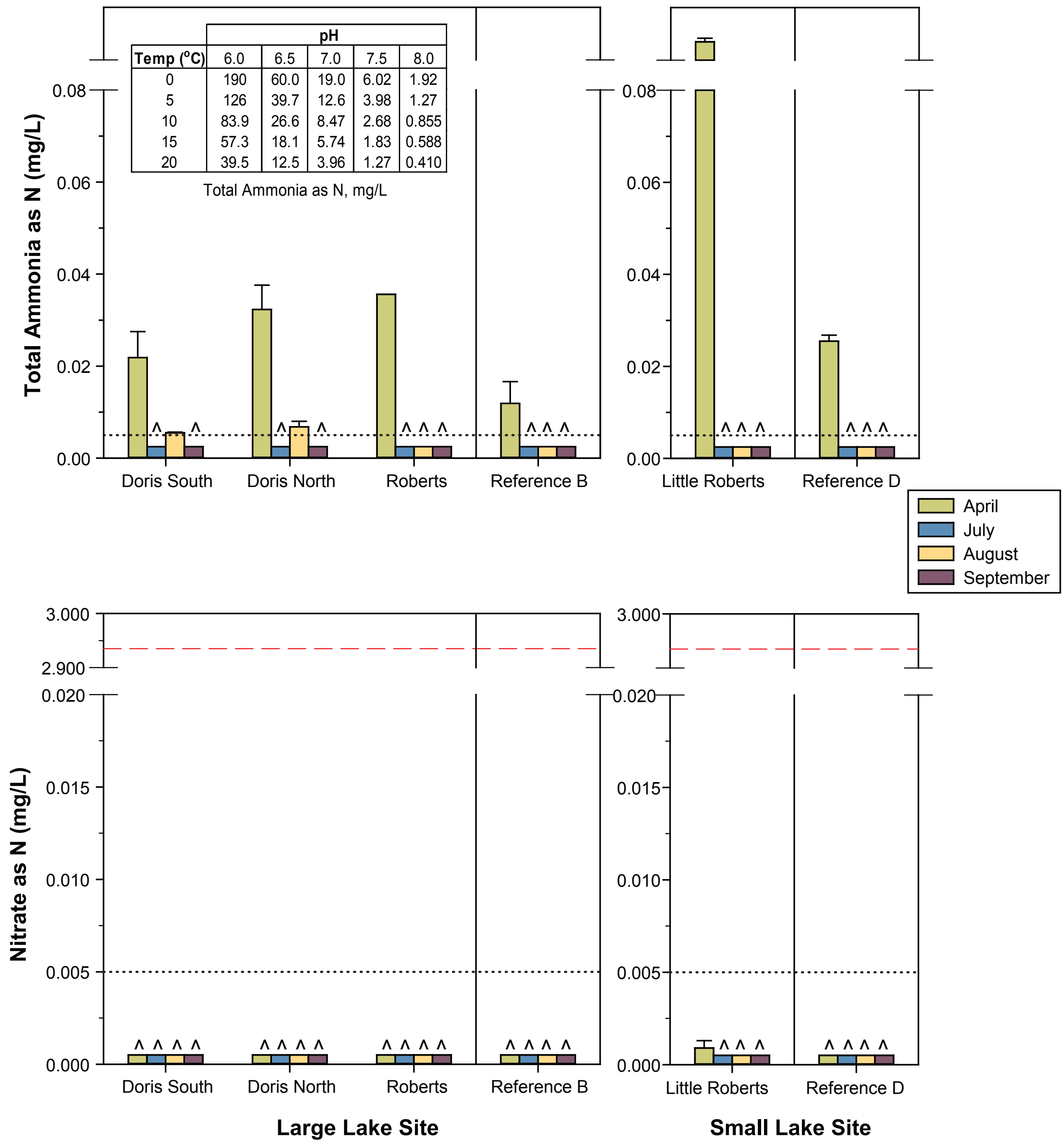
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for total suspended solids is dependent upon background levels.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

NEWMONT NORTH AMERICA

Hardness and Total Suspended Solids in Lake Sites, Doris North Project, 2012

Figure A3-11

Rescan Engineers & Scientists



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

Total Ammonia as N, mg/L

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 applicable detection limit.
^ Indicates that total ammonia or nitrate concentrations in all samples were below detection limits.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Red dashed line represents the interim CCME freshwater 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 Lake Sites, Doris North Project, 2012

Figure A3-12

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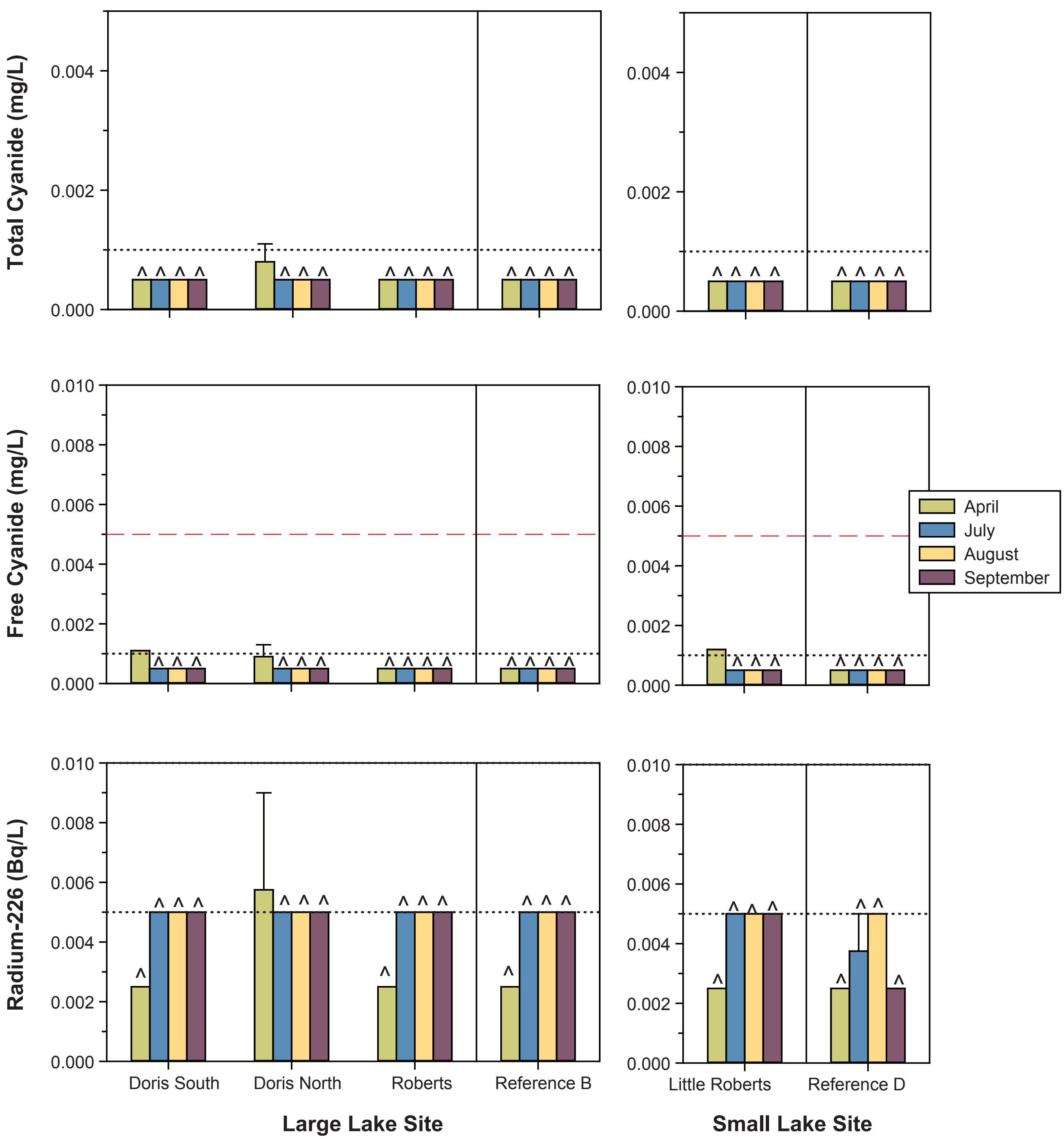


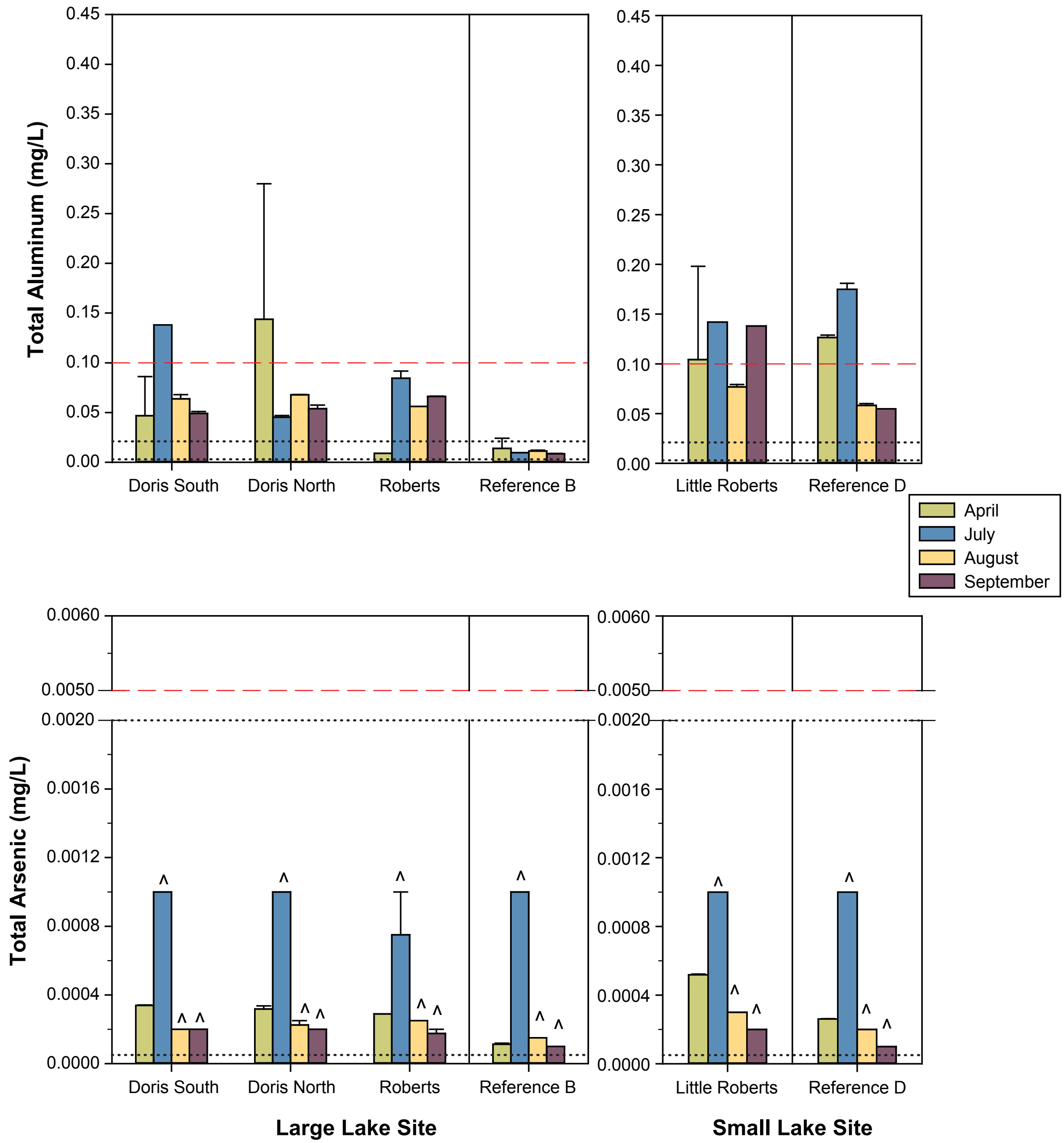
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ indicates that total cyanide or free cyanide concentrations in all samples were below detection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

NEWMONT NORTH AMERICA

Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Lake Sites, Doris North Project, 2012

Figure A3-13

Rescan Engineers & Scientists



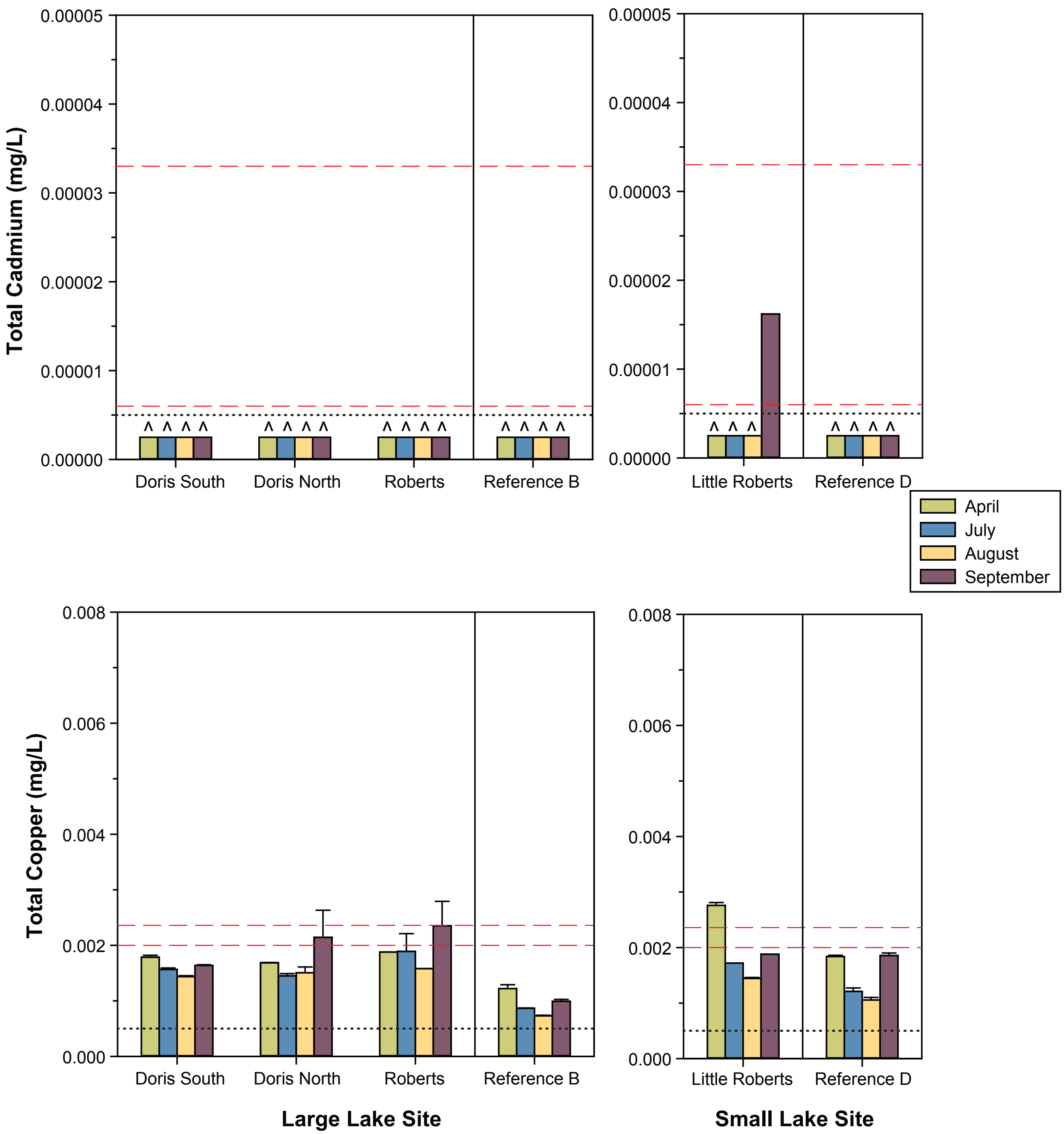
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5).
and the CCME freshwater guideline for arsenic (0.005 mg/L).
pH was greater than 6.5 in all lake samples.
^ Indicates that total arsenic concentration in all samples were below the detection limits.
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.

NEWMONT NORTH AMERICA

Total Aluminum and Total Arsenic Concentrations in Lake Sites, Doris North Project, 2012

Figure A3-14

Rescan Engineers & Scientists



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 applicable detection limit.
The CCME freshwater guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum site-specific CCME freshwater guidelines for cadmium (0.000006 and 0.000033 mg/L) and for copper (0.002 and 0.00236 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 12.9 to 100 mg/L.
^ Indicates that total cadmium concentrations in all samples were below the dectection limit.
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 Lake Sites, Doris North Project, 2012

Figure A3-15

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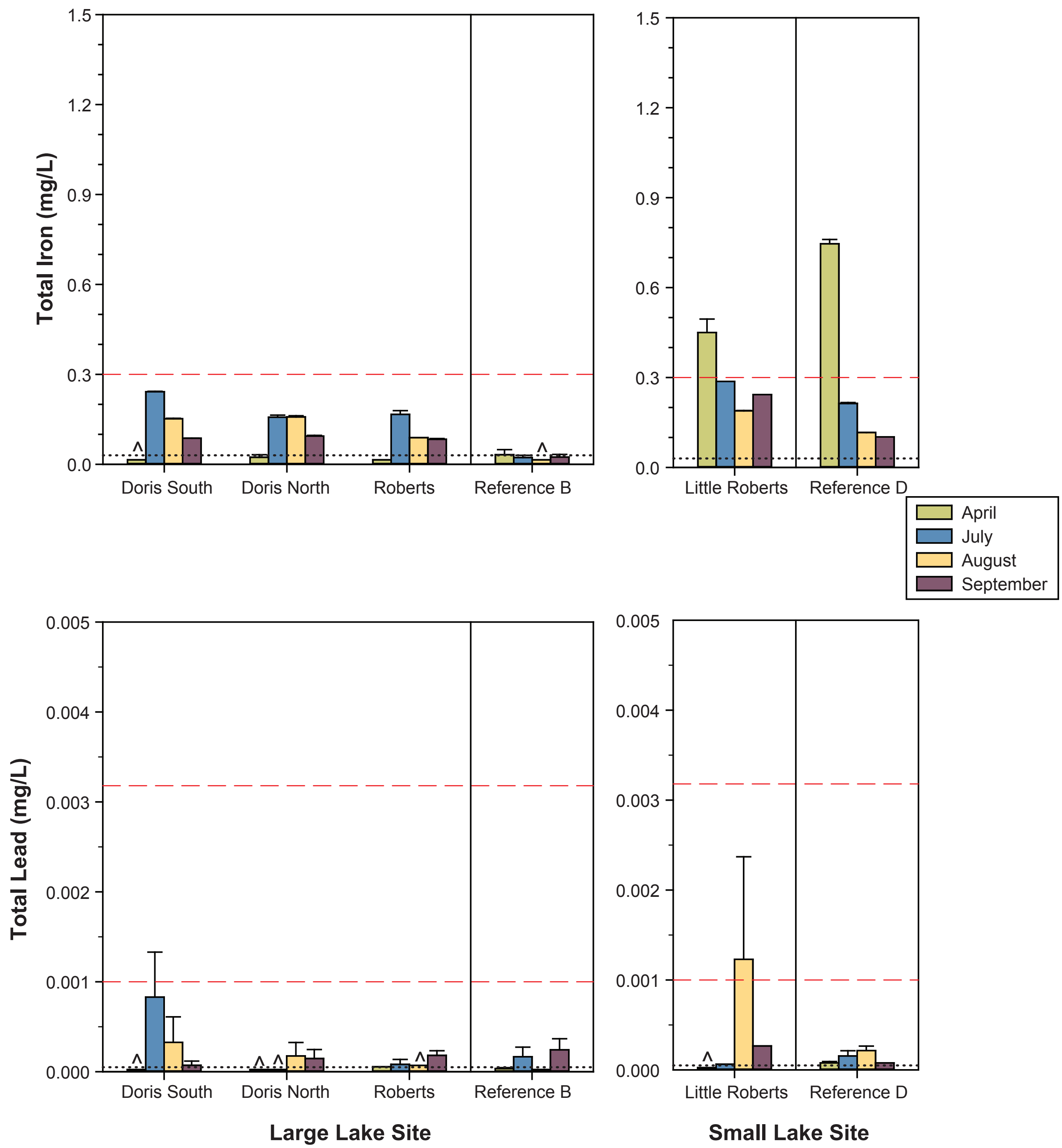


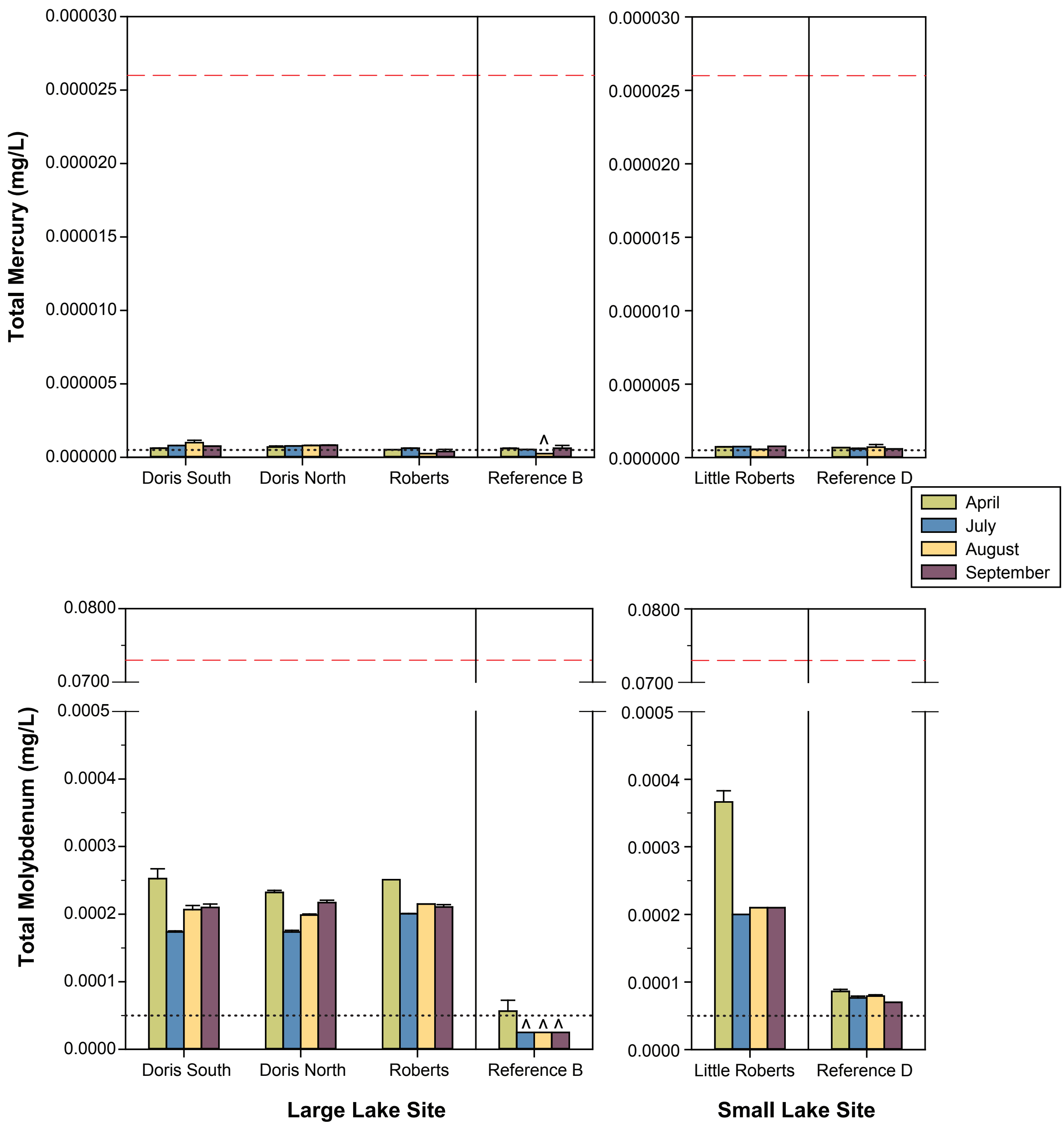
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L) and the minimum and maximum site-specific CCME freshwater guideline for lead (0.001 and 0.00318 mg/L) based on the hardness (as CaCO3) range in lakes of 12.9 to 100 mg/L.
^ Indicates that total iron or total lead concentrations in all samples were above detection limits.
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.

NEWMONT NORTH AMERICA

Total Iron and Total Lead Concentrations in Lake Sites, Doris North Project, 2012

Figure A3-16

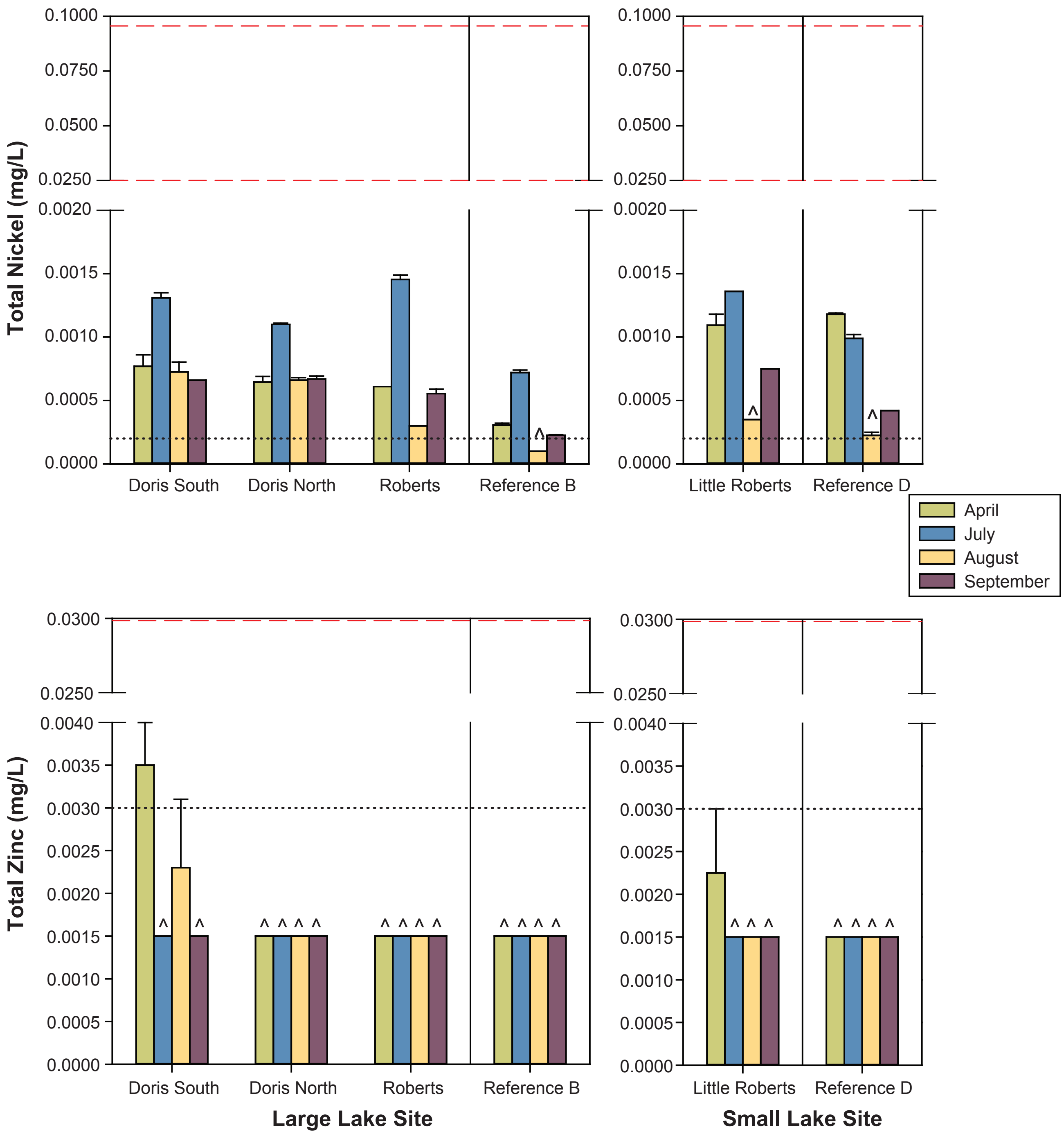
Rescan Engineers & Scientists



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 applicable detection limit.
^ Indicates that total mercury or total molybdenum concentrations in all samples are below dectection limits.
Red dashed lines represent the CCME freshwater 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.

Figure A3-17

Total Mercury and Total Molybdenum Concentrations in Lake Sites, Doris North Project, 2012



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 applicable detection limit.
The CCME guideline for nickel is hardness dependent.
^ Indicates that total nickel or total zinc concentrations in all samples are below dectection limits.
Red dashed lines represent the CCME freshwater guideline for zinc (0.03 mg/L) and the minimum and maximum site-specific CCME guideline for nickel (0.025 and 0.096 mg/L) based on the hardness (as CaCO3) range in lakes of 12.9 to 100 mg/L.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Nickel and Total Zinc Concentrations in Lake Sites, Doris North Project, 2012

Figure A3-18

Rescan Engineers & Scientists

Table A.3-3. Water Quality in Lake Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)	Arsenic (As)	Boron (B)	Cadmium (Cd)
			6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	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]
Large Lake Site														
Doris Lake South	9		0	0	0	0	0	0	Oligotrophic to Mesotrophic	0	22.2	0	0	0
Doris Lake North	9		0	0	0	0	0	0	Mesotrophic	0	11.1	0	0	0
Roberts Lake	6		0	0	0	0	0	0	Oligotrophic	0	0	0	0	0
Reference Lake B	10		0	0	0	0	0	0	Ultra-oligotrophic to Oligotrophic	0	0	0	0	0
Small Lake Site														
Little Roberts Lake	6		0	33.3	0	0	0	0	Oligotrophic to Mesotrophic	0	50	0	0	0
Reference Lake D	7		0	0	0	0	0	0	Oligotrophic	0	57.1	0	0	0

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Zinc (Zn)
			Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥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 Lake South	9		0	0	0	11.1	0	0	0	0	0	0	0	0
Doris Lake North	9		0	11.1	0	0	0	0	0	0	0	0	0	0
Roberts Lake	6		0	33.3	0	0	0	0	0	0	0	0	0	0
Reference Lake B	10		0	0	0	0	0	0	0	0	0	0	0	0
Small Lake Site														
Little Roberts Lake	6		16.7[h]	33.3	33.3	16.7	0	0	0	0	0	0	0	0
Reference Lake D	7		0	0	28.6	0	0	0	0	0	0	0	0	0

Values represent the percentages of 2012 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) =* $10^{\{0.86[\log(hardness)]-3.2\}}/1000$.

[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.*

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

Table A.3-4. Water Quality in Lake Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Lake Site	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)	Arsenic (As)	Boron (B)	Cadmium (Cd)
			6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	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]
Large Lake Site														
Doris Lake South	9		-	-	-	-	-	-	Oligotrophic to Mesotrophic	-	1.38	-	-	-
Doris Lake North	9		-	-	-	-	-	-	Mesotrophic	-	2.8	-	-	-
Roberts Lake	6		-	-	-	-	-	-	Oligotrophic	-	-	-	-	-
Reference Lake B	10		-	-	-	-	-	-	Ultra-oligotrophic to Oligotrophic	-	-	-	-	-
Small Lake Site														
Little Roberts Lake	6		-	1.11	-	-	-	-	Oligotrophic to Mesotrophic	-	1.593	-	-	-
Reference Lake D	7		-	-	-	-	-	-	Oligotrophic	-	1.21	-	-	-

Lake Site	Total Number of Samples Collected	CCME Guideline Value[a]:	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Thallium (Tl)	Uranium (U)	Zinc (Zn)
			Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥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 Lake South	9		-	-	-	1.053	-	-	-	-	-	-	-	-
Doris Lake North	9		-	1.560	-	-	-	-	-	-	-	-	-	-
Roberts Lake	6		-	1.250	-	-	-	-	-	-	-	-	-	-
Reference Lake B	10		-	-	-	-	-	-	-	-	-	-	-	-
Small Lake Site														
Little Roberts Lake	6	1.59	-	1.253	1.500	2.013	-	-	-	-	-	-	-	-
Reference Lake D	7		-	-	2.487	-	-	-	-	-	-	-	-	-

Values represent the factor by which average 2012 concentrations are higher than CCME guidelines; dashes represent average 2012 concentrations that are below CCME guidelines.

The average 2012 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.

For hardness-dependent guidelines, the average hardness over all sampling periods was used to determine the site-specific CCME guideline.

[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.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2012 (continued)

Site ID:				LITTLE ROBERTS LAKE	LITTLE ROBERTS LAKE	DORIS LAKE NORTH	DORIS LAKE NORTH	DORIS LAKE SOUTH	DORIS LAKE SOUTH	REFERENCE LAKE B	REFERENCE LAKE B	REFERENCE LAKE B	REFERENCE LAKE D	REFERENCE LAKE D	ROBERTS LAKE	DORIS LAKE NORTH
Depth Zone:				Surface	Surface	Surface	Deep	Surface	Deep	Surface	Suface	Deep	Surface	Surface	Surface	Surface
Depth Sampled (m):				1	1	1	11.5	1	8.5	1	1		1	1	1	1
Replicate:				1	2	1	1	1	1	1	2	1	1	2	1	1
Date Sampled:		CCME guideline for the		15-APR-12	15-APR-12	14-APR-12	14-APR-12	14-APR-12	14-APR-12	18-APR-12	18-APR-12	18-APR-12	16-APR-12	16-APR-12	17-APR-12	24-JUL-12
ALS Sample ID:	Units	Protection of Aquatic life[a]	Realized Detection Limit	L1137583-1	L1137583-2	L1137585-3	L1137583-3	L1137585-1	L1137585-2	L1137589-1	L1137589-2	L1137589-3	L1137597-1	L1137597-2	L1137597-3	L1185682-7
Physical Tests																
Conductivity	uS/cm		2.0	540	541	309	304	316	320	74.2	73.1	66.4	236	239	284	248
Hardness (as $CaCO_3$)	mg/L		0.50	92.7	91.3	59.9	58.0	60.5	59.5	23.0	23.4	21.3	48.8	49.1	48.3	49.9
pH	pH	6.5-9.0	0.10	7.50	7.50	7.64	7.62	7.63	7.60	7.34	7.29	7.16	7.27	7.23	7.58	7.60
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.0	2.2	2.6	2.8	3.2	1.4	<1.0	<1.0	<1.0	2.0	1.8	<1.0	3.2
Turbidity	NTU	dependent on background levels	0.10	3.98	3.86	4.62	4.05	4.89	3.08	0.39	0.39	0.55	3.86	3.78	0.67	4.09
Anions and Nutrients																
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	53.6	56.6	34.5	34.1	34.9	35.2	17.0	17.0	15.7	30.1	30.6	27.3	28.2
Ammonia, Total (as N)	mg/L	pH- and temperature-dependent	0.0050	0.171	0.164	0.0270	0.0376	0.0162	0.0275	0.0174	0.0158	<0.0050	0.0268	0.0242	0.0356	<0.0050
Bromide (Br)	mg/L		0.050	0.514	0.509	0.267	0.217	0.272	0.312	<0.050	<0.050	<0.050	0.175	0.182	0.238	0.204
Chloride (Cl)	mg/L	short-term: 640; long-term: 120	0.50	133	133	73.1	72.9	74.6	76.0	10.6	10.4	9.15	52.0	52.4	68.7	59.1
Fluoride (F)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.090	0.089	0.066	0.067	0.068	0.068	0.030	0.030	0.024	0.064	0.064	0.057	0.053
Nitrate (as N)	mg/L	2.935[b]	0.0050	0.0749	0.0754	0.0470	0.0333	0.0347	0.0703	0.0410	0.0412	0.0907	0.249	0.257	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	0.0013	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0232	0.0233	0.0260	0.0258	0.0273	0.0198	0.0043	0.0039	0.0044	0.0114	0.0116	0.0120	0.0201
Sulfate (SO_4)	mg/L		0.50	8.64	8.63	3.48	3.46	3.54	3.58	2.97	2.96	2.70	4.55	4.58	5.41	2.67
Cyanides																
Cyanide, Total	mg/L		0.0010	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	0.005	0.0010	0.0012	0.0012	<0.0010	0.0013	0.0011	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon																
Total Organic Carbon	mg/L		0.50	10.2	10.5	6.41	5.90	7.33	7.40	4.57	4.39	3.53	7.94	8.10	6.12	5.31
Total Metals																
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.003 to 0.021	0.198	<0.021	0.280	<0.015	0.0862	<0.015	<0.0060	<0.0090	0.0344	0.129	0.124	<0.018	0.0437
Antimony (Sb)	mg/L		0.00001 to 0.00003	0.000030	0.000027	0.000026	0.000017	0.000024	0.000018	0.000013	0.000014	<0.000010	0.000014	0.000019	0.000017	0.000020
Arsenic (As)	mg/L	0.005	0.00005 to 0.002	0.000522	0.000514	0.000336	0.000299	0.000341	0.000337	0.000121	0.000117	0.000099	0.000259	0.000262	0.000289	<0.0020
Barium (Ba)	mg/L		0.00010	0.00679	0.00687	0.00297	0.00312	0.00388	0.00361	0.00310	0.00302	0.00301	0.00785	0.00750	0.00320	0.00341
Beryllium (Be)	mg/L		0.000005 or 0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000056	0.0000052	<0.0000050	0.0000069
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
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.005 to 0.035	0.0555	0.0552	0.0318	0.0329	0.0337	0.0304	0.0116	0.0120	0.0103	0.0288	0.0300	0.0369	<0.035
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
Calcium (Ca)	mg/L		0.050	14.4	14.1	11.2	10.8	11.2	11.0	5.56	5.64	5.11	7.88	7.88	7.14	9.05
Cesium (Cs)	mg/L		0.000005 or 0.00001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000071	0.0000069	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	0.00159	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00059	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000087	0.000074	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000157	0.000152	0.000157	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00281	0.00271	0.00168	0.00169	0.00182	0.00175	0.00135	0.00120	0.00111	0.00181	0.00186	0.00188	0.00149
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
Iron (Fe)	mg/L	0.3	0.030	0.495	0.405	<0.030	0.032	<0.030	<0.030	<0.030	<0.030	0.066	0.731	0.761	<0.030	0.150
Lead (Pb)	mg/L	≥0.001[f]	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000054	<0.000050	<0.000050	0.000063	0.000092	0.000055	<0.000050
Lithium (Li)	mg/L		0.00020	0.00569	0.00557	0.00435	0.00420	0.00451	0.00427	0.00076	0.00070	0.00061	0.00303	0.00304	0.00298	0.00423
Magnesium (Mg)	mg/L		0.10	13.8	13.6	7.77	7.57	7.89	7.76	2.22	2.26	2.06	7.08	7.14	7.40	6.64
Manganese (Mn)	mg/L		0.00020	0.0916	0.0935	0.00301	0.00609	0.00260	0.00321	0.00108	0.00112	0.0439	0.116	0.112	0.00116	0.0138
Mercury (Hg)	ug/L	Inorganic Hg: 0.000026	0.00000	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000383	0.000350	0.000235	0.000229	0.000267	0.000238	0.000079	0.000065	<0.000050	0.000083	0.000089	0.000251	0.000176
Nickel (Ni)	mg/L	≥0.025[g]	0.0002 to 0.0007	0.00118	0.00101	0.00069	0.00060	0.00086	0.00068	0.00028	0.00031	0.00033	0.00119	0.00117	0.00061	0.00111
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
Potassium (K)	mg/L		2.0	4.6	4.5	2.8	2.6	2.8	2.7	<2.0	<2.0	<2.0	2.5	2.5	2.5	2.3
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
Rubidium (Rb)	mg/L		0.000020	0.00294	0.00283	0.00173	0.00165	0.00180	0.00173	0.00122	0.00122	0.00106	0.00243	0.00246	0.00159	0.00143
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
Silicon (Si)	mg/L		0.050	2.16	2.12	1.53	1.63	1.55	1.55	0.295	0.302	0.754	1.37	1.38	0.680	1.47
Silver (Ag)	mg/L	0.0001	0.000005 or 0.00001	<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	70.8	69.6	37.2	36.2	37.6	37.1	6.0	6.1	5.4	29.2	29.4	37.9	31.4
Strontium (Sr)	mg/L		0.000050	0.0821	0.0796	0.0508	0.0506	0.0532	0.0532	0.0257	0.0246	0.0233	0.0438	0.0465	0.0443	0.0379
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
Thallium (Tl)	mg/L	0.0008	0.000002 or 0.00002	0.0000046	0.0000027	<0.0000020	<0.0000020	0.0000021	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000036	0.0000028	<0.0000020	<0.0000020
Thorium (Th)	mg/L		0.000005 or 0.000035	0.0000335	0.0000342	0.0000101	0.0000112	0.0000126	0.0000123	0.0000095	0.0000093	0.0000064	0.0000690	0.0000741	0.0000201	0.0000241

(continued)

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2012 (continued)

Site ID:				LITTLE ROBERTS LAKE	LITTLE ROBERTS LAKE	DORIS LAKE NORTH	DORIS LAKE NORTH	DORIS LAKE SOUTH	DORIS LAKE SOUTH	REFERENCE LAKE B	REFERENCE LAKE B	REFERENCE LAKE B	REFERENCE LAKE D	REFERENCE LAKE D	ROBERTS LAKE	DORIS LAKE NORTH
Depth Zone:				Surface	Surface	Surface	Deep	Surface	Deep	Surface	Suface	Deep	Surface	Surface	Surface	Surface
Depth Sampled (m):				1	1	1	11.5	1	8.5	1	1		1	1	1	1
Replicate:				1	2	1	1	1	1	1	2	1	1	2	1	1
Date Sampled:		CCME guideline for the		15-APR-12	15-APR-12	14-APR-12	14-APR-12	14-APR-12	14-APR-12	18-APR-12	18-APR-12	18-APR-12	16-APR-12	16-APR-12	17-APR-12	24-JUL-12
ALS Sample ID:	Units	Protection of Aquatic life[a]	Realized Detection Limit	L1137583-1	L1137583-2	L1137585-3	L1137583-3	L1137585-1	L1137585-2	L1137589-1	L1137589-2	L1137589-3	L1137597-1	L1137597-2	L1137597-3	L1185682-7
Total Metals *(cont'd)*																
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
Titanium (Ti)	mg/L		0.00020	0.00034	0.00028	<0.00020	0.00022	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	0.00441	0.00415	<0.00020	0.00109
Tungsten (W)	mg/L		0.000010	<0.000010	<0.000010	0.000014	0.000010	0.000013	0.000013	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000012
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000736	0.0000744	0.0000419	0.0000383	0.0000460	0.0000427	0.0000670	0.0000667	0.0000352	0.0000631	0.0000691	0.0000568	0.0000372
Vanadium (V)	mg/L		0.000050	0.000159	0.000136	0.000109	0.000083	0.000088	0.000086	<0.000050	<0.000050	<0.000050	0.000281	0.000286	0.000073	0.000137
Yttrium (Y)	mg/L		0.0000050	0.0000631	0.0000605	0.0000208	0.0000212	0.0000232	0.0000227	0.0000194	0.0000204	0.0000206	0.0000909	0.0000980	0.0000331	0.0000315
Zinc (Zn)	mg/L	0.03	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
Zirconium (Zr)	mg/L		0.000050	0.000121	0.000073	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000077	0.000087	<0.000050	0.000050
Radiochemistry																
Radium-226	Bq/L	0.005	0.005													

Notes:

(continued)

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 2012.*

[b] *Interim guideline.*

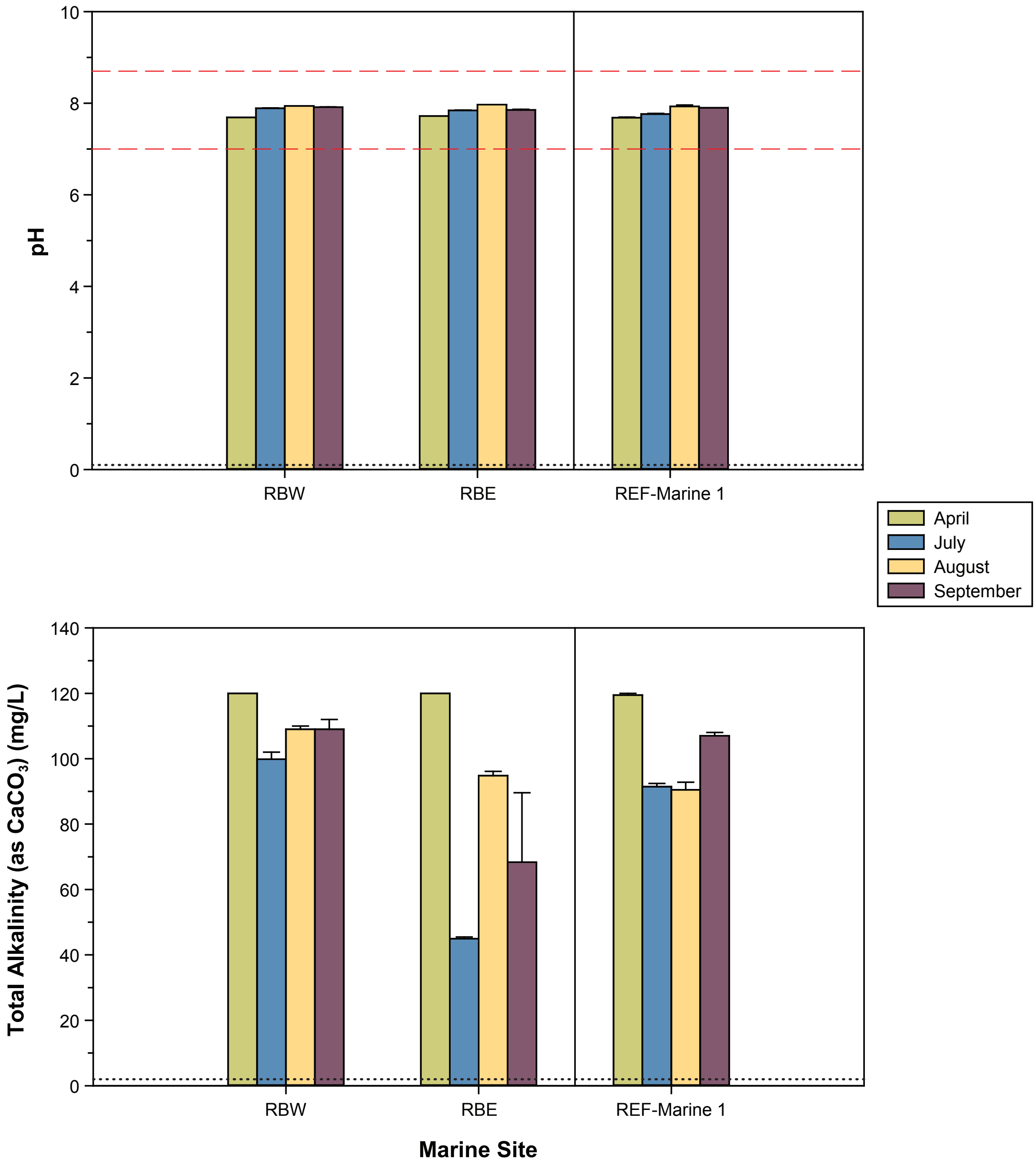
[c] *Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.*

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



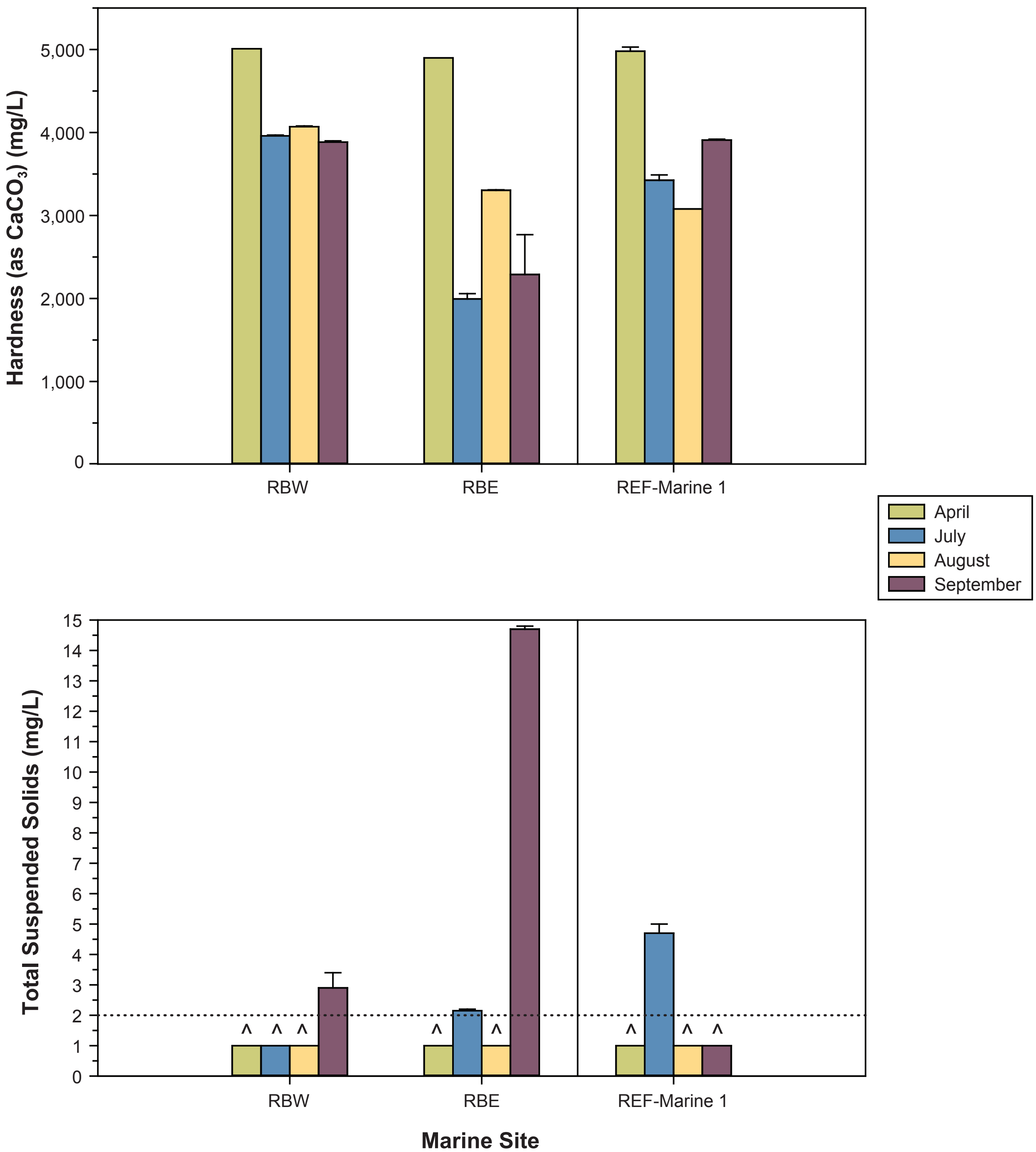
Notes: *Error bars represent the standard error of the mean.*
Black dotted lines represent the analytical detection limits.
Red dashed lines represent the CCME marine and estuarine guideline pH range (7.0–8.7).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the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

NEWMONT NORTH AMERICA

pH and Total Alkalinity in Marine Sites,Doris North Project, 2012

Figure A3-19

Rescan Engineers & Scientists



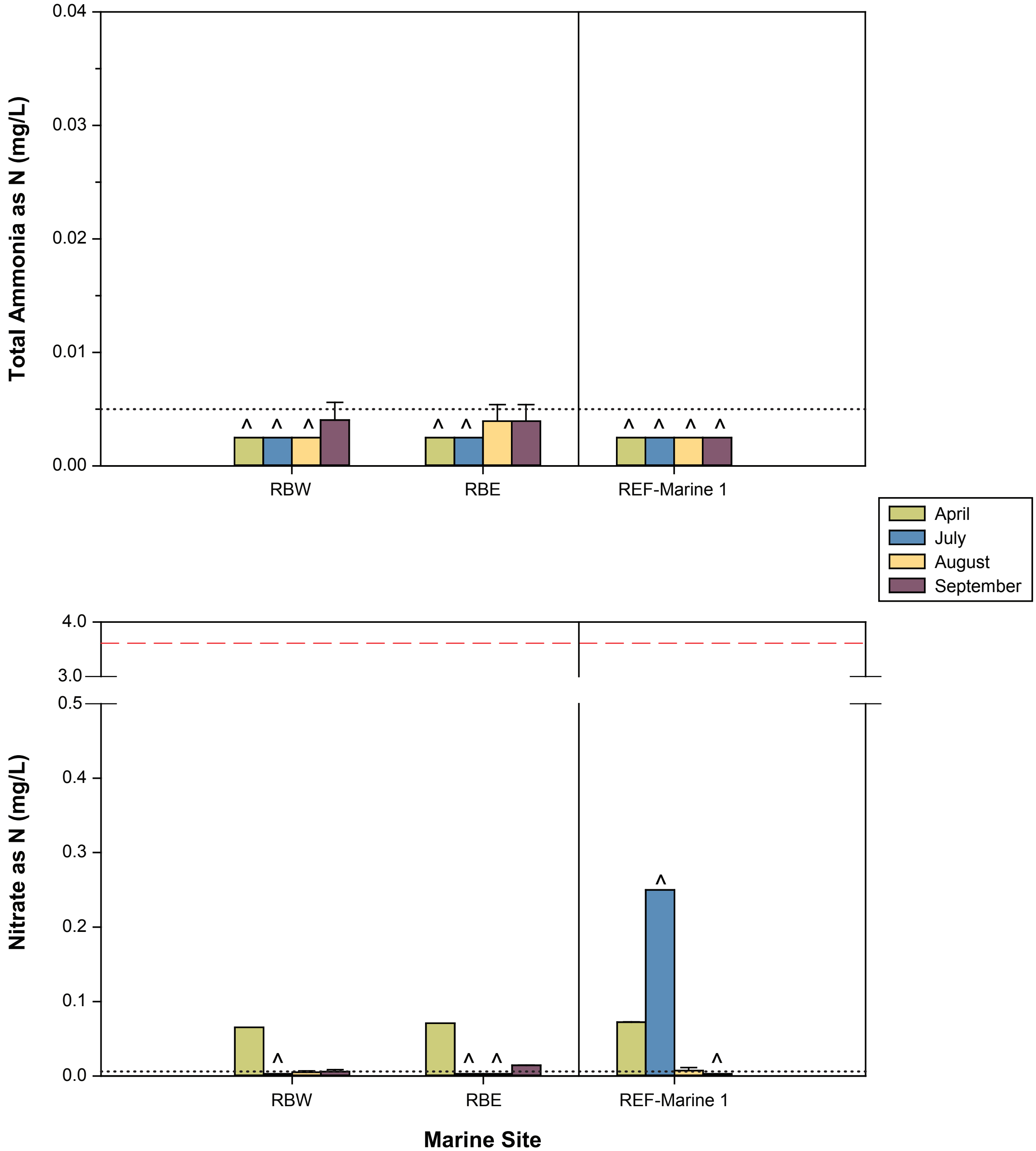
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME marine guideline for total suspended solids is dependent upon background levels.
Hardness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

NEWMONT NORTH AMERICA

Hardness and Total Suspended Solids in Marine Sites, Doris North Project, 2012

Figure A3-20

Rescan Engineers & Scientists



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 applicable detection limit.
^ Indicates that total ammonia or nitrate concentrations in all samples were below detection limits.
Red dashed line represents the interim CCME marine 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 Marine Sites, Doris North Project, 2012

Figure A3-21

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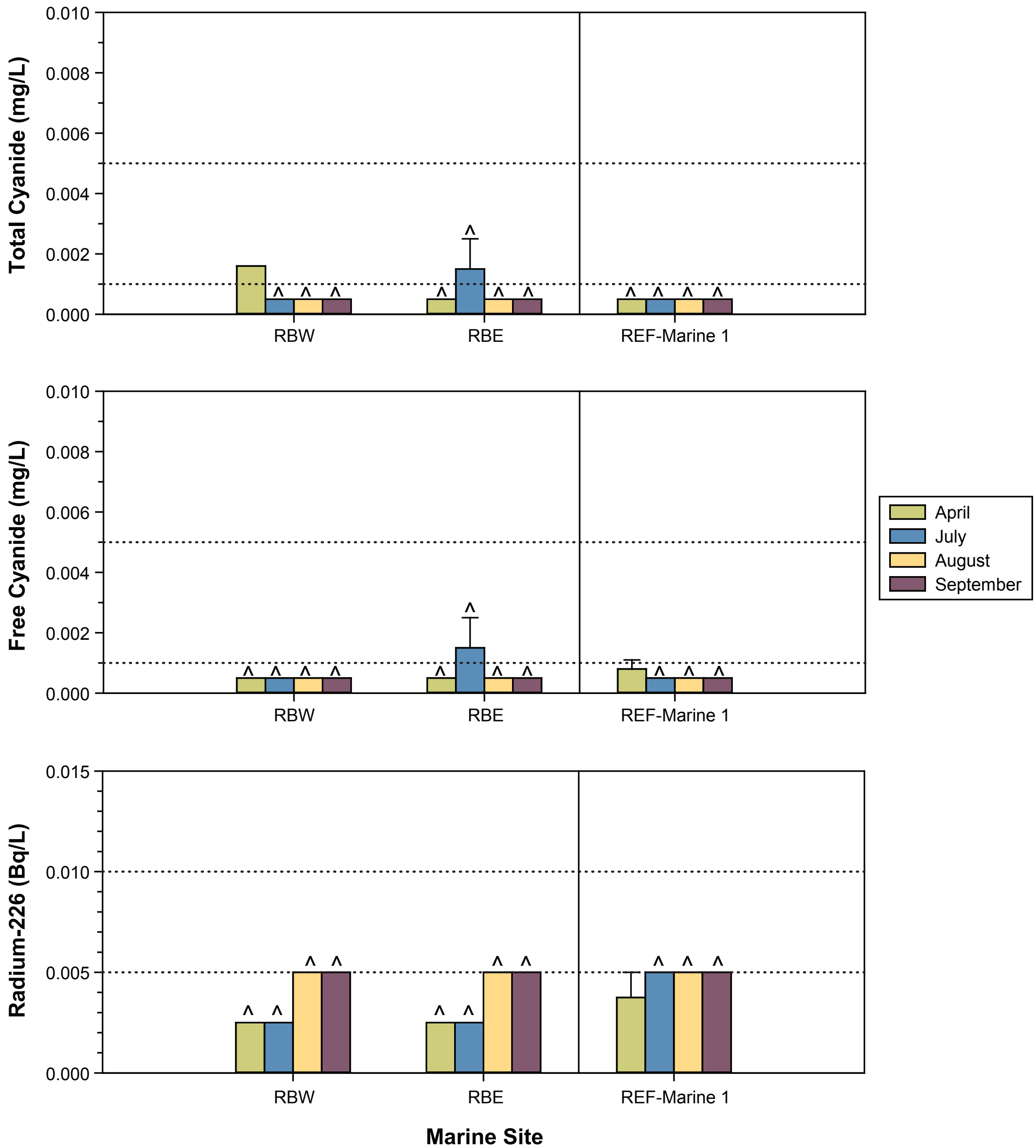
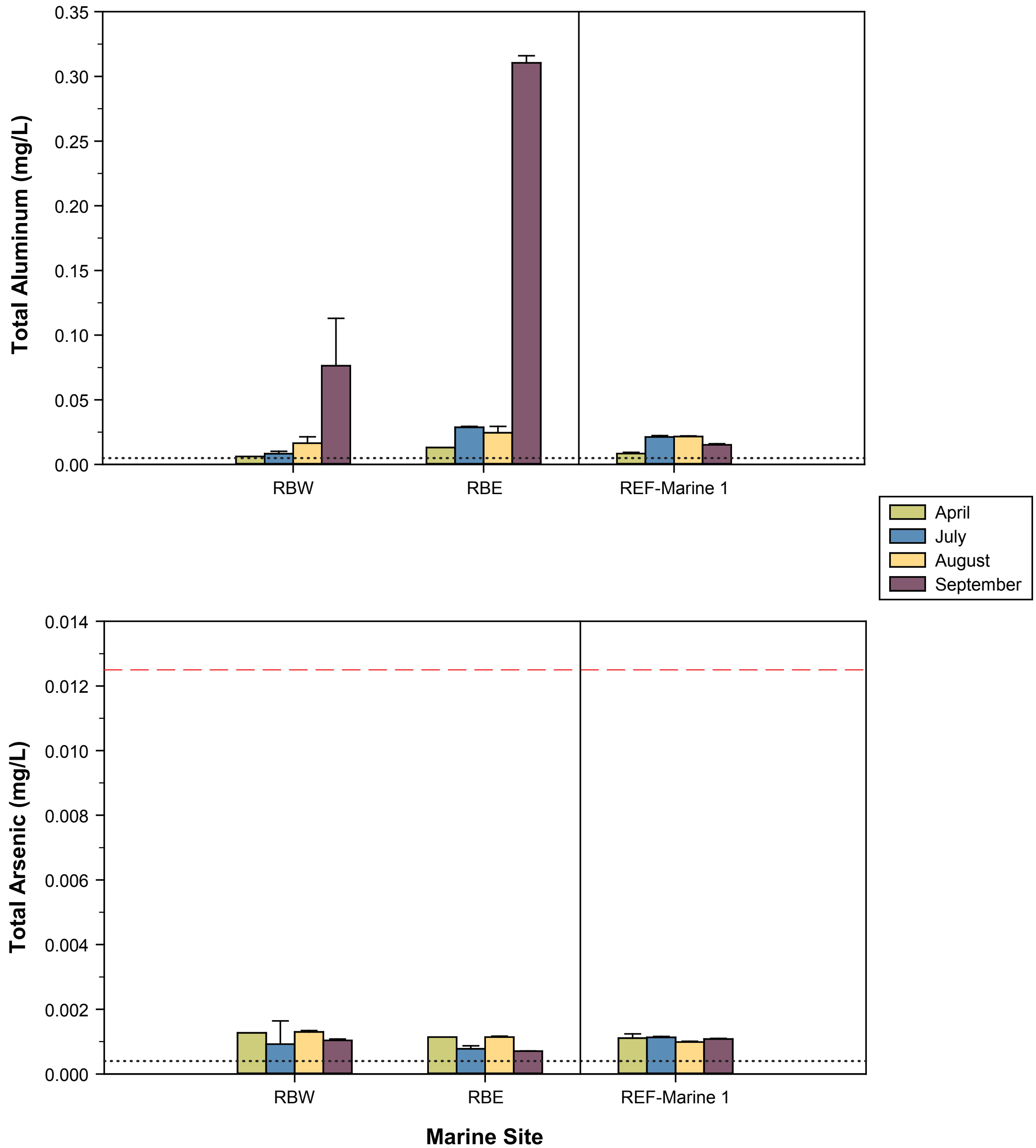


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ indicates that total cyanide or free cyanide concentratations in all samples were below detection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

Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Marine Sites, Doris North Project, 2012

Figure A3-22



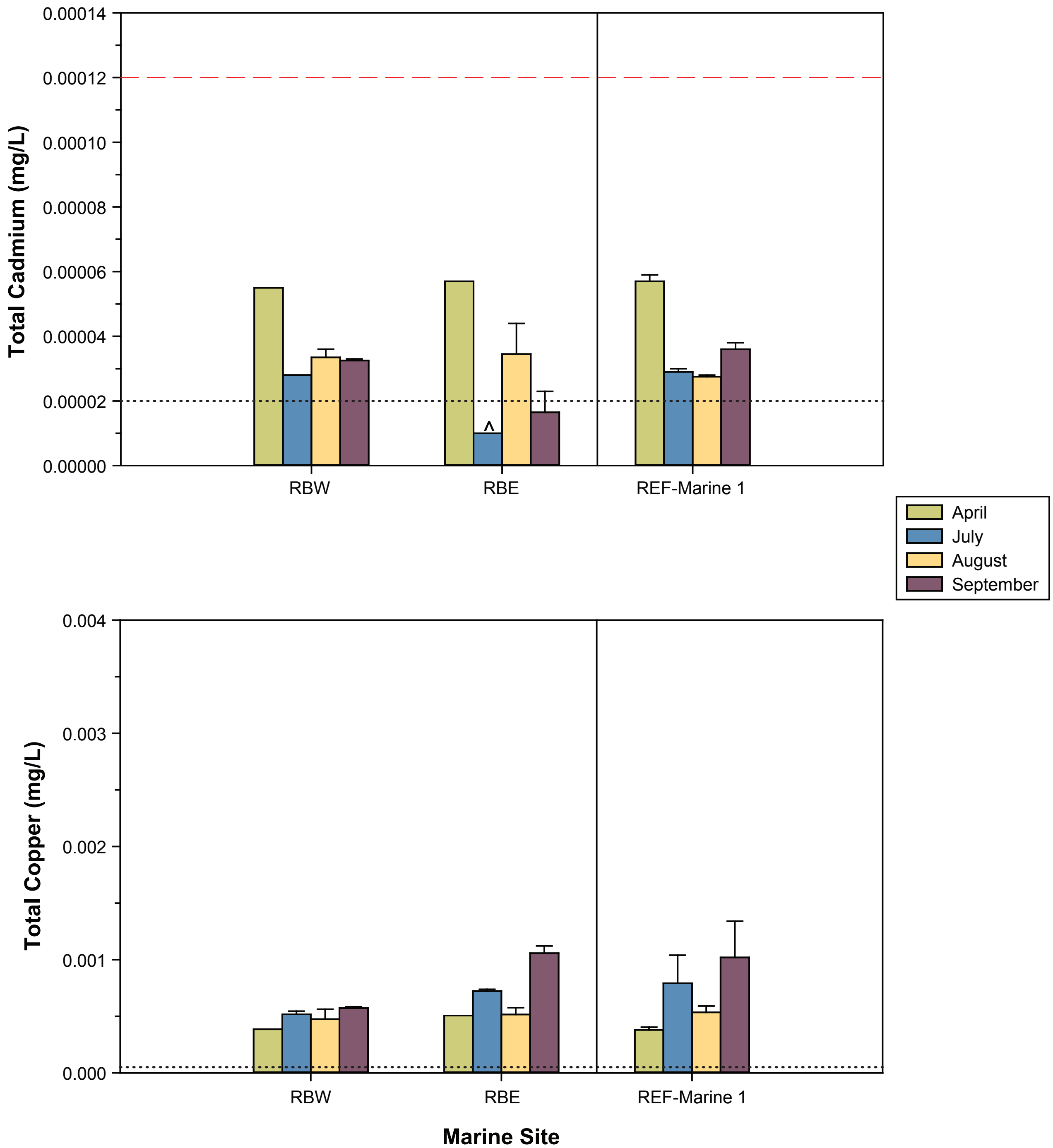
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed line represents the interim CCME marine guideline for arsenic (0.0125 mg/L).
Total 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.

NEWMONT NORTH AMERICA

Total Aluminum and Total Arsenic Concentrations in Marine Sites, Doris North Project, 2012

Figure A3-23

Rescan Engineers & Scientists



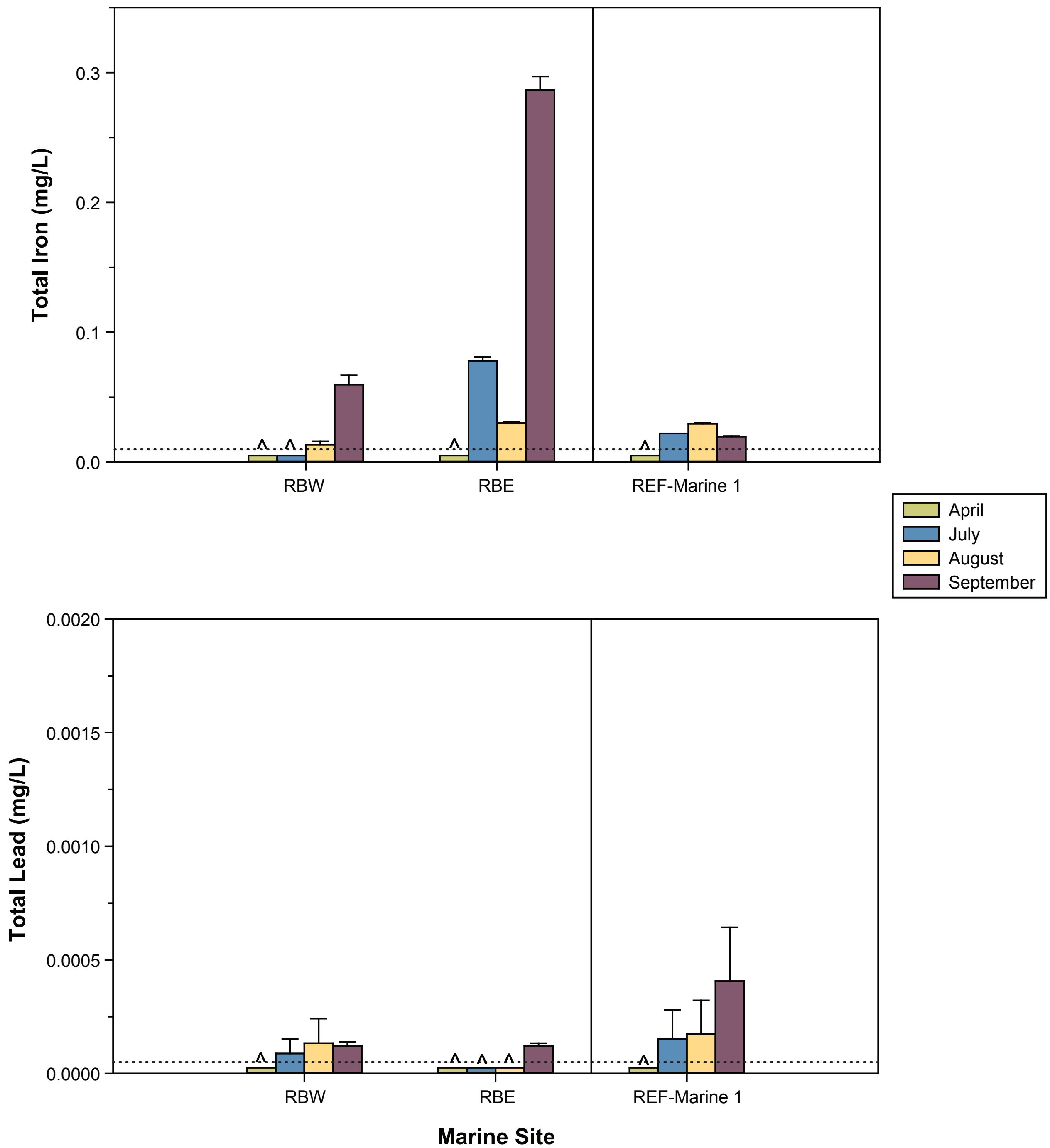
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed line represents the CCME marine guideline for cadmium (0.00012 mg/L).
^ Indicates that total cadmium concentrations in all samples were below the detection limit.
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.

NEWMONT™ NORTH AMERICA

Total Cadmium and Total Copper Concentrations in Marine Sites, Doris North Project, 2012

Figure A3-24

Rescan™ Engineers & Scientists



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 applicable detection limit.
^ Indicates that total iron or total lead concentrations in all samples were below detection limits.
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.

Figure A3-25

Total Iron and Total Lead Concentrations in Marine Sites, Doris North Project, 2012

NEWMONT NORTH AMERICA

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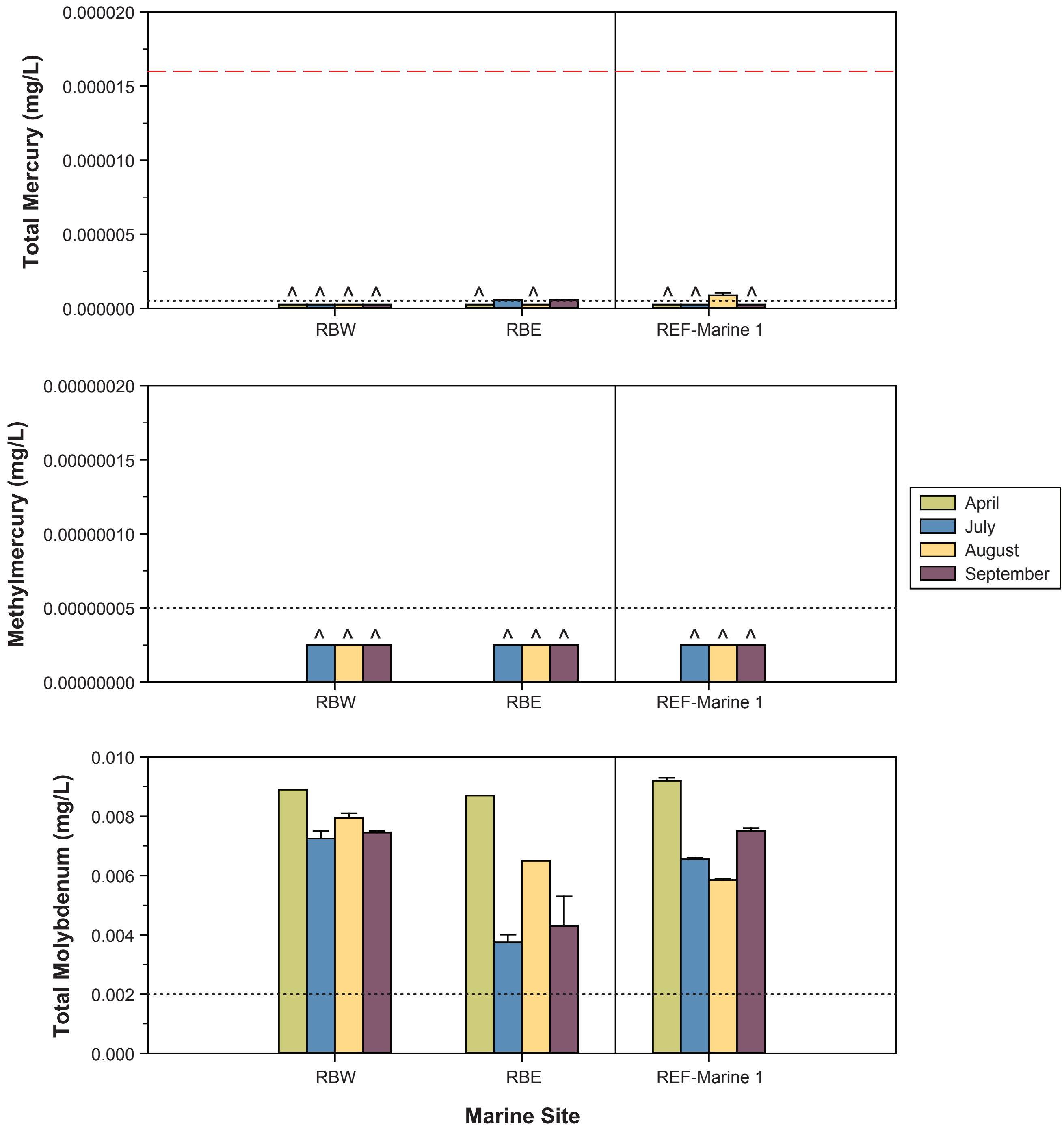


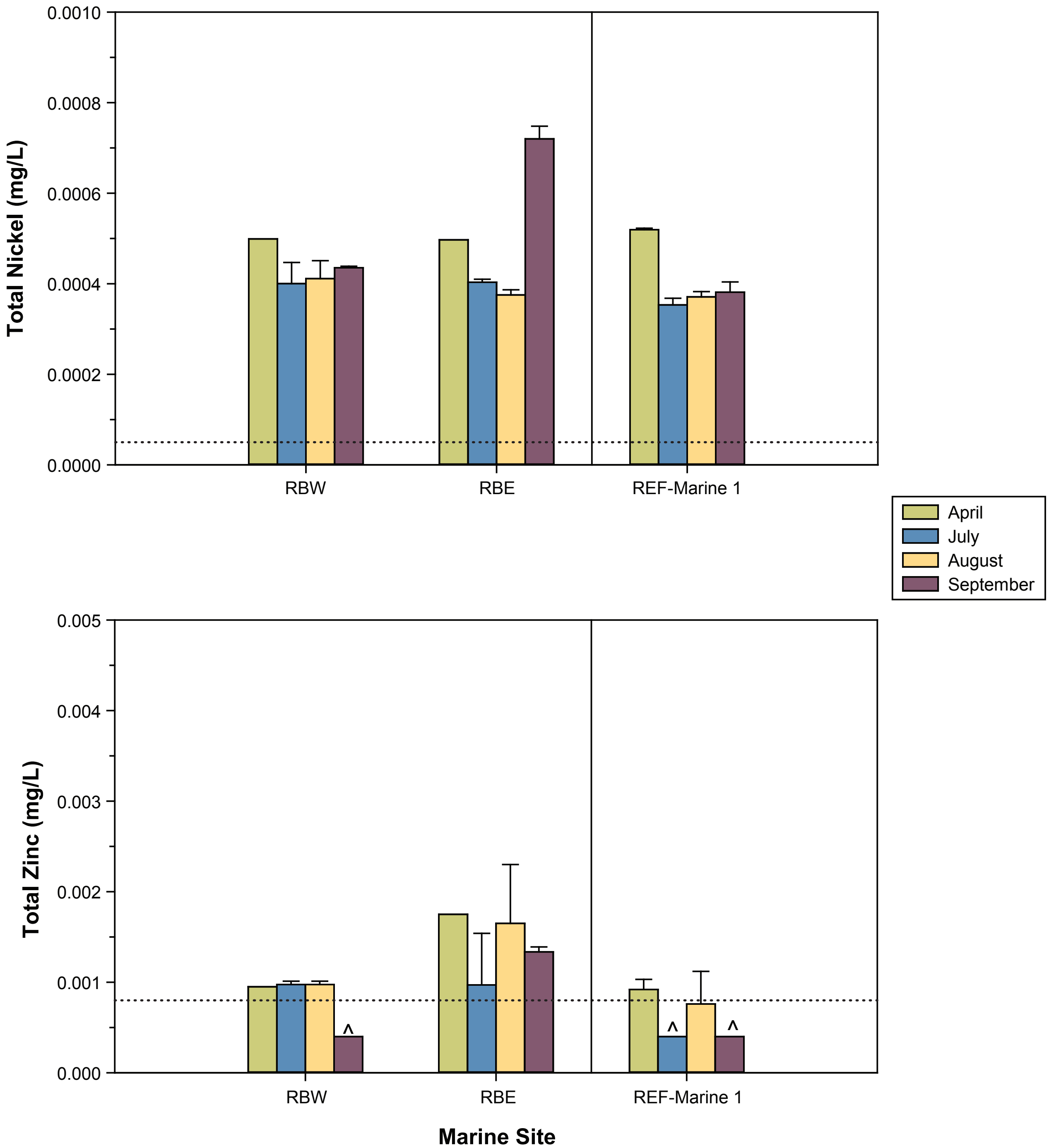
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that total mercury or methylmercury concentrations in all samples were below detection limits.
Red dashed line represents the interim CCME marine 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.

NEWMONT NORTH AMERICA

Total Mercury, Methylmercury, and Total Molybdenum Concentrations in Marine Sites, Doris North Project, 2012

Figure A3-26

Rescan Engineers & Scientists



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 applicable detection limit.
^ Indicates that total zinc concentrations in all samples were below detection limits.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Nickel and Total Zinc Concentrations in Marine Sites, Doris North Project, 2012

Figure A3-27

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Annex A.3-3. Marine Water Quality Data, Doris North Project, 2012 (continued)

Site ID:				ROBERTS BAY WEST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE	ROBERTS BAY WEST	ROBERTS BAY WEST	ROBERTS BAY EAST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE	ROBERTS BAY WEST
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				1	1	1	1	1	1	0.5	0.5	0.5	0.5	1
Replicate:				1	1	1	2	1	1	2	2	1	2	1
Date Sampled:		CCME guideline for the	Realized	19-APR-12	19-APR-12	19-APR-12	19-APR-12	22-JUL-12	22-JUL-12	22-JUL-12	22-JUL-12	26-JUL-12	26-JUL-12	18-AUG-12
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1137600-1	L1137607-3	L1137607-1	L1137607-2	L1182743-1	L1182743-2	L1182743-3	L1182743-4	L1185685-1	L1185685-2	L1196639-3
Physical Tests														
Hardness (as $CaCO_3$)	mg/L		2.2 or 4.3	5010	4900	4930	5030	3950	3970	1930	2060	3490	3360	4080
pH	pH	7.0-8.7	0.10	7.69	7.72	7.67	7.70	7.88	7.90	7.84	7.85	7.75	7.78	7.94
Salinity		<10% fluctuation[b]		27.4	27.2	27.2	27.1	21.9	21.8	10.9	11.8	19.1	19.2	23.8
Total Suspended Solids	mg/L	dependent on background levels	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	2.2	4.4	5.0	<2.0
Turbidity	NTU	dependent on background levels	0.10	0.12	0.23	0.61	0.32	0.49	0.49	2.04	2.30	1.11	0.89	0.56
Anions and Nutrients														
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	120	120	120	119	102	97.7	44.4	45.5	90.5	92.4	110
Ammonia, Total (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
Bromide (Br)	mg/L		5.000	53.8	57.9	60.7	52.8	41.5	41.8	20.3	22.1	39.0	39.1	53.9
Chloride (Cl)	mg/L		50.00	15100	15900	15700	15700	12200	12300	5980	6550	10700	10800	13000
Fluoride (F)	mg/L		0.75 or 0.03	1.03	1.04	1.04	1.05	0.75	<0.75	<0.75	<0.75	0.79	0.81	0.96
Nitrate and Nitrite (as N)	mg/L			0.0654	0.0709	0.0727	0.0717	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	0.0069
Nitrate (as N)	mg/L	3.612[b]	0.0060	0.0654	0.0709	0.0727	0.0717	<0.0060	<0.0060	<0.0060	<0.0060	<0.50	<0.50	0.0069
Nitrite (as N)	mg/L		0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.10	<0.10	<0.0020
Phosphorus (P)	mg/L		0.0020	0.0431	0.0417	0.0457	0.0424	0.0274	0.0261	0.0185	0.0169	0.0210	0.0217	0.0280
Sulfate (SO_4)	mg/L		50.00	2160	2240	2220	2220	1710	1720	824	903	1500	1520	1840
Cyanides														
Cyanide, Total	mg/L		0.001 or 0.005	0.0016	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L		0.001 or 0.005	<0.0010	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon														
Total Organic Carbon	mg/L		0.50	1.49	1.84	1.42	1.22	1.37	1.38	3.27	3.34	1.85	1.82	1.29
Total Metals														
Aluminum (Al)	mg/L		0.0500	0.0062	0.0131	0.0094	0.0075	0.0065	0.0102	0.0294	0.0280	0.0223	0.0202	0.0214
Antimony (Sb)	mg/L		0.000500	<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	0.000400	0.00127	0.00114	0.00124	0.00098	0.00164	<0.00040	0.00087	0.00068	0.00116	0.00110	0.00126
Barium (Ba)	mg/L		0.00100	0.0127	0.0118	0.0126	0.0126	0.0102	0.0099	0.0062	0.0067	0.0093	0.0091	0.0111
Beryllium (Be)	mg/L		0.0005000	<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		0.000500	<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		0.1000	3.71	3.75	3.81	3.85	2.84	2.87	1.47	1.56	2.93	2.93	3.23
Cadmium (Cd)	mg/L	0.00012	0.0000200	0.000055	0.000057	0.000055	0.000059	0.000028	0.000028	<0.000020	<0.000020	0.000028	0.000030	0.000036
Calcium (Ca)	mg/L		0.25 or 0.5	325	319	321	326	254	263	123	134	234	223	266
Cesium (Cs)	mg/L		0.0005000	<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[b]	0.0001 or 0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00053	0.00068	0.00019
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
Copper (Cu)	mg/L		0.00005	0.000385	0.000506	0.000356	0.000403	0.000488	0.000545	0.000738	0.000705	0.000543	0.00104	0.000562
Gallium (Ga)	mg/L		0.000500	<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	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.081	0.075	0.022	0.022	0.016
Lead (Pb)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000151	<0.000050	<0.000050	<0.000050	0.000280	0.000241
Lithium (Li)	mg/L		0.02000	0.149	0.156	0.149	0.153	0.113	0.110	0.055	0.060	0.117	0.116	0.132
Magnesium (Mg)	mg/L		0.5 or 1.0	1020	997	1000	1020	804	806	394	420	706	681	829
Manganese (Mn)	mg/L		0.00005	0.00161	0.00151	0.00161	0.00167	0.00147	0.00150	0.00650	0.00598	0.00166	0.00172	0.00175
Mercury (Hg)	mg/L	Inorganic Hg: 0.000016	0.00000	<0.00000050	<0.00000050	<0.00000050	<0.00000050	<0.00000050	<0.00000050	0.00000	0.00000	<0.00000050	<0.00000050	<0.00000050
Molybdenum (Mo)	mg/L		0.002000	0.0089	0.0087	0.0093	0.0091	0.0075	0.0070	0.0035	0.0040	0.0066	0.0065	0.0078
Nickel (Ni)	mg/L		0.00005	0.000499	0.000497	0.000516	0.000523	0.000354	0.000447	0.000410	0.000397	0.000339	0.000368	0.000451
Phosphorus (P)	mg/L		1.00	<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		10 or 20	301	306	312	316	246	237	119	129	215	206	253
Rhenium (Re)	mg/L		0.0005000	<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		0.005000	0.0909	0.0945	0.0911	0.0925	0.0728	0.0712	0.0346	0.0381	0.0667	0.0659	0.0799

(continued)

Annex A.3-3. Marine Water Quality Data, Doris North Project, 2012 (continued)

Site ID:				ROBERTS BAY WEST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE	ROBERTS BAY WEST	ROBERTS BAY WEST	ROBERTS BAY EAST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE	ROBERTS BAY WEST
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				1	1	1	1	1	1	0.5	0.5	0.5	0.5	1
Replicate:				1	1	1	2	1	1	2	2	1	2	1
Date Sampled:		CCME guideline for the	Realized	19-APR-12	19-APR-12	19-APR-12	19-APR-12	22-JUL-12	22-JUL-12	22-JUL-12	22-JUL-12	26-JUL-12	26-JUL-12	18-AUG-12
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1137600-1	L1137607-3	L1137607-1	L1137607-2	L1182743-1	L1182743-2	L1182743-3	L1182743-4	L1185685-1	L1185685-2	L1196639-3
Total Metals *(cont'd)*														
Selenium (Se)	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
Silicon (Si)	mg/L		0.25 or 0.5	0.50	0.59	0.58	0.61	<0.50	<0.50	0.54	0.49	<0.50	<0.50	<0.50
Silver (Ag)	mg/L		0.0001000	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L		10 to 20	8660	8700	8810	8900	7430	7270	3520	3820	6190	5900	7150
Strontium (Sr)	mg/L		0.025 or 0.05	5.83	5.82	5.90	5.96	4.86	4.78	2.29	2.52	4.25	4.04	4.92
Tellurium (Te)	mg/L		0.000500	<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		0.0000500	0.000082	0.000079	0.000089	0.000082	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000062
Thorium (Th)	mg/L		0.0005000	<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		0.00100	<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		0.00500	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L		0.001000	<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		0.0000500	0.00237	0.00238	0.00247	0.00245	0.00207	0.00205	0.00102	0.00107	0.00173	0.00169	0.00222
Vanadium (V)	mg/L		0.000500	0.00084	0.00079	0.00087	0.00079	0.00062	0.00063	<0.00050	<0.00050	0.00058	0.00059	0.00071
Yttrium (Y)	mg/L		0.0005000	<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		0.0008	0.00095	0.00175	0.00081	0.00103	0.00101	0.00094	<0.00080	0.00154	<0.00080	<0.00080	0.00104
Zirconium (Zr)	mg/L		0.000500	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Speciated Metals														
Methyl Mercury			0.000050					<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry														
Radium-226	Bq/L		0.005											

Notes: *(continued)*

[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.*

No parameters exceeded CCME guidelines for the protection of marine aquatic life.

Annex A.3-3. Marine Water Quality Data, Doris North Project, 2012 (continued)

Site ID:				ROBERTS BAY WEST	ROBERTS BAY EAST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE	ROBERTS BAY WEST	ROBERTS BAY WEST	ROBERTS BAY EAST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				1	1	1	1	1	1	1	0.5	0.5	1	1
Replicate:				2	1	2	1	2	1	2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	18-AUG-12	18-AUG-12	18-AUG-12	17-AUG-12	17-AUG-12	19-SEP-12	19-SEP-12	19-SEP-12	19-SEP-12	17-SEP-12	17-SEP-12
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1196639-4	L1196639-5	L1196639-6	L1196639-1	L1196639-2	L1213175-3	L1213175-4	L1213175-5	L1213175-6	L1213175-1	L1213175-2
Physical Tests														
Hardness (as $CaCO_3$)	mg/L		2.2 or 4.3	4060	3300	3310	3080	3080	3870	3900	2770	1810	3900	3920
pH	pH	7.0-8.7	0.10	7.94	7.97	7.97	7.90	7.96	7.92	7.91	7.87	7.84	7.90	7.90
Salinity		<10% fluctuation[b]		23.8	19.0	19.3	18.1	18.4	22.9	23.0	15.5	10.5	23.2	23.0
Total Suspended Solids	mg/L	dependent on background levels	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.4	2.4	14.6	14.8	<2.0	<2.0
Turbidity	NTU	dependent on background levels	0.10	0.36	1.18	1.06	0.79	0.66	2.23	1.49	12.4	14.3	0.68	0.62
Anions and Nutrients														
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	108	93.5	96.1	88.1	92.8	106	112	89.6	47.1	108	106
Ammonia, Total (as N)	mg/L		0.0050	<0.0050	0.0054	<0.0050	<0.0050	<0.0050	0.0056	<0.0050	<0.0050	0.0054	<0.0050	<0.0050
Bromide (Br)	mg/L		5.000	53.0	42.5	42.4	38.6	42.0	49.3	47.1	30.3	21.1	48.0	46.9
Chloride (Cl)	mg/L		50.00	12700	10200	10300	9210	10000	12900	12600	8220	5710	12500	12400
Fluoride (F)	mg/L		0.75 or 0.03	0.95	0.80	0.80	0.93	0.92	0.91	0.90	<0.75	<0.75	0.86	0.99
Nitrate and Nitrite (as N)	mg/L			<0.0060	<0.0060	<0.0060	0.0113	<0.0060	0.0084	<0.0060	0.0146	0.0140	<0.0060	<0.0060
Nitrate (as N)	mg/L	3.612[b]	0.0060	<0.0060	<0.0060	<0.0060	0.0113	<0.0060	0.0084	<0.0060	0.0146	0.0140	<0.0060	<0.0060
Nitrite (as N)	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
Phosphorus (P)	mg/L		0.0020	0.0271	0.0217	0.0220	0.0198	0.0184	0.0246	0.0262	0.0245	0.0273	0.0276	0.0274
Sulfate (SO_4)	mg/L		50.00	1790	1430	1430	1290	1410	1840	1790	1160	798	1770	1760
Cyanides														
Cyanide, Total	mg/L		0.001 or 0.005	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L		0.001 or 0.005	<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	1.36	1.98	2.07	1.80	1.85	1.50	1.48	3.16	4.05	1.59	1.47
Total Metals														
Aluminum (Al)	mg/L		0.0500	0.0115	0.0196	0.0294	0.0221	0.0211	0.113	0.0396	0.316	0.305	0.0160	0.0145
Antimony (Sb)	mg/L		0.000500	<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	0.000400	0.00134	0.00111	0.00117	0.00101	0.00096	0.00100	0.00108	0.00071	0.00070	0.00110	0.00106
Barium (Ba)	mg/L		0.00100	0.0113	0.0103	0.0096	0.0090	0.0090	0.0109	0.0106	0.0109	0.0089	0.0109	0.0105
Beryllium (Be)	mg/L		0.0005000	<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		0.000500	<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		0.1000	3.34	2.70	2.70	2.41	2.45	3.28	3.25	2.34	1.55	3.27	3.26
Cadmium (Cd)	mg/L	0.00012	0.0000200	0.000031	0.000044	0.000025	0.000027	0.000028	0.000033	0.000032	0.000023	<0.000020	0.000038	0.000034
Calcium (Ca)	mg/L		0.25 or 0.5	268	216	220	202	201	250	252	178	119	253	265
Cesium (Cs)	mg/L		0.0005000	<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[b]	0.0001 or 0.0005	0.00018	0.00034	0.00021	0.00013	0.00019	<0.00050	<0.00050	0.00075	0.00058	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000057	0.000051	0.000194	0.000179	<0.000050	<0.000050
Copper (Cu)	mg/L		0.00005	0.000385	0.000575	0.000456	0.000590	0.000477	0.000561	0.000583	0.000994	0.00112	0.00134	0.000700
Gallium (Ga)	mg/L		0.000500	<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	0.011	0.031	0.029	0.029	0.030	0.067	0.052	0.297	0.276	0.020	0.019
Lead (Pb)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	0.000322	<0.000050	0.000104	0.000139	0.000133	0.000111	0.000643	0.000170
Lithium (Li)	mg/L		0.02000	0.136	0.109	0.109	0.098	0.100	0.129	0.126	0.090	0.059	0.130	0.126
Magnesium (Mg)	mg/L		0.5 or 1.0	824	670	671	626	627	788	794	565	366	794	791
Manganese (Mn)	mg/L		0.00005	0.00136	0.00298	0.00284	0.00211	0.00215	0.00281	0.00254	0.00934	0.0107	0.00164	0.00163
Mercury (Hg)	mg/L	Inorganic Hg: 0.000016	0.00000	<0.00000050	<0.00000050	<0.00000050	0.00000	0.00000	<0.00000050	<0.00000050	0.00000	0.00000	<0.00000050	<0.00000050
Molybdenum (Mo)	mg/L		0.002000	0.0081	0.0065	0.0065	0.0058	0.0059	0.0075	0.0074	0.0053	0.0033	0.0076	0.0074
Nickel (Ni)	mg/L		0.00005	0.000372	0.000387	0.000364	0.000359	0.000383	0.000439	0.000432	0.000748	0.000692	0.000404	0.000359
Phosphorus (P)	mg/L		1.00	<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		10 or 20	257	207	213	194	194	242	243	169	115	241	256
Rhenium (Re)	mg/L		0.0005000	<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		0.005000	0.0820	0.0663	0.0654	0.0597	0.0608	0.0770	0.0785	0.0553	0.0360	0.0802	0.0766

(continued)

Annex A.3-3. Marine Water Quality Data, Doris North Project, 2012 (completed)

Site ID:				ROBERTS BAY WEST	ROBERTS BAY EAST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE	ROBERTS BAY WEST	ROBERTS BAY WEST	ROBERTS BAY EAST	ROBERTS BAY EAST	MARINE REFERENCE	MARINE REFERENCE
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				1	1	1	1	1	1	1	0.5	0.5	1	1
Replicate:				2	1	2	1	2	1	2	1	2	1	2
Date Sampled:		CCME guideline for the	Realized	18-AUG-12	18-AUG-12	18-AUG-12	17-AUG-12	17-AUG-12	19-SEP-12	19-SEP-12	19-SEP-12	19-SEP-12	17-SEP-12	17-SEP-12
ALS Sample ID:	Units	Protection of Aquatic life[a]	Detection Limit	L1196639-4	L1196639-5	L1196639-6	L1196639-1	L1196639-2	L1213175-3	L1213175-4	L1213175-5	L1213175-6	L1213175-1	L1213175-2
Selenium (Se)	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
Silicon (Si)	mg/L		0.25 or 0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	1.26	1.46	<0.50	<0.50
Silver (Ag)	mg/L		0.0001000	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L		10 to 20	7250	5500	5580	5190	5190	6630	6660	4590	3040	6640	7010
Strontium (Sr)	mg/L		0.025 or 0.05	4.98	4.01	4.05	3.77	3.77	4.69	4.68	3.29	2.20	4.71	4.92
Tellurium (Te)	mg/L		0.000500	<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		0.0000500	0.000063	0.000066	0.000058	0.000062	0.000066	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thorium (Th)	mg/L		0.0005000	<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		0.00100	<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		0.00500	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0174	0.0164	<0.0050	<0.0050
Tungsten (W)	mg/L		0.001000	<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		0.0000500	0.00226	0.00181	0.00182	0.00164	0.00172	0.00209	0.00210	0.00154	0.000990	0.00216	0.00207
Vanadium (V)	mg/L		0.000500	0.00067	0.00061	0.00059	0.00059	0.00061	0.00077	0.00074	0.00139	0.00123	0.00073	0.00064
Yttrium (Y)	mg/L		0.0005000	<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		0.0008	<0.00080	0.00230	0.00100	0.00112	<0.00080	<0.00080	<0.00080	0.00128	0.00139	<0.00080	<0.00080
Zirconium (Zr)	mg/L		0.000500	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00052	<0.00050	<0.00050	<0.00050
Speciated Metals														
Methyl Mercury			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											

Notes:

[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.*

No parameters exceeded CCME guidelines for the protection of marine aquatic life.

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2012

Blank Type			Equipment Blank (Freshwater)	Field Blank (Freshwater)	Travel Blank (Freshwater)	Equipment Blank (Marine)	Field Blank (Marine)	Travel Blank (Marine)	Field Blank (Freshwater)	Travel Blank (Freshwater)	Equipment Blank (Freshwater)	Travel Blank (Freshwater)	Field Blank (Freshwater)	Equipment Blank (Marine)	Travel Blank (Marine)	Field Blank (Marine)	Equipment Blank (Freshwater)
Date Sampled:			14-APR-12	14-APR-12	14-APR-12	19-APR-12	19-APR-12	19-APR-12	16-JUN-12	16-JUN-12	22-JUL-12	24-JUL-12	23-JUL-12	22-JUL-12	22-JUL-12	22-JUL-12	14-AUG-12
ALS Sample ID:	Units	Realized Detection Limit	L1137612-1	L1137612-2	L1137612-3	L1137605-1	L1137605-2	L1137605-3	L1164238-11	L1164238-12	L1182753-11	L1185682-3	L1185682-9	L1182743-5	L1182743-6	L1182743-7	L1195945-1
Physical Tests																	
Conductivity	µS/cm	2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.50	<0.50	<0.50	<2.0
Hardness (as $CaCO_3$)	mg/L	0.5 or 2.2 or 4.3	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	6.14	5.70	5.65	<0.50
pH	pH	0.10	5.56	5.58	5.59	5.65	5.61	5.60	5.95	6.04	6.14	5.79	5.84	<1.0	<1.0	<1.0	5.90
Salinity		1.00															
Total Suspended Solids	mg/L	1 or 2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0	<1.0
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	0.13	<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
Ammonia, Total (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
Bromide (Br)	mg/L	0.05 or 5	<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	0.5 or 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	0.02 or 0.75 or 0.03	<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 and Nitrite (as N)	mg/L	0.006												<0.0060	<0.0060	<0.0060	
Nitrate (as N)	mg/L	0.005 or 0.006	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0060	<0.0060	<0.0060	0.0229
Nitrite (as N)	mg/L	0.001 or 0.002	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0020	<0.0020	<0.0020	<0.0010
Phosphorus (P)	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
Sulfate (SO_4)	mg/L	0.5 or 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																	
Cyanide, Total	mg/L	0.001 or 0.005	<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
Cyanide, Free	mg/L	0.001 or 0.005	<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	<0.50	<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
Total Metals																	
Aluminum (Al)	mg/L	0.003 to 0.021	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0111	<0.0050	<0.0050	0.0258
Antimony (Sb)	mg/L	0.00001 to 0.0005	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010
Arsenic (As)	mg/L	0.00005 to 0.002	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00040	<0.00040	<0.00040	<0.000050
Barium (Ba)	mg/L	0.0001 or 0.001	0.00931	<0.00010	<0.00010	0.00182	<0.00010	<0.00010	<0.00010	<0.00010	0.00185	<0.00010	<0.00010	<0.0010	<0.0010	<0.0010	0.00051
Beryllium (Be)	mg/L	0.000005 to 0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Bismuth (Bi)	mg/L	0.00005 or 0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Boron (B)	mg/L	0.005 to 0.1	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.10	<0.10	<0.10	<0.0050
Cadmium (Cd)	mg/L	0.000005 or 0.00002	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.000020	<0.000020	<0.000020	<0.0000050
Calcium (Ca)	mg/L	0.05 or 0.25 or 0.5	<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	0.000005 or 0.00001 or 0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Chromium (Cr)	mg/L	0.0001 or 0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<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
Copper (Cu)	mg/L	0.00005 or 0.00005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.00050
Gallium (Ga)	mg/L	0.00005 or 0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Iron (Fe)	mg/L	0.03 or 0.01	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.010	<0.010	<0.010	<0.030
Lead (Pb)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000107	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L	0.0002 or 0.02	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.020	<0.020	<0.020	<0.00020
Magnesium (Mg)	mg/L	0.1 or 0.5 or 1.0	<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	0.0002 or 0.00005	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	0.00022
Mercury (Hg)	ug/L	0.00000050	<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
Molybdenum (Mo)	mg/L	0.00005 or 0.002	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.0020	<0.0020	<0.0020	<0.000050
Nickel (Ni)	mg/L	0.00005 to 0.0007	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	<0.00020
Phosphorus (P)	mg/L	0.30 or 1	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<1.0	<1.0	<1.0	<0.30
Potassium (K)	mg/L	2 or 10 or 20	<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	0.000005 or 0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Rubidium (Rb)	mg/L	0.00002 or 0.005	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.0050	<0.0050	<0.0050	<0.000020
Selenium (Se)	mg/L	0.0002 or 0.0005	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050	<0.00050	<0.00020

(continued)

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2012 (continued)

Blank Type			Equipment Blank (Freshwater)	Field Blank (Freshwater)	Travel Blank (Freshwater)	Equipment Blank (Marine)	Field Blank (Marine)	Travel Blank (Marine)	Field Blank (Freshwater)	Travel Blank (Freshwater)	Equipment Blank (Freshwater)	Travel Blank (Freshwater)	Field Blank (Freshwater)	Equipment Blank (Marine)	Travel Blank (Marine)	Field Blank (Marine)	Equipment Blank (Freshwater)
Date Sampled:			**14-APR-12**	**14-APR-12**	**14-APR-12**	**19-APR-12**	**19-APR-12**	**19-APR-12**	**16-JUN-12**	**16-JUN-12**	**22-JUL-12**	**24-JUL-12**	**23-JUL-12**	**22-JUL-12**	**22-JUL-12**	**22-JUL-12**	**14-AUG-12**
ALS Sample ID:	**Units**	**Realized Detection Limit**	**L1137612-1**	**L1137612-2**	**L1137612-3**	**L1137605-1**	**L1137605-2**	**L1137605-3**	**L1164238-11**	**L1164238-12**	**L1182753-11**	**L1185682-3**	**L1185682-9**	**L1182743-5**	**L1182743-6**	**L1182743-7**	**L1195945-1**
Total Metals *(cont'd)*																	
Silicon (Si)	mg/L	0.05 or 0.25 or 0.5	<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	0.000005 or 0.00001 or 0.0001	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00010	<0.00010	<0.00010	<0.0000050
Sodium (Na)	mg/L	2 or 10 to 20	<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	0.00005 or 0.025 or 0.05	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.0050	<0.0050	<0.0050	<0.000050
Tellurium (Te)	mg/L	0.0001 or 0.0005	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010
Thallium (Tl)	mg/L	0.000002 or 0.00002 or 0.00005	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020
Thorium (Th)	mg/L	0.00005 to 0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Tin (Sn)	mg/L	0.002 or 0.001	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.0010	<0.0010	<0.0010	<0.00020
Titanium (Ti)	mg/L	0.002 or 0.005	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.0050	<0.0050	<0.0050	<0.00020
Tungsten (W)	mg/L	0.0001 or 0.001	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.0010	<0.0010	<0.0010	<0.000010
Uranium (U)	mg/L	0.000002 or 0.00005	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020
Vanadium (V)	mg/L	0.00005 or 0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Yttrium (Y)	mg/L	0.000005 or 0.0005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050
Zinc (Zn)	mg/L	0.003 or 0.0008	0.0064	<0.0030	<0.0030	0.0280	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.00080	<0.00080	<0.00080	<0.0030
Zirconium (Zr)	mg/L	0.0005 or 0.0005	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050
Speciated Metals																	
Methyl Mercury		0.000050												<0.000050	<0.000050	<0.000050	
Radiochemistry																	
Radium-226	Bq/L	0.005															

(continued)

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2012 (continued)

Blank Type			Travel Blank (Freshwater)	Field Blank (Freshwater)	Travel Blank (Marine)	Field Blank (Marine)	Equipment Blank (Marine)	Travel Blank (Freshwater)	Field Blank (Freshwater)	Equipment Blank (Freshwater)	Equipment Blank (Marine)	Travel Blank (Marine)	Field Blank (Marine)
Date Sampled:			16-AUG-12	16-AUG-12	18-AUG-12	18-AUG-12	17-AUG-12	20-SEP-12	20-SEP-12	15-SEP-12	16-SEP-12	19-SEP-12	19-SEP-12
ALS Sample ID:	Units	Realized Detection Limit	L1195945-7	L1195945-8	L1196639-7	L1196639-8	L1196639-9	L1213168-11	L1213168-12	L1210628-1	L1210628-14	L1213175-7	L1213175-8
Physical Tests													
Conductivity	µS/cm	2	<2.0	<2.0	<0.50	<0.50	<0.50	2.9	<2.0	<2.0	<0.50	-	-
Hardness (as $CaCO_3$)	mg/L	0.5 or 2.2 or 4.3	<0.50	<0.50	6.51	5.82	5.63	<0.50	<0.50	<0.50	5.78	6.04	5.67
pH	pH	0.10	5.63	5.74	<1.0	<1.0	<1.0	5.89	5.77	6.03	<1.0	<1.0	<1.0
Salinity		1.00											
Total Suspended Solids	mg/L	1 or 2	<1.0	<1.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0
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
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
Ammonia, Total (as N)	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0118	<0.0050
Bromide (Br)	mg/L	0.05 or 5	<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	0.5 or 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	0.02 or 0.75 or 0.03	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrate and Nitrite (as N)	mg/L	0.006			-	<0.0060	<0.0060				<0.0060	<0.0060	<0.0060
Nitrate (as N)	mg/L	0.005 or 0.006	<0.0050	<0.0050	<0.0050	<0.0060	<0.0060	0.183	<0.0050	<0.0050	0.0064	<0.0060	<0.0060
Nitrite (as N)	mg/L	0.001 or 0.002	<0.0010	<0.0010	<0.0010	<0.0020	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010	<0.0020	<0.0020
Phosphorus (P)	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
Sulfate (SO_4)	mg/L	0.5 or 50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Cyanides													
Cyanide, Total	mg/L	0.001 or 0.005	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	0.001 or 0.005	<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	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.74	<0.50	0.56	<0.50	<0.50
Total Metals													
Aluminum (Al)	mg/L	0.003 to 0.021	<0.0030	<0.0030	<0.0050	<0.0050	0.0111	<0.0030	<0.0030	0.0100	0.0056	-	-
Antimony (Sb)	mg/L	0.00001 to 0.0005	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010	<0.000010	<0.000010	<0.00050	-	-
Arsenic (As)	mg/L	0.00005 to 0.002	<0.000050	<0.000050	<0.00040	<0.00040	<0.00040	<0.000050	<0.000050	<0.000050	<0.00040	-	-
Barium (Ba)	mg/L	0.0001 or 0.001	<0.00010	<0.00010	<0.0010	<0.0010	<0.0010	<0.00010	<0.00010	0.00019	<0.0010	-	-
Beryllium (Be)	mg/L	0.000005 to 0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.00050	-	-
Bismuth (Bi)	mg/L	0.00005 or 0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.00050	-	-
Boron (B)	mg/L	0.005 to 0.1	<0.0050	<0.0050	<0.10	<0.10	<0.10	<0.0050	<0.0050	<0.0050	<0.10	-	-
Cadmium (Cd)	mg/L	0.000005 or 0.00002	<0.0000050	<0.0000050	<0.000020	<0.000020	<0.000020	<0.0000050	<0.0000050	<0.0000050	<0.000020	-	-
Calcium (Ca)	mg/L	0.05 or 0.25 or 0.5	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	-	-
Cesium (Cs)	mg/L	0.000005 or 0.00001 or 0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.00050	-	-
Chromium (Cr)	mg/L	0.0001 or 0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00010	-	-
Cobalt (Co)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-
Copper (Cu)	mg/L	0.00005 or 0.00005	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	0.000909	-	-
Gallium (Ga)	mg/L	0.00005 or 0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.00050	-	-
Iron (Fe)	mg/L	0.03 or 0.01	<0.030	<0.030	<0.010	<0.010	<0.010	<0.030	<0.030	<0.030	<0.010	-	-
Lead (Pb)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-
Lithium (Li)	mg/L	0.0002 or 0.02	<0.00020	<0.00020	<0.020	<0.020	<0.020	<0.00020	<0.00020	<0.00020	<0.020	-	-
Magnesium (Mg)	mg/L	0.1 or 0.5 or 1.0	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	-
Manganese (Mn)	mg/L	0.0002 or 0.00005	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	<0.00020	<0.00020	<0.00020	<0.000050	-	-
Mercury (Hg)	ug/L	0.00000050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.00005 or 0.002	<0.000050	<0.000050	<0.0020	<0.0020	<0.0020	<0.000050	<0.000050	<0.000050	<0.0020	-	-
Nickel (Ni)	mg/L	0.00005 to 0.0007	<0.00020	<0.00020	<0.000050	<0.000050	<0.000050	<0.00020	<0.00020	<0.00020	<0.000050	-	-
Phosphorus (P)	mg/L	0.30 or 1	<0.30	<0.30	<1.0	<1.0	<1.0	<0.30	<0.30	<0.30	<1.0	-	-
Potassium (K)	mg/L	2 or 10 or 20	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-	-
Rhenium (Re)	mg/L	0.000005 or 0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.00050	-	-
Rubidium (Rb)	mg/L	0.00002 or 0.005	<0.000020	<0.000020	<0.0050	<0.0050	<0.0050	<0.000020	<0.000020	<0.000020	<0.0050	-	-
Selenium (Se)	mg/L	0.0002 or 0.0005	<0.00020	<0.00020	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020	<0.00050	-	-

(continued)

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2012 (completed)

Blank Type			Travel Blank (Freshwater)	Field Blank (Freshwater)	Travel Blank (Marine)	Field Blank (Marine)	Equipment Blank (Marine)	Travel Blank (Freshwater)	Field Blank (Freshwater)	Equipment Blank (Freshwater)	Equipment Blank (Marine)	Travel Blank (Marine)	Field Blank (Marine)
Date Sampled:			**16-AUG-12**	**16-AUG-12**	**18-AUG-12**	**18-AUG-12**	**17-AUG-12**	**20-SEP-12**	**20-SEP-12**	**15-SEP-12**	**16-SEP-12**	**19-SEP-12**	**19-SEP-12**
ALS Sample ID:	**Units**	**Realized Detection Limit**	**L1195945-7**	**L1195945-8**	**L1196639-7**	**L1196639-8**	**L1196639-9**	**L1213168-11**	**L1213168-12**	**L1210628-1**	**L1210628-14**	**L1213175-7**	**L1213175-8**
Silicon (Si)	mg/L	0.05 or 0.25 or 0.5	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	-	-
Silver (Ag)	mg/L	0.000005 or 0.00001 or 0.0001	<0.0000050	<0.0000050	<0.00010	<0.00010	<0.00010	<0.0000050	<0.0000050	<0.0000050	<0.00010	-	-
Sodium (Na)	mg/L	2 or 10 to 20	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-	-
Strontium (Sr)	mg/L	0.00005 or 0.025 or 0.05	<0.000050	<0.000050	<0.0050	<0.0050	<0.0050	<0.000050	<0.000050	<0.000050	<0.0050	-	-
Tellurium (Te)	mg/L	0.0001 or 0.0005	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050	<0.000010	<0.000010	<0.000010	<0.00050	-	-
Thallium (Tl)	mg/L	0.000002 or 0.00002 or 0.00005	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020	<0.0000020	<0.0000020	<0.000050	-	-
Thorium (Th)	mg/L	0.00005 to 0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.00050	-	-
Tin (Sn)	mg/L	0.002 or 0.001	<0.00020	<0.00020	<0.0010	<0.0010	<0.0010	<0.00020	<0.00020	<0.00020	<0.0010	-	-
Titanium (Ti)	mg/L	0.002 or 0.005	<0.00020	<0.00020	<0.0050	<0.0050	<0.0050	<0.00020	<0.00020	<0.00020	<0.0050	-	-
Tungsten (W)	mg/L	0.0001 or 0.001	<0.000010	<0.000010	<0.0010	<0.0010	<0.0010	<0.000010	<0.000010	<0.000010	<0.0010	-	-
Uranium (U)	mg/L	0.000002 or 0.00005	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050	<0.0000020	<0.0000020	<0.0000020	<0.000050	-	-
Vanadium (V)	mg/L	0.00005 or 0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.00050	-	-
Yttrium (Y)	mg/L	0.000005 or 0.0005	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.00050	-	-
Zinc (Zn)	mg/L	0.003 or 0.0008	<0.0030	<0.0030	<0.00080	<0.00080	<0.00080	<0.0030	<0.0030	<0.0030	<0.00080	-	-
Zirconium (Zr)	mg/L	0.0005 or 0.0005	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.00050	-	-
Speciated Metals					<0.000050	<0.000050	<0.000050				<0.000050	<0.000050	<0.000050
Methyl Mercury		0.000050											
Radiochemistry													
Radium-226	Bq/L	0.005											

A.4 2012 SEDIMENT QUALITY

The following sections present the sediment quality data collected in August 2012 from stream, lake, and marine sites. Only the parameters that were subjected to an evaluation of effects (see main body of AEMP report) are shown graphically. All sediment quality parameters were screened against CCME sediment quality guidelines for the protection of aquatic life (CCME 2012a). 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 2012a). CCME guidelines are included in all graphs, tables, and annexes.

A.4.1 Stream Data

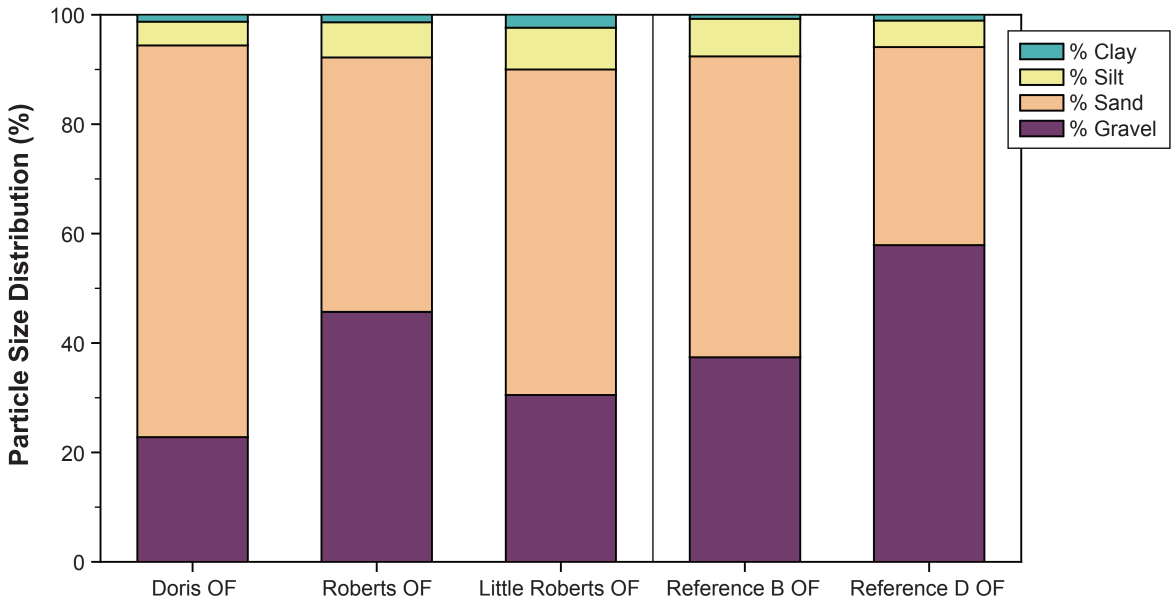
Figures A.4-1 to A.4-5 show select sediment quality parameter concentrations in the AEMP streams. Table A.4-1 presents the percentage of stream sediment samples in which metal concentrations were higher than CCME guidelines, and Table A.4-2 provides the factor by which average 2012 sediment metal concentrations were higher than CCME guidelines. Annex A.4-1 presents the raw stream sediment quality data.

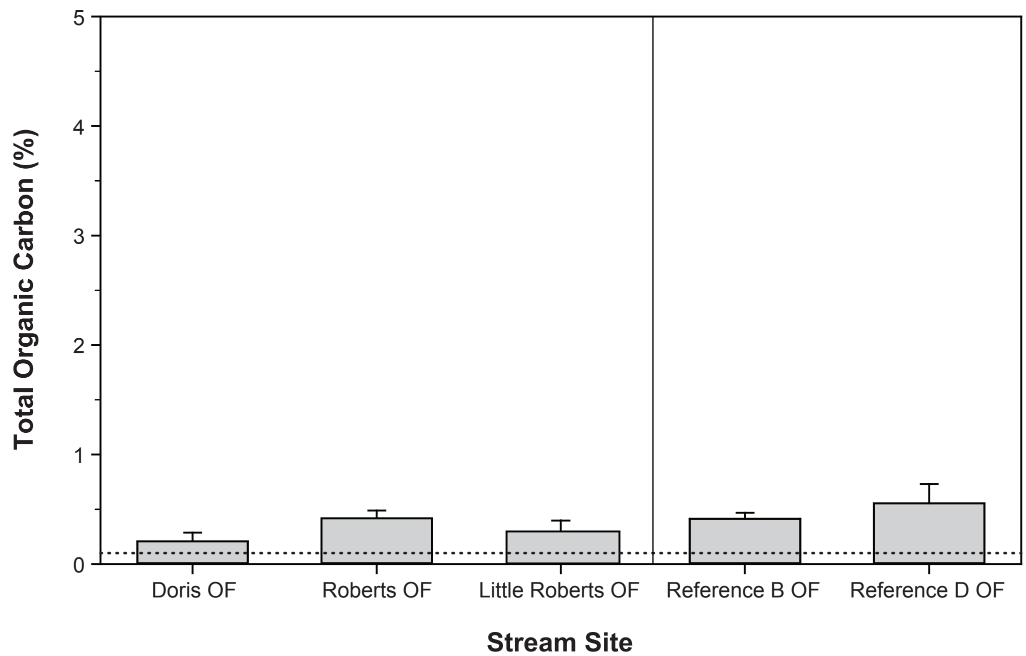
A.4.2 Lake Data

Figures A.4-6 to A.4-10 show select sediment quality parameter concentrations in the surveyed lakes. Table A.4-3 presents the percentage of lake sediment samples in which metal concentrations were higher than CCME guidelines, and Table A.4-4 provides the factor by which average 2012 sediment metal concentrations were higher than CCME guidelines. Annex A.4-2 presents the raw lake sediment quality data.

A.4.3 Marine Data

Figures A.4-11 to A.4-15 show select sediment quality parameter concentrations in the AEMP marine sites. Table A.4-5 presents the percentage of marine sediment samples in which metal concentrations were higher than CCME guidelines, and Table A.4-6 provides the factor by which average 2012 sediment metal concentrations were higher than CCME guidelines. Annex A.4-3 presents the raw marine sediment quality data.





Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Particle size distribution and total organic carbon content of sediments are required parameters as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

NEWMONT NORTH AMERICA

Particle Size Distribution and Total Organic Carbon Concentration in Stream Sediments, Doris North Project, August 2012

Figure A4-1

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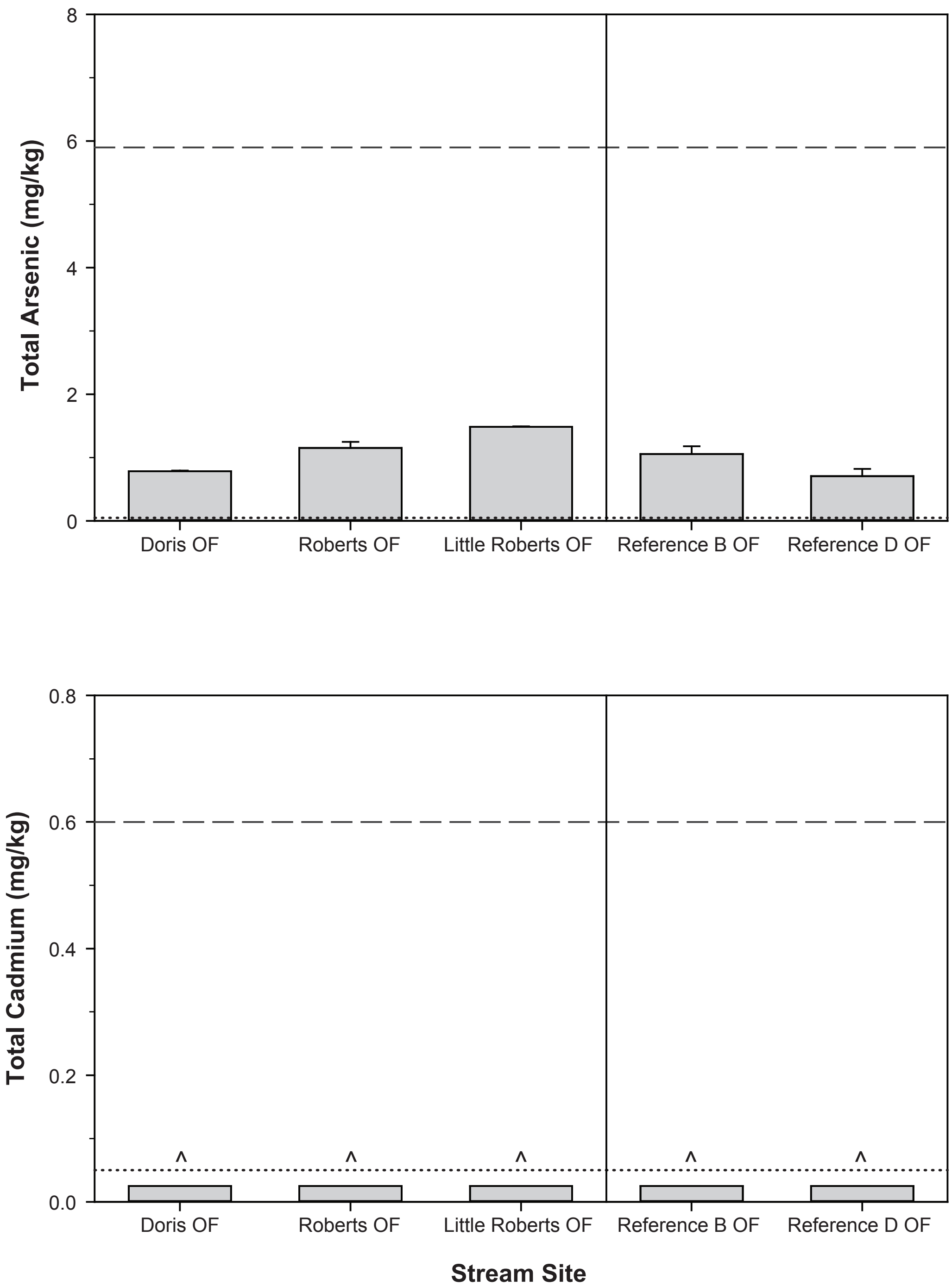


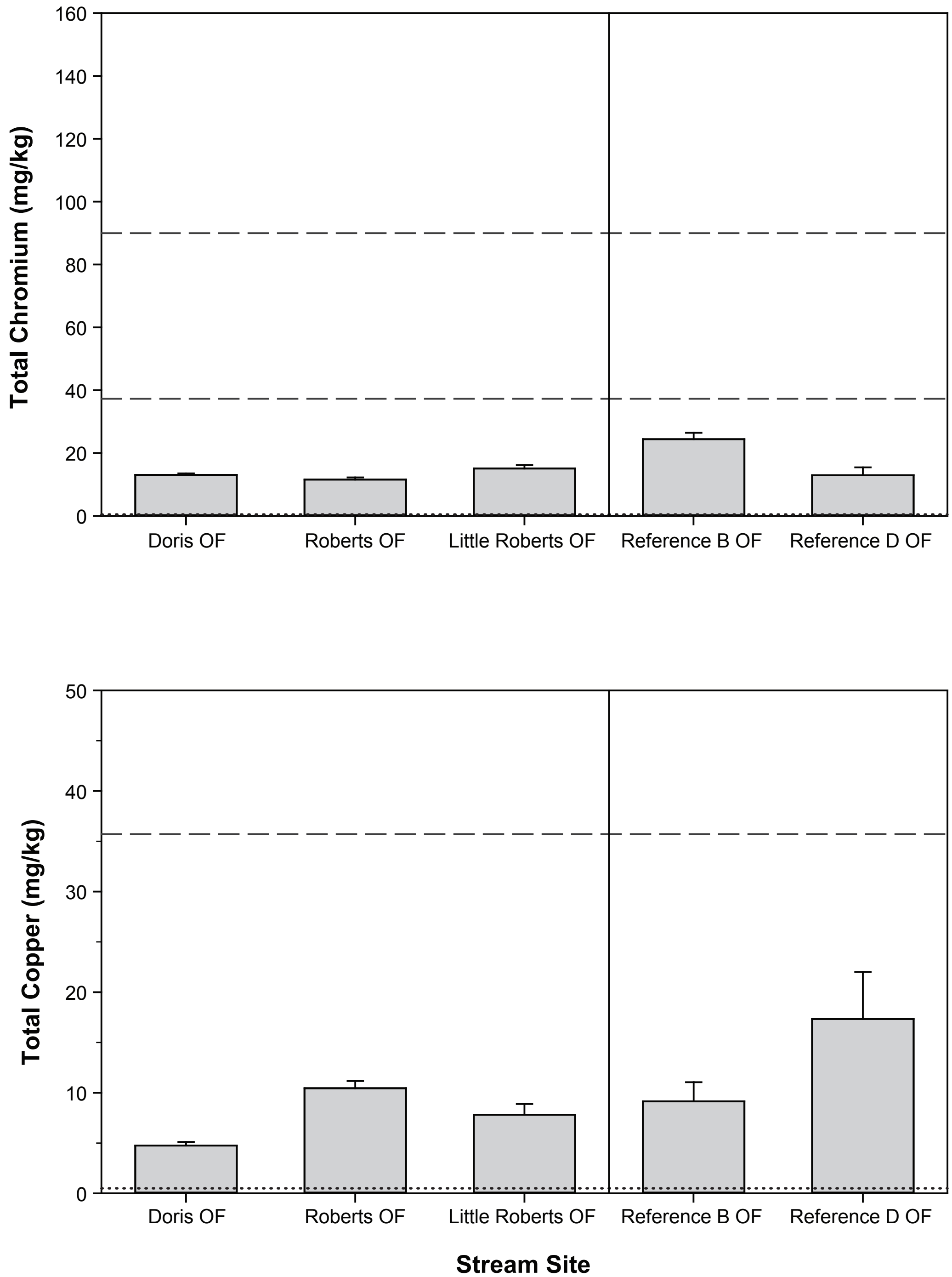
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for arsenic (5.9 mg/kg) and cadmium (0.6 mg/kg); probable effects levels (PELs) for arsenic (17 mg/kg) and cadmium (3.5 mg/kg) are not shown.

NEWMONT NORTH AMERICA

Total Arsenic and Total Cadmium Concentrations in Stream Sediments, Doris North Project, August 2012

Figure A4-2

Rescan Engineers & Scientists



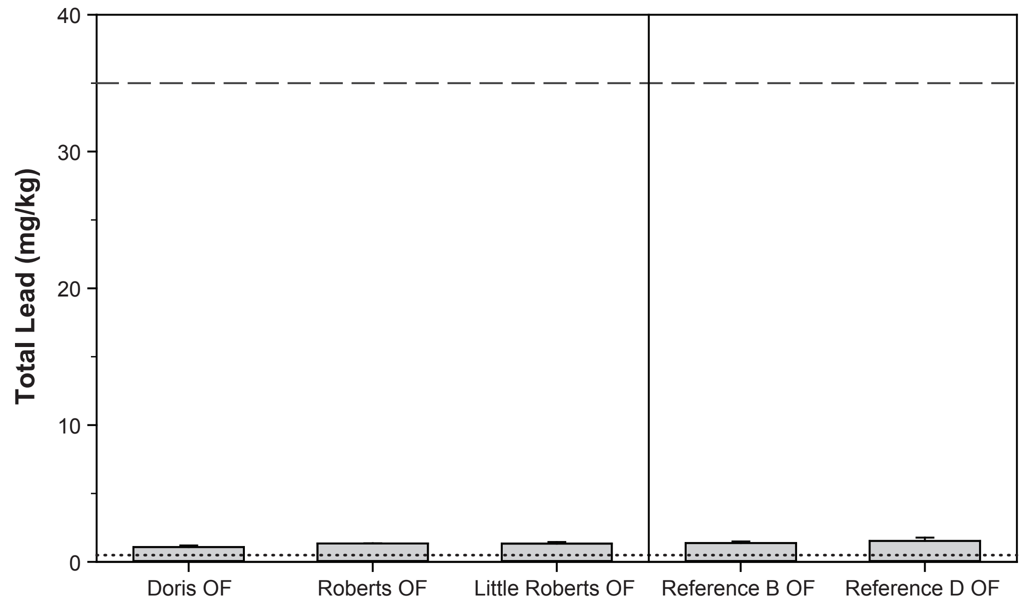
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for chromium (37.3 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.

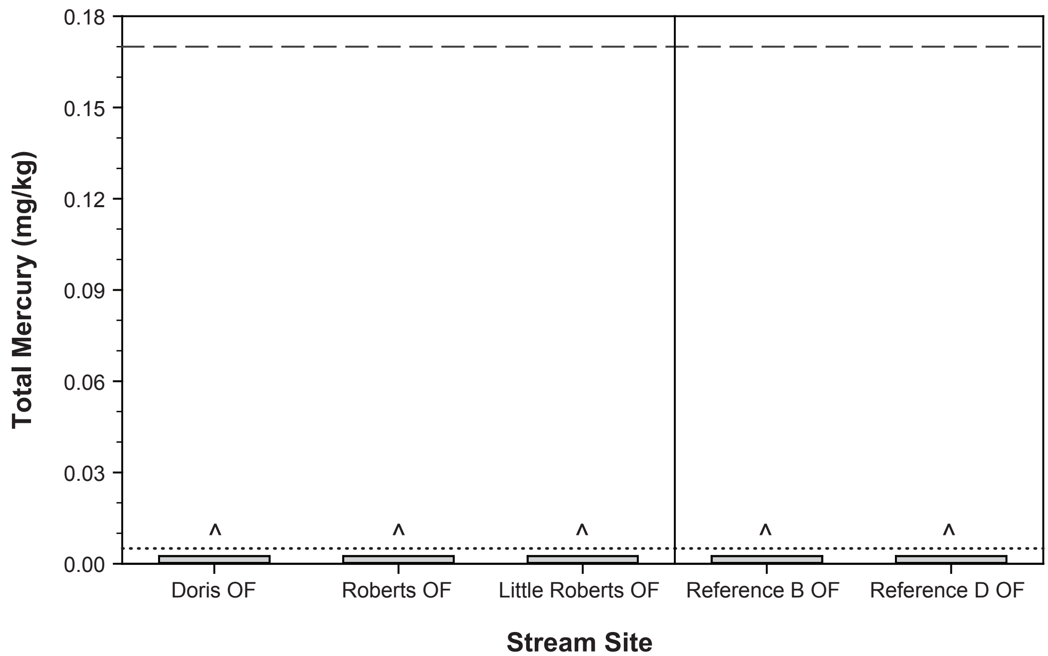
NEWMONT NORTH AMERICA

Total Chromium and Total Copper Concentrations in Stream Sediments, Doris North Project, August 2012

Figure A4-3

Rescan Engineers & Scientists





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

NEWMONT™ NORTH AMERICA

Total Lead and Total Mercury Concentrations in Stream Sediments, Doris North Project, August 2012

Figure A4-4

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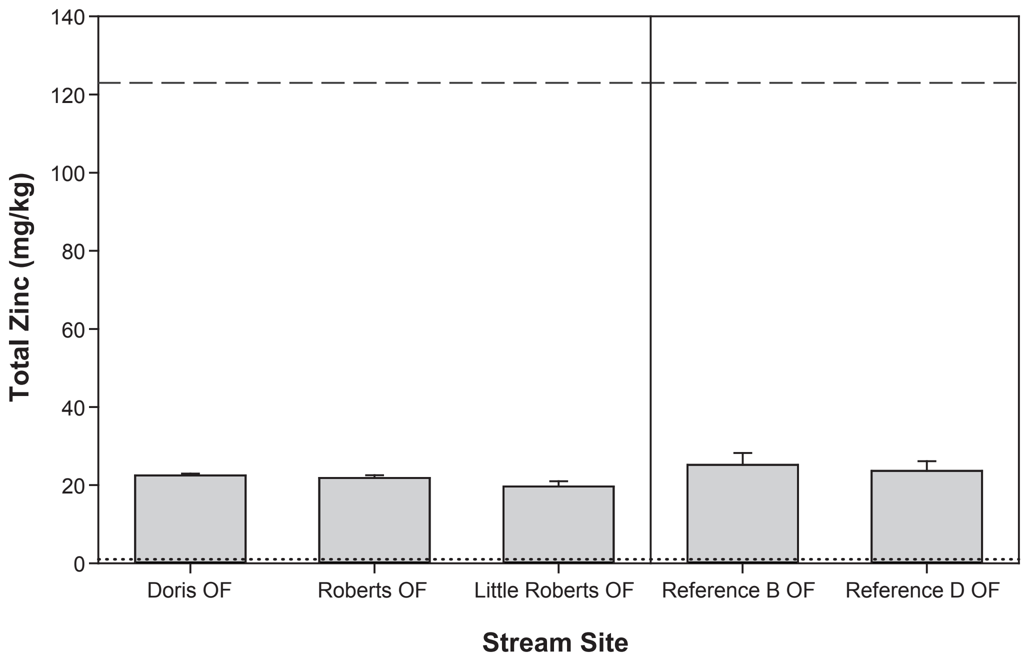

Notes: Error bars represent the standard error of the mean.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Black dashed line represents the CCME freshwater interim sediment quality guideline (ISQG) for zinc (123 mg/kg);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

NEWMONT NORTH AMERICA

Total Zinc Concentrations in Stream Sediments, Doris North Project, August 2012

Figure A4-5

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Table A.4-1. Sediment Quality in AEMP Stream Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Stream Site	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		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

Stream Site	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 2012 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 A.4-2. Sediment Quality in AEMP Stream Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Stream Site	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		-	-	-	-	-	-	-
Little Roberts Outflow	3		-	-	-	-	-	-	-
Reference B Outflow	3		-	-	-	-	-	-	-
Reference D Outflow	3		-	-	-	-	-	-	-

Stream Site	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 2012 concentrations are higher than CCME guidelines; dashes represent average 2012 concentrations that are below CCME guidelines.

The average 2012 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*

Annex A.4-1. Stream Sediment Quality Data, Doris North Project, 2012

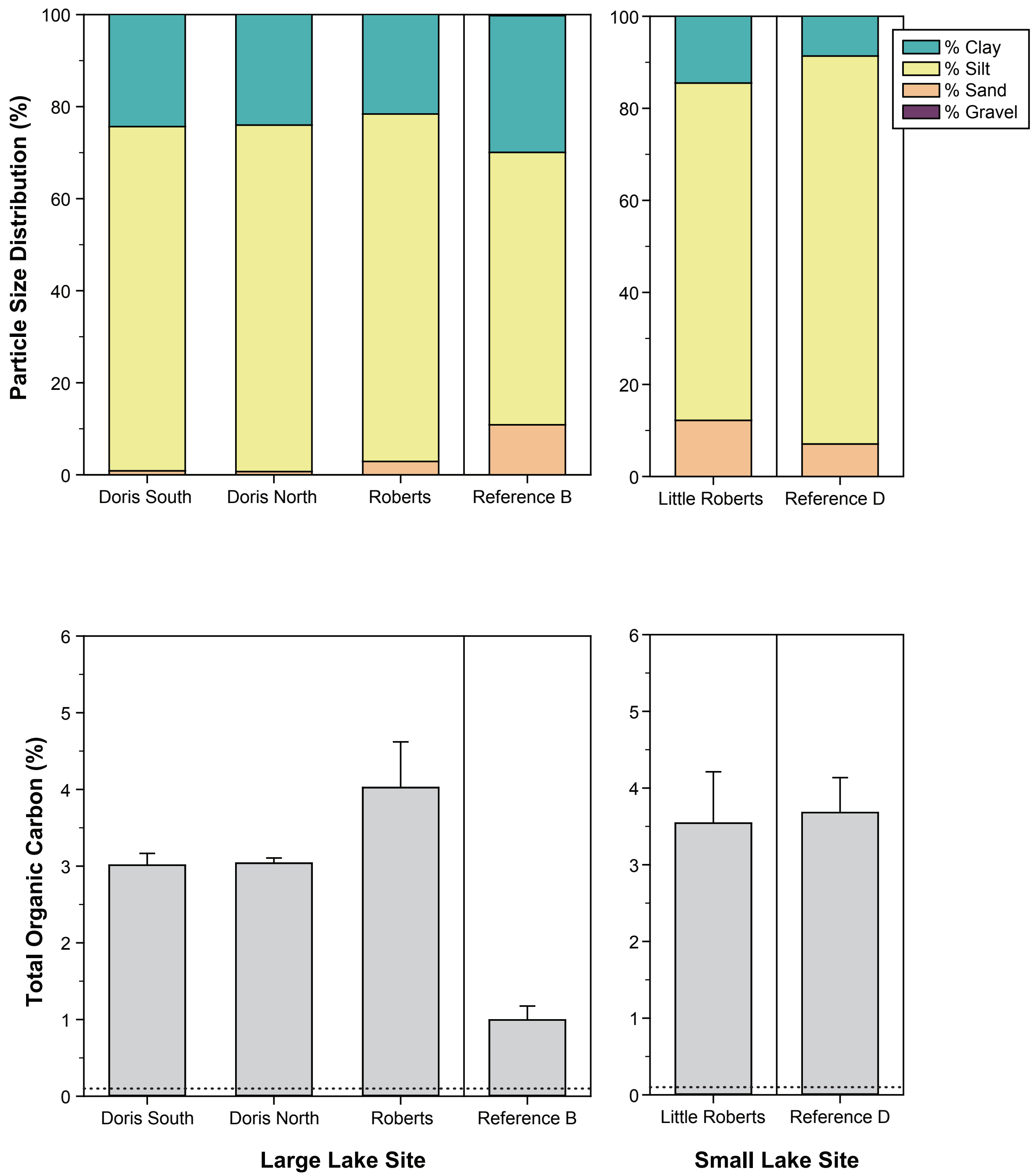
		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit															
Site ID:					Doris OF	Doris OF	Doris OF	Roberts OF	Roberts OF	Roberts OF	Little Roberts OF	Little Roberts OF	Little Roberts OF	Reference B OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Reference D OF
Replicate:					1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Date Sampled:					25-AUG-12	25-AUG-12	25-AUG-12	22-AUG-12	22-AUG-12	22-AUG-12	24-AUG-12	24-AUG-12	24-AUG-12	25-AUG-12	25-AUG-12	25-AUG-12	21-AUG-12	21-AUG-12	21-AUG-12
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1200994-4	L1200994-5	L1200994-6	L1199722-10	L1199722-11	L1199722-12	L1200994-1	L1200994-2	L1200994-3	L1200994-7	L1200994-8	L1200994-9	L1199722-7	L1199722-8	L1199722-9
Physical Tests																			
Moisture	%			0.25	32.3	27.7	33.9	16.8	32.7	28.9	24.6	26.3	36.1	30.3	29.1	30.7	18.1	16.9	19.5
pH	pH			0.10	7.15	7.26	7.02	6.90	6.72	6.81	7.26	7.11	6.96	7.06	6.40	6.70	6.72	6.03	6.04
Particle Size																			
% Gravel (>2 mm)	%			0.10	20.9	26.6	20.8	72.7	15.9	48.5	34.1	34.4	23.1	42.6	17.9	51.8	51.2	41.5	81.1
% Sand (2.0 mm - 0.063 mm)	%			0.10	72.3	71.3	71.3	22.1	75.0	42.3	62.3	48.9	67.3	52.5	65.8	46.7	45.7	47.0	15.9
% Silt (0.063 mm - 4 µm)	%			0.10	5.37	1.60	6.19	4.58	6.94	7.86	2.86	13.0	7.12	4.21	15.2	1.25	2.84	9.02	2.71
% Clay (<4 µm)	%			0.10	1.41	0.47	1.72	0.65	2.09	1.41	0.80	3.66	2.48	0.66	1.11	0.22	0.23	2.51	0.30
Anions & Nutrients																			
Total Nitrogen	%			0.020	0.034	<0.020	0.033	0.045	0.036	0.046	<0.020	0.042	0.035	0.057	0.055	0.044	0.024	0.056	0.074
Organic / Inorganic Carbon																			
Total Organic Carbon	%			0.10	0.28	<0.10	0.29	0.39	0.31	0.55	<0.10	0.41	0.37	0.44	0.49	0.31	0.20	0.69	0.77
Plant Available Nutrients																			
Available Ammonium-N	mg/kg			1.0 or 2.4	2.2	<1.0	3.7	3.9	2.0	4.1	1.8	2.9	2.7	3.7	5.3	1.9	1.9	2.0	6.6
Available Nitrate-N	mg/kg			2.0 to 6.0	<4.0	<2.0	<2.0	<4.0	<4.0	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<4.0	<4.0
Available Nitrite-N	mg/kg			0.40 to 1.2	<0.40	<0.40	<0.40	<0.80	<0.80	<0.80	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.80	<0.80	<0.80
Available Phosphate-P	mg/kg			2.0 to 6.0	3.2	2.2	5.6	2.9	2.6	2.7	2.5	2.2	<2.0	3.3	3.4	3.4	<2.0	4.1	2.5
Metals																			
Aluminum (Al)	mg/kg			50	5760	5740	6410	5240	5110	5550	4980	5530	6100	8010	5840	7520	5520	8030	6740
Antimony (Sb)	mg/kg			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
Arsenic (As)	mg/kg	5.9	17	0.050	0.807	0.764	0.781	1.24	1.26	0.961	1.47	1.49	1.50	1.03	1.28	0.865	0.522	0.918	0.682
Barium (Ba)	mg/kg			0.50	15.7	37.2	13.8	20.9	17.7	21.1	15.8	18.3	19.1	21.6	15.2	20.9	13.9	28.3	25.9
Beryllium (Be)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	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
Calcium (Ca)	mg/kg			50	1470	1400	1480	1820	1740	1820	2380	2010	1820	2270	1870	2090	2160	2840	2310
Chromium (Cr)	mg/kg	37.3	90	0.50	14.0	12.4	12.9	10.7	11.1	13.0	12.9	16.4	16.0	28.1	21.1	24.1	8.18	16.5	14.3
Cobalt (Co)	mg/kg			0.10	4.82	5.13	4.66	3.81	4.31	4.46	4.07	4.22	5.01	7.43	5.21	6.89	3.74	5.29	5.10
Copper (Cu)	mg/kg	35.7	197	0.50	5.49	4.36	4.36	11.0	9.02	11.3	7.76	5.99	9.68	9.02	12.5	5.93	10.1	26.1	15.8
Iron (Fe)	mg/kg			50	11700	11700	12700	11000	11300	11400	9670	10000	10200	15200	11600	14500	10800	12900	12500
Lead (Pb)	mg/kg	35	91.3	0.50	1.21	0.85	1.19	1.35	1.38	1.34	1.12	1.38	1.52	1.34	1.60	1.19	1.10	1.93	1.58
Lithium (Li)	mg/kg			5.0	9.4	10.3	10.6	11.4	11.5	12.1	8.9	9.7	10.4	12.7	9.2	12.3	13.6	17.0	15.6
Magnesium (Mg)	mg/kg			20	4670	5410	4830	4010	4030	4490	4290	4440	4900	6320	4490	6070	4240	5750	5010
Manganese (Mn)	mg/kg			1.0	177	176	159	133	117	148	163	160	184	331	140	203	136	144	175
Mercury (Hg)	mg/kg	0.17	0.486	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
Molybdenum (Mo)	mg/kg			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
Nickel (Ni)	mg/kg			0.50	9.18	10.6	9.64	8.19	7.38	8.93	8.98	10.8	11.1	16.5	12.2	15.2	6.81	12.5	11.0
Phosphorus (P)	mg/kg			50	301	311	287	279	279	284	269	302	244	392	255	344	321	403	386
Potassium (K)	mg/kg			100	700	760	590	850	750	910	650	890	880	760	530	890	600	1210	1020
Selenium (Se)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silver (Ag)	mg/kg			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
Sodium (Na)	mg/kg			100	130	<100	100	190	360	190	120	150	180	<100	<100	<100	170	250	210
Strontium (Sr)	mg/kg			0.50	6.10	6.14	7.13	9.91	10.2	8.76	10.3	8.83	10.3	11.9	8.30	7.81	11.8	13.6	11.1
Sulphur (S)	mg/kg			500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	500	<500	<500
Thallium (Tl)	mg/kg			0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	0.052	<0.050	<0.050	<0.050	<0.050	0.052	<0.050
Tin (Sn)	mg/kg			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
Titanium (Ti)	mg/kg			1.0	323	315	314	380	380	384	414	362	396	530	494	604	364	502	494
Uranium (U)	mg/kg			0.050	0.358	0.252	0.369	0.536	0.355	0.368	0.387	0.419	0.425	0.652	0.615	0.381	0.460	1.24	0.687
Vanadium (V)	mg/kg			0.20	22.1	23.7	22.0	19.9	26.8	25.4	21.2	19.2	22.6	27.4	23.0	26.4	24.5	32.7	30.7
Zinc (Zn)	mg/kg	123	315	1.0	23.4	22.1	21.9	20.8	21.6	23.1	17.1	19.8	21.9	30.1	19.6	25.8	18.7	25.8	26.4

Notes:

[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*



Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Particle size distribution and total organic carbon content of sediments are required parameters as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

NEWMONT NORTH AMERICA

Particle Size Distribution and Total Organic Carbon Concentration in Lake Sediments, Doris North Project, August 2012

Figure A4-6

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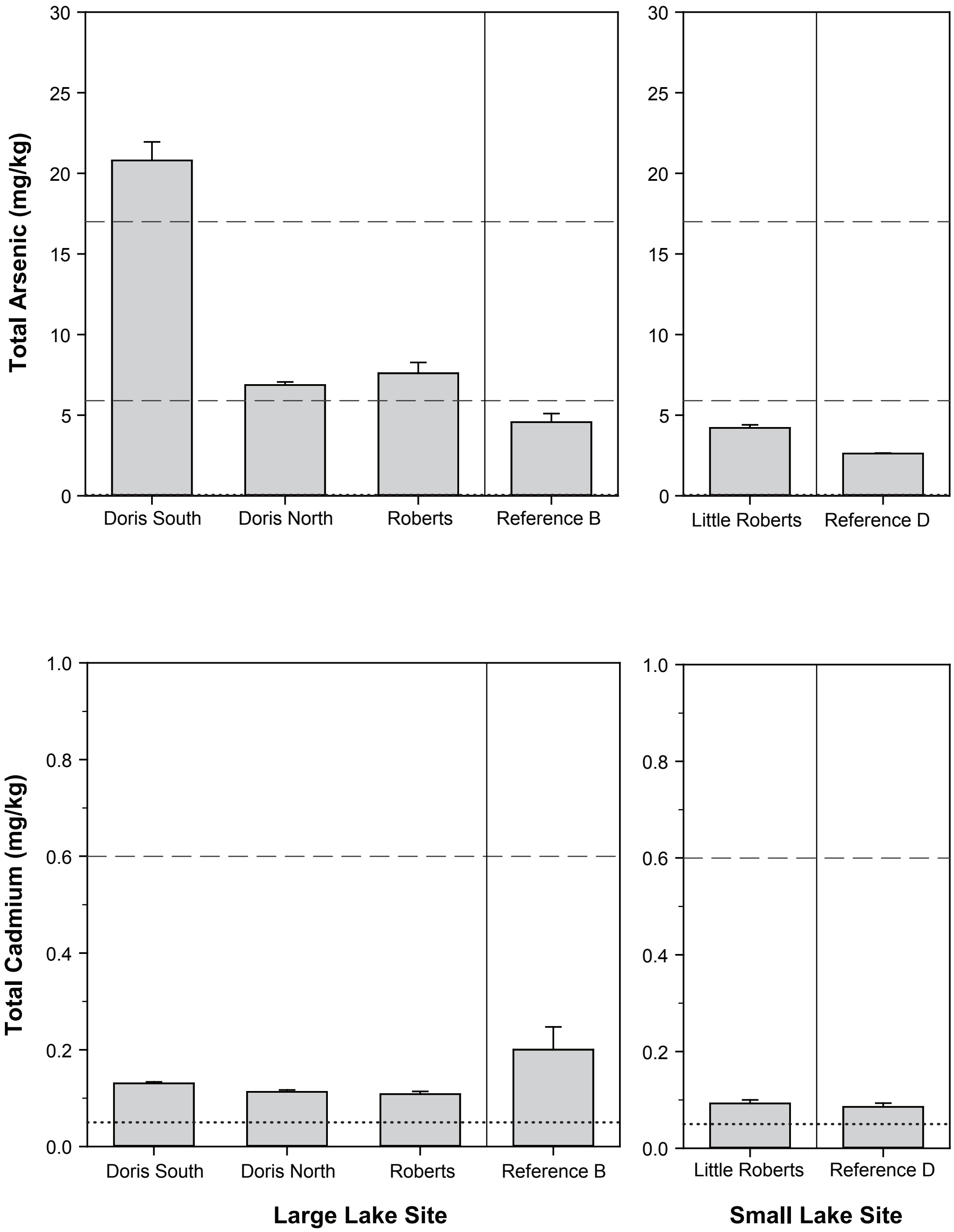

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for arsenic (5.9 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.

NEWMONT NORTH AMERICA

Total Arsenic and Total Cadmium Concentrations in Lake Sediments, Doris North Project, August 2012

Figure A4-7

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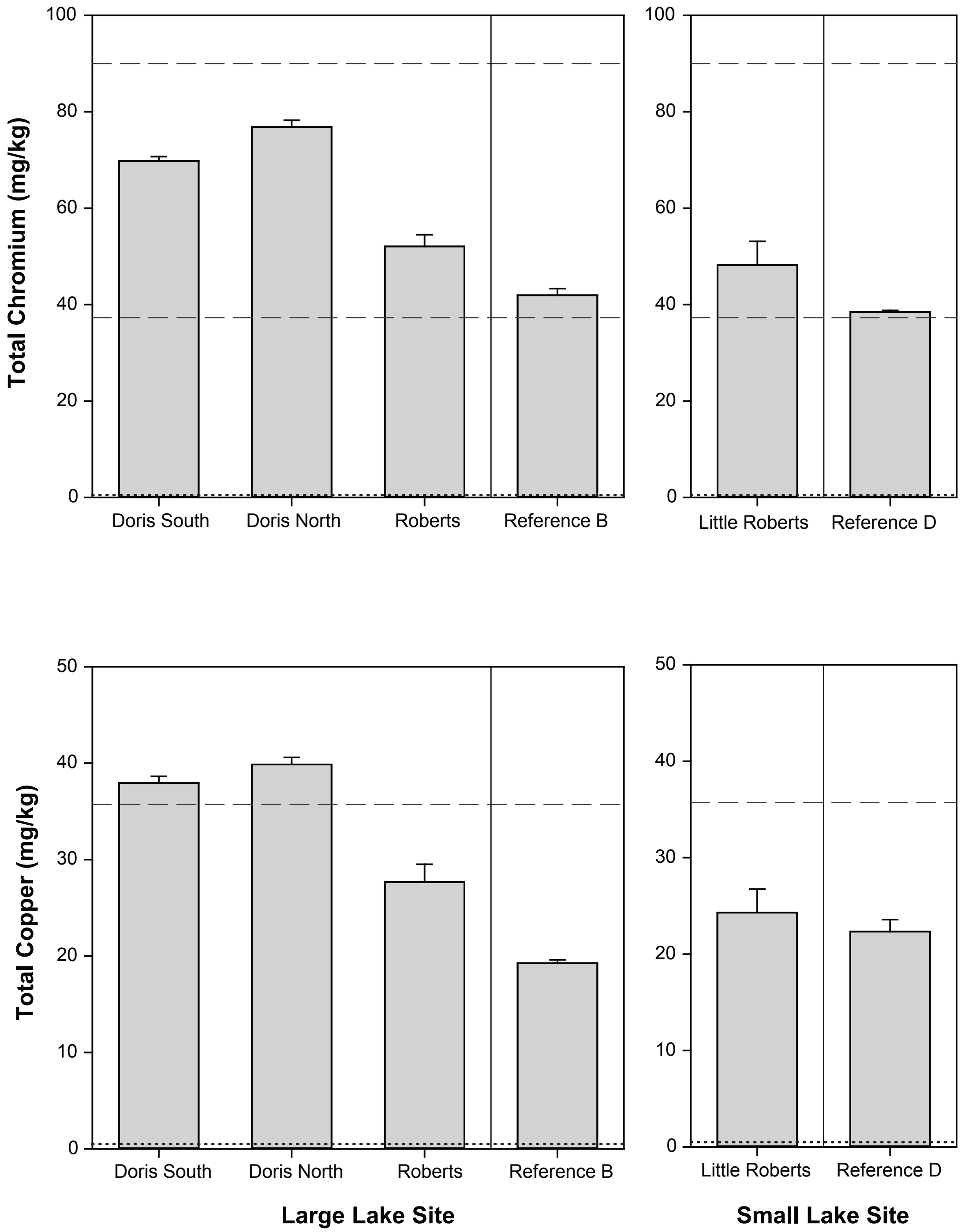

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for chromium (37.3 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.

NEWMONT™ NORTH AMERICA

Total Chromium and Total Copper Concentrations in Lake Sediments, Doris North Project, August 2012

Figure A4-8

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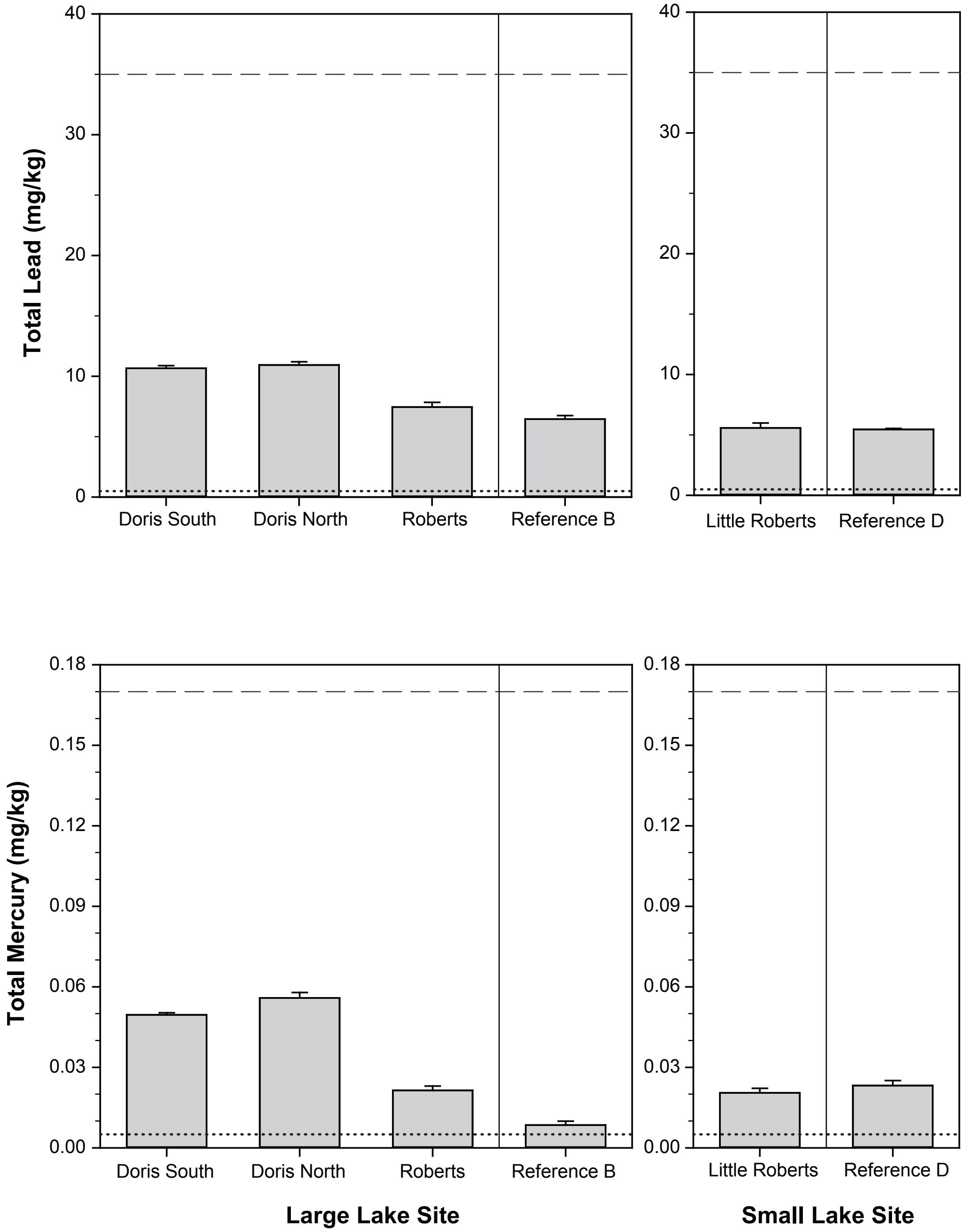


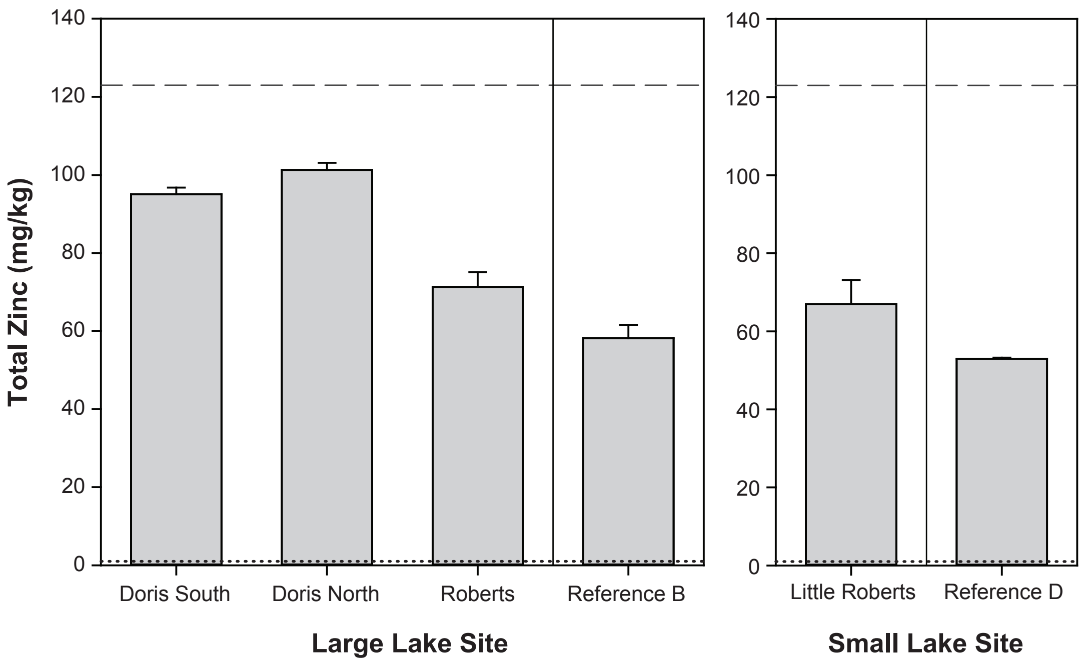
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for lead (35 mg/kg)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

NEWMONT NORTH AMERICA

Total Lead and Total Mercury Concentrations in Lake Sediments, Doris North Project, August 2012

Figure A4-9

Rescan Engineers & Scientists



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

Figure A4-10

Total Zinc Concentrations in Lake Sediments, Doris North Project, August 2012

Table A.4-3. Sediment Quality in AEMP Lake Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

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

Lake Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of Samples Higher Than PEL[c] Guidelines						
			Arsenic (As) 17	Cadmium (Cd) 3.5	Chromium (Cr) 90	Copper (Cu) 197	Lead (Pb) 91.3	Mercury (Hg) 0.486	Zinc (Zn) 315
Large Lake Site									
Doris Lake South	3		100	0	0	0	0	0	0
Doris Lake North	3		0	0	0	0	0	0	0
Roberts Lake	3		0	0	0	0	0	0	0
Reference Lake B	3		0	0	0	0	0	0	0
Small Lake Site									
Little Roberts Lake	3		0	0	0	0	0	0	0
Reference Lake D	3		0	0	0	0	0	0	0

Values represent the percentages of 2012 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 A.4-4. Sediment Quality in AEMP Lake Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Lake Site	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 Lake South	3		3.525	-	1.871	1.063	-	-	-
Doris Lake North	3		1.164	-	2.060	1.167	-	-	-
Roberts Lake	3		1.288	-	1.396	-	-	-	-
Reference Lake B	3		-	-	1.124	-	-	-	-
Small Lake Site									
Little Roberts Lake	3		-	-	1.285	-	-	-	-
Reference Lake D	3		-	-	1.031	-	-	-	-

Lake Site	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 Lake South	3		1.224	-	-	-	-	-	-
Doris Lake North	3		-	-	-	-	-	-	-
Roberts Lake	3		-	-	-	-	-	-	-
Reference Lake B	3		-	-	-	-	-	-	-
Small Lake Site									
Little Roberts Lake	3		-	-	-	-	-	-	-
Reference Lake D	3		-	-	-	-	-	-	-

The average 2012 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*

Annex A.4-2. Lake Sediment Quality Data, Doris North Project, 2012

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Doris Lake South	Doris Lake South	Doris Lake South	Doris Lake North	Doris Lake North	Doris Lake North	Roberts Lake	Roberts Lake	Roberts Lake	Reference Lake B	Reference Lake B
Depth Sampled:					10.5	10.5	10.2	13.5	13.5	13.5	2.0	2.1	2.0	10.1	10.1
Replicate:					1	2	3	1	2	3	1	2	3	1	2
Date Sampled:					22-AUG-12	22-AUG-12	22-AUG-12	21-AUG-12	21-AUG-12	21-AUG-12	14-AUG-12	14-AUG-12	14-AUG-12	15-AUG-12	15-AUG-12
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1199722-1	L1199722-2	L1199722-3	L1199722-4	L1199722-5	L1199722-6	L1196683-1	L1196683-2	L1196683-3	L1196683-4	L1196683-5
Physical Tests															
Moisture	%			0.25	74.4	74.6	73.9	72.9	74.0	71.8	77.7	72.4	63.8	41.7	45.5
pH	pH			0.10	6.15	6.25	6.14	5.98	5.90	5.82	6.27	6.03	5.85	5.38	5.77
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	0.37	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	0.80	0.89	0.77	0.79	0.57	0.69	2.96	1.55	4.08	8.30	11.5
% Silt (0.063 mm - 4 µm)	%			0.10	54.6	85.5	84.2	80.6	67.1	78.3	74.7	76.2	75.5	56.6	60.4
% Clay (<4 µm)	%			0.10	44.7	13.6	15.0	18.6	32.3	21.1	22.4	22.2	20.4	34.7	28.1
Anions & Nutrients															
Total Nitrogen	%			0.020	0.331	0.385	0.336	0.373	0.361	0.370	21.9	54.3	19.4	3.2	2.9
Organic / Inorganic Carbon															
Total Organic Carbon	%			0.10	2.84	3.32	2.87	3.11	2.90	3.10	3.85	5.13	3.09	0.69	0.97
Plant Available Nutrients															
Available Ammonium-N	mg/kg			1.0 or 2.4	21.6	21.1	23.8	22.6	25.0	20.0	21.9	54.3	19.4	3.2	2.9
Available Nitrate-N	mg/kg			2.0 to 6.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	6.5	<6.0	<4.0	<2.0	<2.0
Available Nitrite-N	mg/kg			0.40 to 1.2							<0.80	<1.2	<0.80	<0.40	<0.40
Available Phosphate-P	mg/kg			2.0 to 6.0							4.1	5.1	2.8	2.9	<2.0
Metals															
Aluminum (Al)	mg/kg			50	25100	23700	24500	25800	25800	27300	16400	18500	18900	15600	13900
Antimony (Sb)	mg/kg			0.10	0.16	0.16	0.17	0.16	0.15	0.16	0.11	0.18	0.13	0.17	0.14
Arsenic (As)	mg/kg	5.9	17	0.050	20.3	23.0	19.1	7.01	6.49	7.11	8.20	8.34	6.26	5.43	4.70
Barium (Ba)	mg/kg			0.50	194	194	189	156	155	163	109	120	115	88.9	76.3
Beryllium (Be)	mg/kg			0.20	0.85	0.81	0.86	0.89	0.91	0.98	0.51	0.58	0.57	0.55	0.54
Bismuth (Bi)	mg/kg			0.20	0.25	0.26	0.26	0.25	0.24	0.26	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.130	0.126	0.136	0.119	0.106	0.114	0.117	0.110	0.098	0.292	0.170
Calcium (Ca)	mg/kg			50	5830	5790	5470	6010	5950	6430	5760	5820	5600	3800	3320
Chromium (Cr)	mg/kg	37.3	90	0.50	70.3	68.0	71.1	77.2	74.2	79.1	47.3	53.6	55.3	44.7	41.2
Cobalt (Co)	mg/kg			0.10	15.7	15.5	16.4	15.3	15.0	16.0	11.1	12.5	12.2	16.3	14.7
Copper (Cu)	mg/kg	35.7	197	0.50	37.8	36.8	39.2	40.6	38.4	40.6	24.0	29.4	29.6	19.9	19.1
Iron (Fe)	mg/kg			50	57900	63700	59300	46400	44100	48600	31900	34000	33900	32100	37200
Lead (Pb)	mg/kg	35	91.3	0.50	10.4	10.5	11.1	11.1	10.4	11.3	6.68	7.92	7.77	7.03	6.15
Lithium (Li)	mg/kg			5.0	41.1	41.0	41.3	45.8	47.1	50.2	27.1	31.1	32.2	27.2	23.6
Magnesium (Mg)	mg/kg			20	14100	13800	14200	15300	14500	15700	11200	12300	12600	9050	7760
Manganese (Mn)	mg/kg			1.0	2420	2970	2310	588	595	601	1090	692	525	248	267
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0481	0.0509	0.0495	0.0596	0.0553	0.0526	0.0206	0.0245	0.0190	0.0057	0.0097
Molybdenum (Mo)	mg/kg			0.50	2.71	2.71	2.39	1.24	1.51	1.46	1.44	1.55	1.31	2.35	2.07
Nickel (Ni)	mg/kg			0.50	45.8	44.0	47.4	47.7	45.2	47.7	27.7	30.8	29.8	27.0	22.6
Phosphorus (P)	mg/kg			50	1360	1470	1360	1090	990	1070	1080	1000	970	694	768
Potassium (K)	mg/kg			100	5970	5680	5780	6190	6070	6420	5410	5210	4900	3790	3100
Selenium (Se)	mg/kg			0.20	0.46	0.47	0.44	0.40	0.41	0.40	0.24	0.29	0.25	0.40	0.31
Silver (Ag)	mg/kg			0.10	0.11	0.12	0.11	0.23	0.18	0.21	<0.10	0.17	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	1600	1510	1470	1520	1460	1580	1010	1100	990	440	370
Strontium (Sr)	mg/kg			0.50	43.2	41.5	38.1	40.4	40.4	42.8	36.4	36.5	33.9	26.0	22.8
Sulphur (S)	mg/kg			500	1500	1600	1500	1400	1300	1200	1800	2600	1500	2200	1300
Thallium (Tl)	mg/kg			0.050	0.278	0.290	0.288	0.290	0.273	0.311	0.202	0.229	0.233	0.290	0.206
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1390	1310	1260	1430	1390	1510	1080	1210	1240	920	773
Uranium (U)	mg/kg			0.050	2.51	2.48	2.62	2.39	2.31	2.47	1.93	2.10	1.92	1.91	1.76
Vanadium (V)	mg/kg			0.20	80.1	77.6	82.0	82.7	79.0	84.6	56.3	63.3	63.6	50.4	46.3
Zinc (Zn)	mg/kg	123	315	1.0	94.3	92.7	98.3	102	97.9	104	64.7	71.5	77.8	64.6	56.9

Notes:

(continued)

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*

Annex A.4-2. Lake Sediment Quality Data, Doris North Project, 2012 (completed)

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]			Reference Lake B	Little Roberts Lake	Little Roberts Lake	Little Roberts Lake	Reference Lake D	Reference Lake D	Reference Lake D
Depth Sampled:					10.2	1.8	1.8	1.8	2.5	2.5	2.4
Replicate:				Realized Detection Limit	3	1	2	3	1	2	3
Date Sampled:					15-AUG-12	16-AUG-12	16-AUG-12	16-AUG-12	16-AUG-12	16-AUG-12	16-AUG-12
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1196683-6	L1196683-10	L1196683-11	L1196683-12	L1196683-7	L1196683-8	L1196683-9
Physical Tests											
Moisture	%			0.25	54.5	72.2	64.8	66.7	69.9	76.2	64.0
pH	pH			0.10	5.77	6.33	6.23	6.44	6.06	5.76	5.88
Particle Size											
% Gravel (>2 mm)	%			0.10	0.35	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	12.7	5.07	13.0	18.4	6.92	5.03	9.15
% Silt (0.063 mm - 4 µm)	%			0.10	60.7	78.3	73.2	68.4	84.0	85.4	83.5
% Clay (<4 µm)	%			0.10	26.3	16.7	13.8	13.2	9.07	9.53	7.35
Anions & Nutrients											
Total Nitrogen	%			0.020	3.3	63.8	19.6	47.1	27.1	27.1	28.9
Organic / Inorganic Carbon											
Total Organic Carbon	%			0.10	1.32	4.83	2.57	3.22	3.20	4.59	3.25
Plant Available Nutrients											
Available Ammonium-N	mg/kg			1.0 or 2.4	3.3	38.8	19.6	29.8	27.1	27.1	28.9
Available Nitrate-N	mg/kg			2.0 to 6.0	<4.0	30.3	<4.0	19.9	<4.0	<6.0	<6.0
Available Nitrite-N	mg/kg			0.40 to 1.2	<0.80	<1.2	<0.80	<1.2	<0.80	<1.2	<1.2
Available Phosphate-P	mg/kg			2.0 to 6.0	6.1	24.5	4.0	5.0	6.1	6.2	5.8
Metals											
Aluminum (Al)	mg/kg			50	13500	16600	18100	12300	13400	13800	13100
Antimony (Sb)	mg/kg			0.10	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Arsenic (As)	mg/kg	5.9	17	0.050	3.58	3.98	4.59	4.06	2.56	2.66	2.66
Barium (Ba)	mg/kg			0.50	75.7	97.9	110	81.2	74.6	77.9	73.4
Beryllium (Be)	mg/kg			0.20	0.51	0.52	0.45	0.37	0.43	0.48	0.42
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.139	0.095	0.104	0.079	0.085	0.099	0.073
Calcium (Ca)	mg/kg			50	3140	5650	5120	4090	4710	4900	4400
Chromium (Cr)	mg/kg	37.3	90	0.50	39.9	51.0	55.0	38.7	38.6	39.0	37.8
Cobalt (Co)	mg/kg			0.10	10.9	10.6	12.1	9.91	7.96	7.72	7.81
Copper (Cu)	mg/kg	35.7	197	0.50	18.7	24.7	28.3	19.9	22.5	24.4	20.1
Iron (Fe)	mg/kg			50	33700	28900	27600	24000	20000	20300	19600
Lead (Pb)	mg/kg	35	91.3	0.50	6.21	6.06	5.92	4.75	5.35	5.61	5.43
Lithium (Li)	mg/kg			5.0	22.8	29.0	26.9	21.9	22.9	23.3	22.6
Magnesium (Mg)	mg/kg			20	7600	11200	12400	8480	8310	8490	8180
Manganese (Mn)	mg/kg			1.0	240	575	397	701	262	256	255
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0101	0.0232	0.0209	0.0173	0.0237	0.0261	0.0197
Molybdenum (Mo)	mg/kg			0.50	1.66	1.04	1.12	1.65	0.91	0.95	0.90
Nickel (Ni)	mg/kg			0.50	20.9	27.8	30.7	21.6	21.5	21.8	20.5
Phosphorus (P)	mg/kg			50	645	1100	1060	796	760	847	712
Potassium (K)	mg/kg			100	2970	4740	4920	3580	3180	3520	3230
Selenium (Se)	mg/kg			0.20	0.27	0.26	0.25	0.20	0.20	0.26	<0.20
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	360	940	1070	700	590	680	590
Strontium (Sr)	mg/kg			0.50	21.1	31.4	29.0	23.7	25.2	28.8	24.5
Sulphur (S)	mg/kg			500	800	2600	1600	1800	1400	1600	1400
Thallium (Tl)	mg/kg			0.050	0.190	0.189	0.185	0.153	0.150	0.160	0.152
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	701	1080	1170	804	921	919	942
Uranium (U)	mg/kg			0.050	1.72	1.56	1.46	1.27	2.03	2.53	1.85
Vanadium (V)	mg/kg			0.20	45.0	55.6	61.9	43.3	46.3	46.2	45.2
Zinc (Zn)	mg/kg	123	315	1.0	53.0	69.5	76.2	55.2	53.5	52.9	52.4

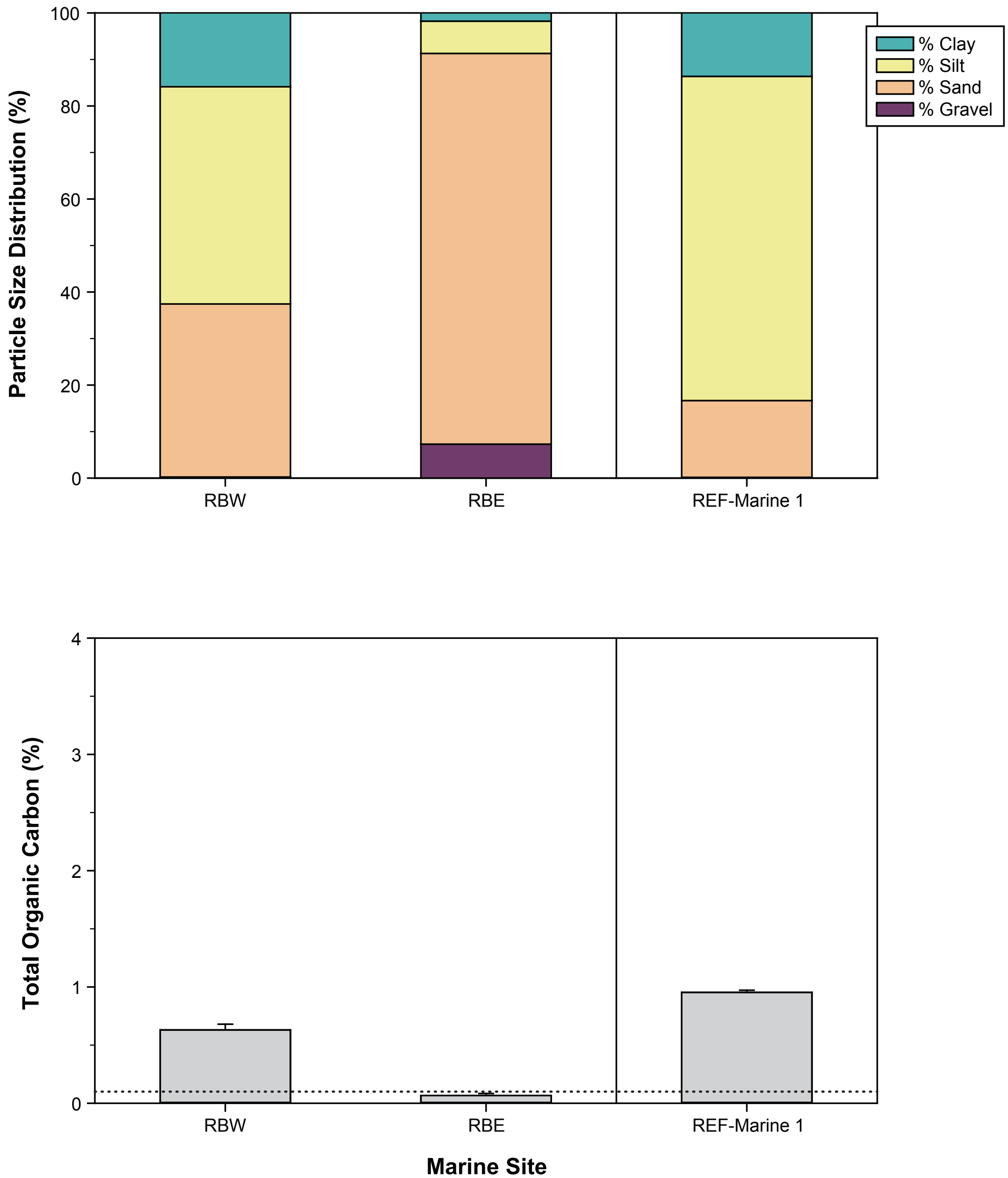
Notes:

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*



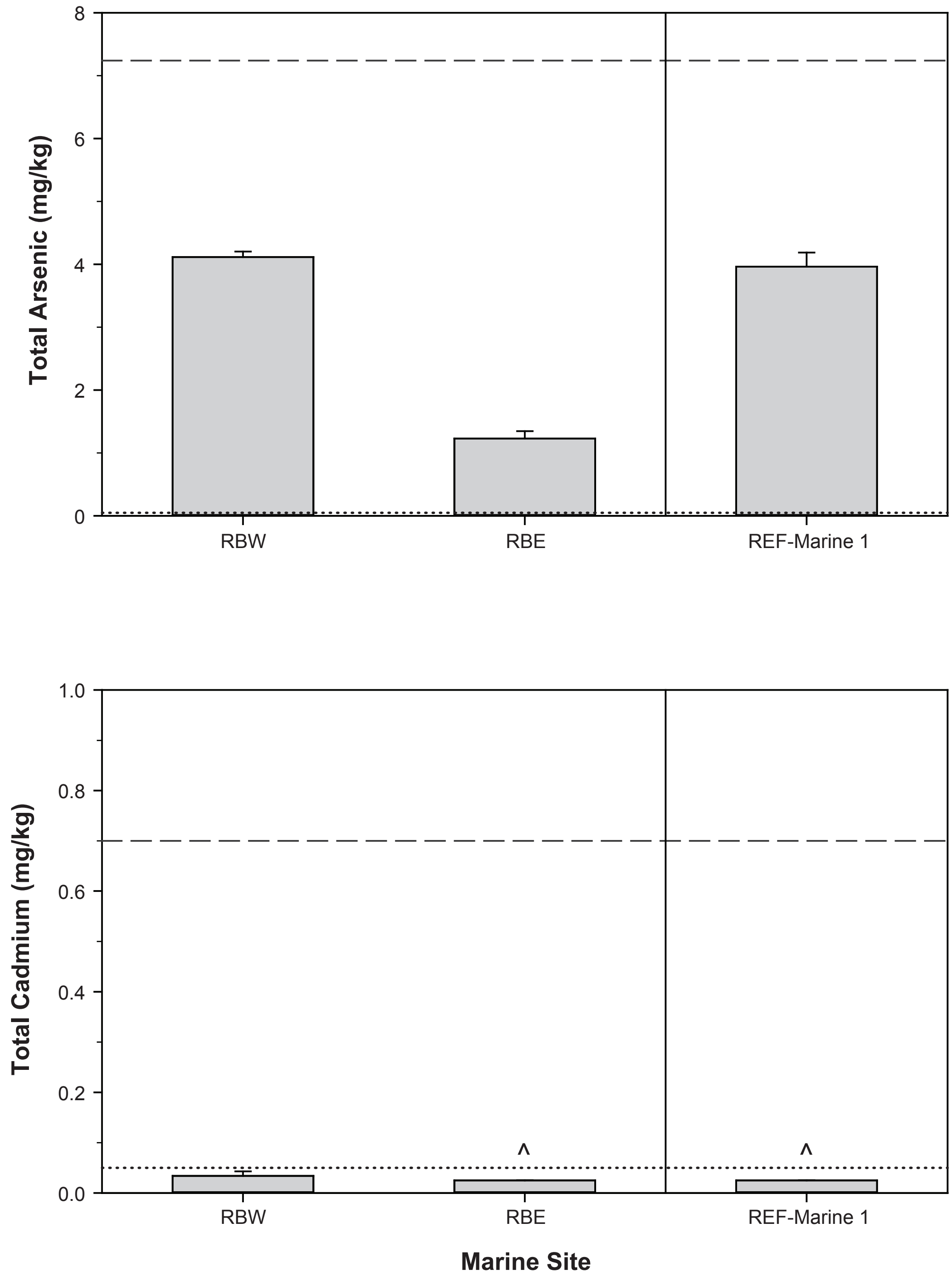
Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Particle size distribution and total organic carbon content of sediments are required parameters as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

NEWMONT NORTH AMERICA

Particle Size Distribution and Total Organic Carbon Concentration in Marine Sediments, Doris North Project, August 2012

Figure A4-11

Rescan Engineers & Scientists



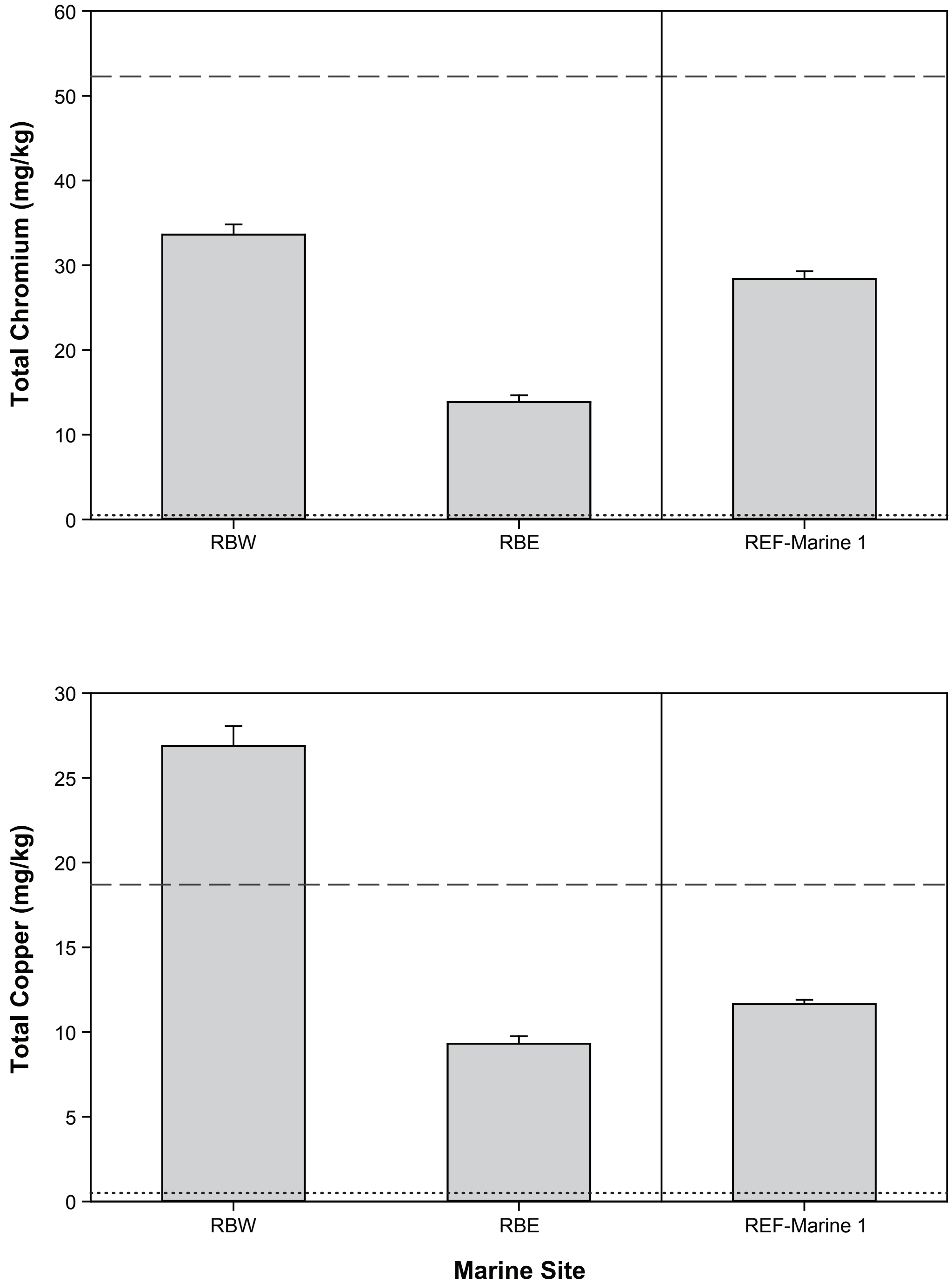
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (ISQGs) for arsenic (7.24 mg/kg) and cadmium (0.7 mg/kg); probable effects levels (PELs) for arsenic (41.6 mg/kg) and cadmium (4.2 mg/kg) are not shown.

NEWMONT NORTH AMERICA

Total Arsenic and Total Cadmium Concentrations in Marine Sediments, Doris North Project, August 2012

Figure A4-12

Rescan Engineers & Scientists



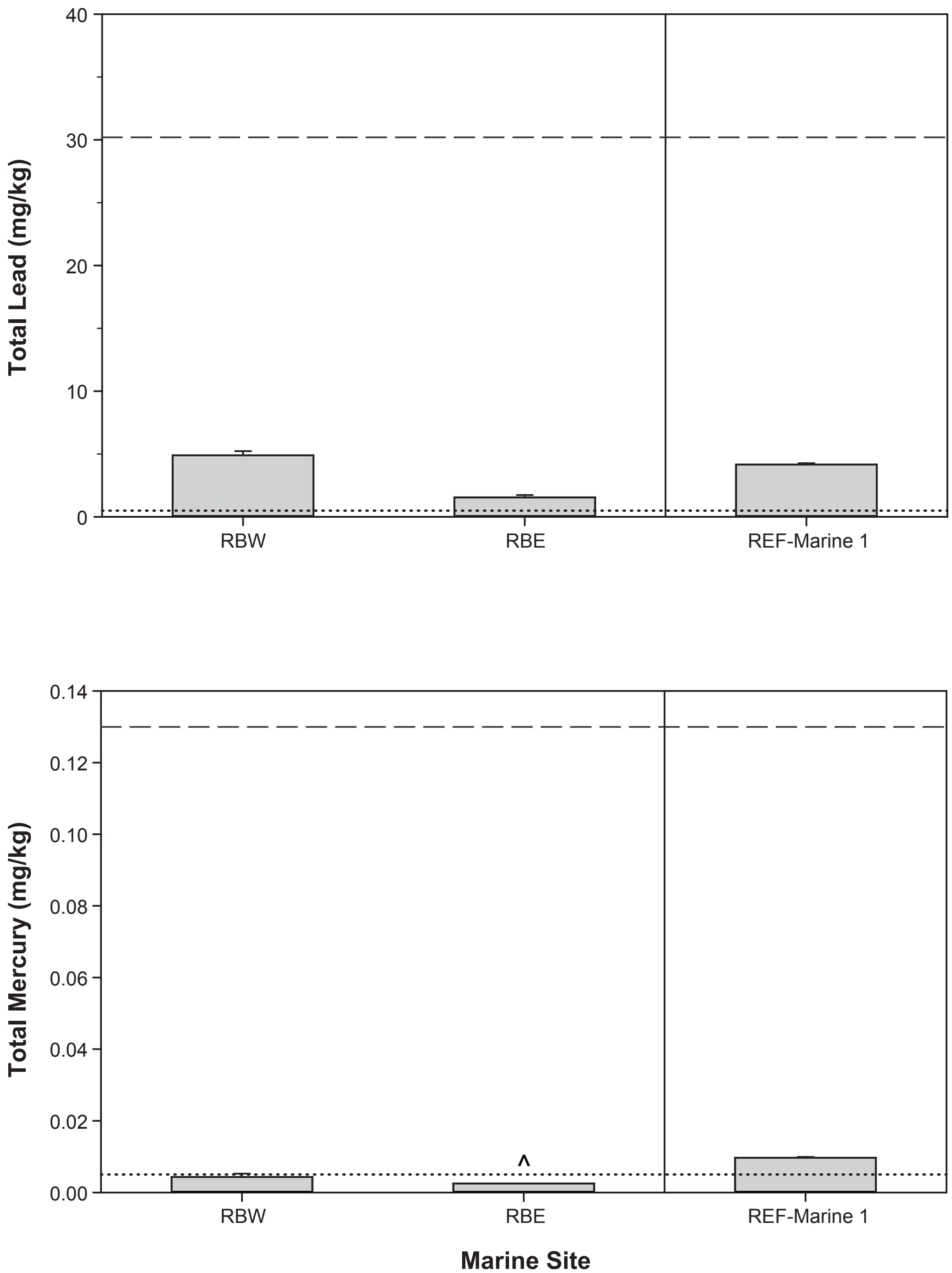
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (ISQGs) for chromium (52.3 mg/kg) and copper (18.7 mg/kg); probable effects levels (PELs) for chromium (160 mg/kg) and copper (108 mg/kg) are not shown.

NEWMONT NORTH AMERICA

Total Chromium and Total Copper Concentrations in Marine Sediments, Doris North Project, August 2012

Figure A4-13

Rescan Engineers & Scientists



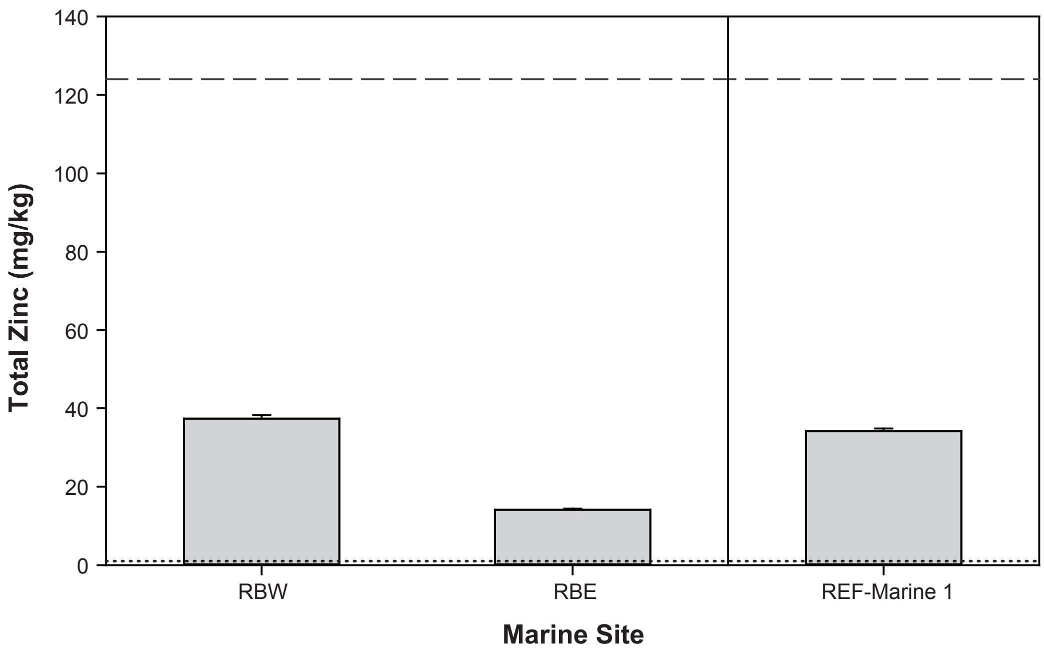
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (ISQGs) for lead (30.2 mg/kg) and mercury (0.13 mg/kg); probable effects levels (PELs) for lead (112 mg/kg) and mercury (0.7 mg/kg) are not shown.

NEWMONT™ NORTH AMERICA

Total Lead and Total Mercury Concentrations in Marine Sediments, Doris North Project, August 2012

Figure A4-14

Rescan™ Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Black dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (ISQGs) (124 mg/kg); probable effects levels (PELs) (271 mg/kg) are not shown.

NEWMONT NORTH AMERICA

Total Zinc Concentrations in Marine Sediments, Doris North Project, August 2012

Figure A4-15

Rescan Engineers & Scientists

Table A.4-5. Sediment Quality in AEMP Marine Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Marine Site	Total Number of Samples Collected	CCME Guideline Value[a] (mg/kg):	Percent of Samples Higher than ISQG[b] Guidelines						
			Arsenic (As) 7.24	Cadmium (Cd) 0.7	Chromium (Cr) 52.3	Copper (Cu) 18.7	Lead (Pb) 30.2	Mercury (Hg) 0.13	Zinc (Zn) 124
RBW	3		0	0	0	100	0	0	0
RBE	3		0	0	0	0	0	0	0
REF-Marine 1	3		0	0	0	0	0	0	0

Marine Site	Total Number of Samples Collected	CCME Guideline Value[a] (mg/kg):	Percent of Samples Higher than PEL[c] Guidelines						
			Arsenic (As) 41.6	Cadmium (Cd) 4.2	Chromium (Cr) 160	Copper (Cu) 108	Lead (Pb) 112	Mercury (Hg) 0.7	Zinc (Zn) 271
RBW	3		0	0	0	0	0	0	0
RBE	3		0	0	0	0	0	0	0
REF-Marine 1	3		0	0	0	0	0	0	0

Values represent the percentages of 2012 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 A.4-6. Sediment Quality in AEMP Marine Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2012

Marine Site	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)
			7.24	0.7	52.3	18.7	30.2	0.13	124
RBW	3		-	-	-	1.439	-	-	-
RBE	3		-	-	-	-	-	-	-
REF-Marine 1	3		-	-	-	-	-	-	-

Marine Site	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)
			41.6	4.2	160	108	112	0.7	271
RBW	3		-	-	-	-	-	-	-
RBE	3		-	-	-	-	-	-	-
REF-Marine 1	3		-	-	-	-	-	-	-

The average 2012 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*

A.5 2012 PRIMARY PRODUCERS

The following sections present the periphyton and phytoplankton biomass (as chlorophyll *a*) data collected between April and September 2012 from stream, lake, and marine sites.

A.5.1 Stream Data

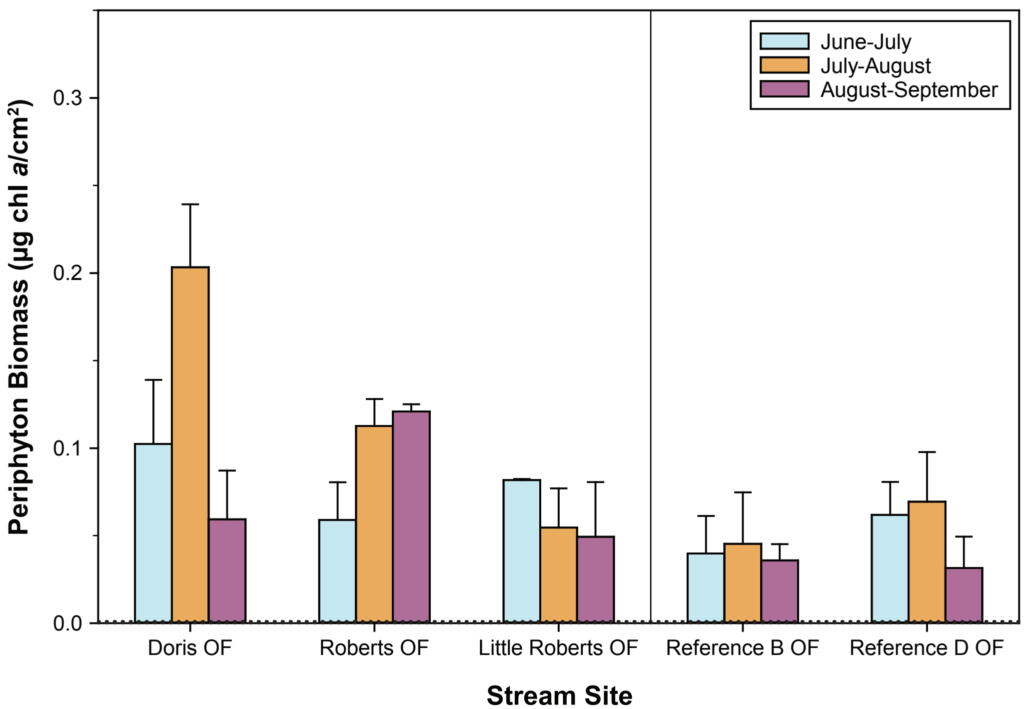
Stream periphyton sampling plates were installed three times in AEMP streams (in June, July, and August), and were retrieved after approximately one month (in July, August, and September, respectively). Figure A.5-1 shows the periphyton biomass levels measured in streams. Annex A.5-1 presents the raw periphyton biomass data.

A.5.2 Lake Data

Lake phytoplankton samples were collected in April (under-ice sampling) and monthly from July to September 2012. Figure A.5-2 shows the phytoplankton biomass levels measured in lakes. Annex A.5-2 presents the raw phytoplankton biomass data.

A.5.3 Marine Data

Marine phytoplankton samples were collected in April (under-ice sampling) and monthly from July to September 2012. Figure A.5-3 shows the phytoplankton biomass levels measured at marine sites. Annex A.5-3 presents the raw phytoplankton biomass data.



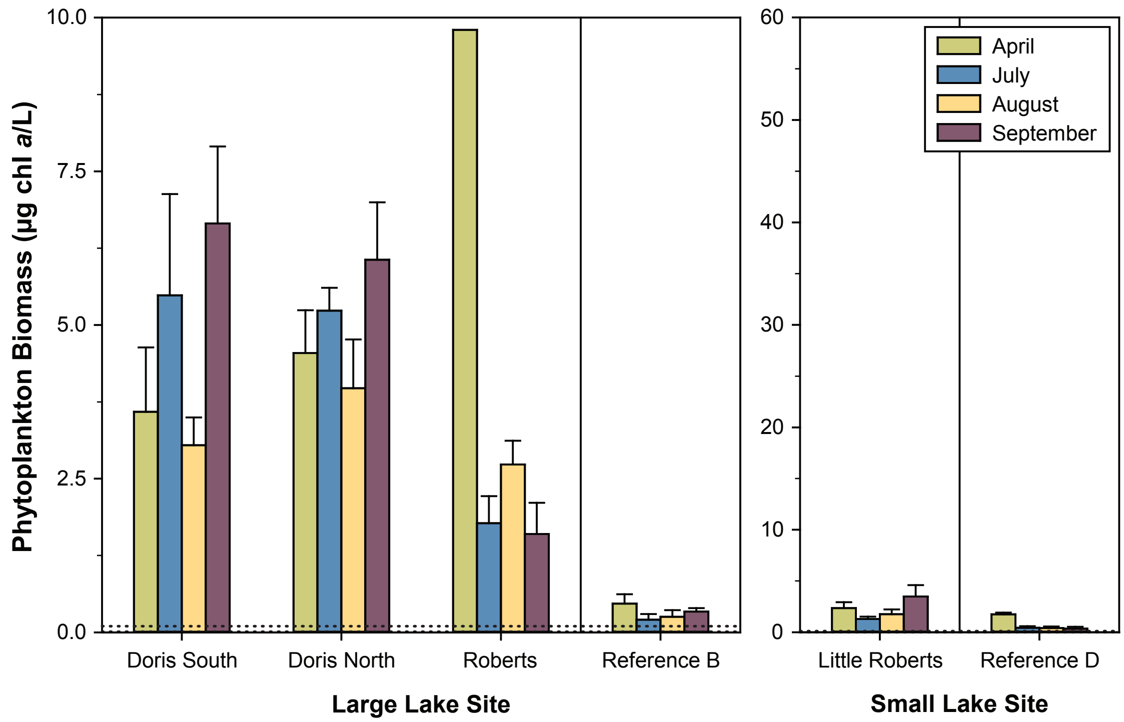
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.

Periphyton Biomass (as Chlorophyll *a*) in Stream Sites, Doris North Project, 2012

Annex A.5-1. Stream Periphyton Biomass Data, Doris North Project, 2012

Stream Site	Date Sampler Installed	Date Sampler Retrieved	Number of Days Immersed	Area sampled (cm^2)	ALS Sample ID	Replicate #	Periphyton Biomass (µg chl *a* /cm^2)	Mean	SE
Doris OF	16-Jun-12	21-Jul-12	35	100	L1201938-1	1	0.138	0.1024	0.0366
Doris OF	16-Jun-12	21-Jul-12	35	100	L1201938-2	2	0.14		
Doris OF	16-Jun-12	21-Jul-12	35	100	L1201938-3	3	0.0293		
Doris OF	21-Jul-12	25-Aug-12	35	100	L1201946-10	1	0.133	0.2033	0.0359
Doris OF	21-Jul-12	25-Aug-12	35	100	L1201946-11	2	0.251		
Doris OF	21-Jul-12	25-Aug-12	35	100	L1201946-12	3	0.226		
Doris OF	25-Aug-12	20-Sep-12	26	100	L1213785-1	1	0.00899	0.059	0.028
Doris OF	25-Aug-12	20-Sep-12	26	100	L1213785-2	2	0.105		
Doris OF	25-Aug-12	20-Sep-12	26	100	L1213785-3	3	0.0638		
Roberts OF	16-Jun-12	21-Jul-12	35	100	L1201938-10	1	0.0883	0.059	0.022
Roberts OF	16-Jun-12	21-Jul-12	35	100	L1201938-11	2	0.0716		
Roberts OF	16-Jun-12	21-Jul-12	35	100	L1201938-14	3	0.0169		
Roberts OF	21-Jul-12	22-Aug-12	32	100	L1201946-4	1	0.126	0.113	0.015
Roberts OF	21-Jul-12	22-Aug-12	32	100	L1201946-5	2	0.13		
Roberts OF	21-Jul-12	22-Aug-12	32	100	L1201946-6	3	0.082		
Roberts OF	22-Aug-12	20-Sep-12	29	100	L1213785-4	1	0.118	0.121	0.004
Roberts OF	22-Aug-12	20-Sep-12	29	100	L1213785-5	2	0.116		
Roberts OF	22-Aug-12	20-Sep-12	29	100	L1213785-6	3	0.129		
Little Roberts OF	16-Jun-12	21-Jul-12	35	100	L1201938-12	1	0.0823	0.08165	0.00065
Little Roberts OF	16-Jun-12	21-Jul-12	35	100	L1201938-13	2	0.081		
Little Roberts OF	21-Jul-12	24-Aug-12	34	100	L1201946-7	1	0.0467	0.0546	0.0224
Little Roberts OF	21-Jul-12	24-Aug-12	34	100	L1201946-8	2	0.0203		
Little Roberts OF	21-Jul-12	24-Aug-12	34	100	L1201946-9	3	0.0967		
Little Roberts OF	24-Aug-12	20-Sep-12	27	100	L1213785-7	1	0.111	0.049	0.031
Little Roberts OF	24-Aug-12	20-Sep-12	27	100	L1213785-8	2	0.0266		
Little Roberts OF	24-Aug-12	20-Sep-12	27	100	L1213785-9	3	0.0103		
Reference B OF	16-Jun-12	21-Jul-12	35	100	L1201938-4	1	0.0826	0.03980	0.02142
Reference B OF	16-Jun-12	21-Jul-12	35	100	L1201938-5	2	0.0167		
Reference B OF	16-Jun-12	21-Jul-12	35	100	L1201938-6	3	0.0201		
Reference B OF	21-Jul-12	25-Aug-12	35	100	L1201946-13	1	0.0177	0.0453	0.0294
Reference B OF	21-Jul-12	25-Aug-12	35	100	L1201946-14	2	0.0142		
Reference B OF	21-Jul-12	25-Aug-12	35	100	L1201946-15	3	0.104		
Reference B OF	25-Aug-12	20-Sep-12	26	100	L1213785-13	1	0.0543	0.036	0.009
Reference B OF	25-Aug-12	20-Sep-12	26	100	L1213785-14	2	0.0276		
Reference B OF	25-Aug-12	20-Sep-12	26	100	L1213785-15	3	0.0255		
Reference D OF	16-Jun-12	21-Jul-12	35	100	L1201938-7	1	0.0807	0.0618	0.0188
Reference D OF	16-Jun-12	21-Jul-12	35	100	L1201938-8	2	0.0242		
Reference D OF	16-Jun-12	21-Jul-12	35	100	L1201938-9	3	0.0806		
Reference D OF	21-Jul-12	21-Aug-12	31	100	L1201946-1	1	0.123	0.0693	0.0284
Reference D OF	21-Jul-12	21-Aug-12	31	100	L1201946-2	2	0.0263		
Reference D OF	21-Jul-12	21-Aug-12	31	100	L1201946-3	3	0.0587		
Reference D OF	21-Aug-12	20-Sep-12	30	100	L1213785-10	1	0.00981	0.031	0.018
Reference D OF	21-Aug-12	20-Sep-12	30	100	L1213785-11	2	0.0671		
Reference D OF	21-Aug-12	20-Sep-12	30	100	L1213785-12	3	0.0174		

SE = standard error of the mean



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.

Figure A5-2

Phytoplankton Biomass (as Chlorophyll *a*) in Lake Sites, Doris North Project, 2012

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Annex A.5-2. Lake Phytoplankton Biomass Data, Doris North Project, 2012

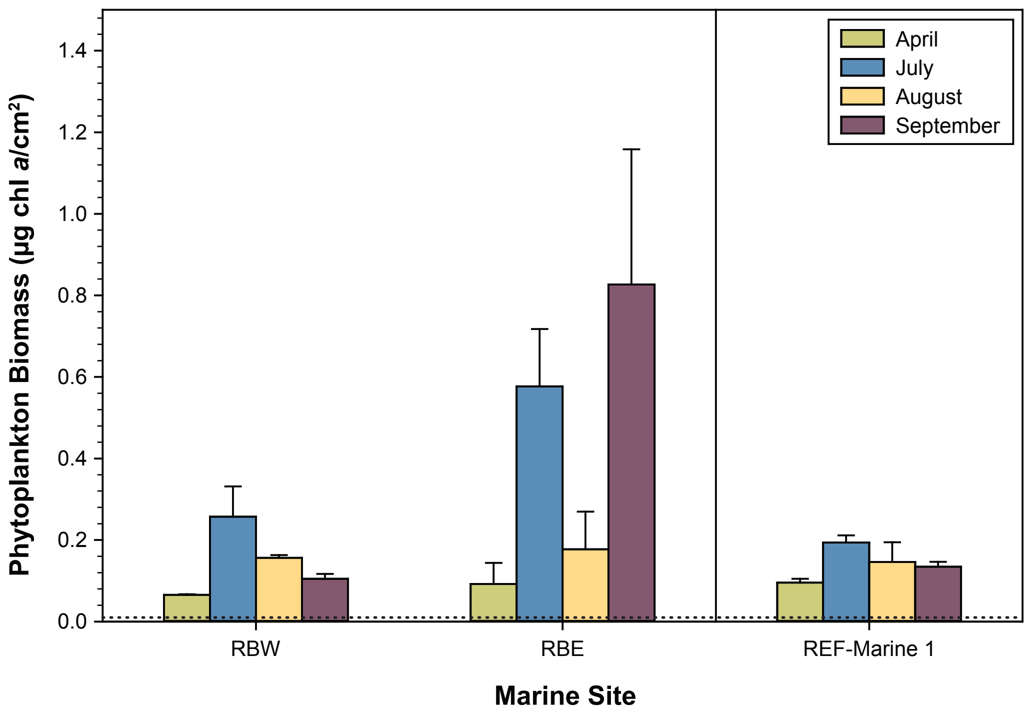
Lake Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
Doris Lake South	14-APR-12	1 m	L1138000-16	1	4.89	3.6	1.0
Doris Lake South	14-APR-12	1 m	L1138000-17	2	4.36		
Doris Lake South	14-APR-12	1 m	L1138000-18	3	1.52		
Doris Lake South	24-JUL-12	1 m	L1201940-10	1	2.31	5.48	1.65
Doris Lake South	24-JUL-12	1 m	L1201940-11	2	7.84		
Doris Lake South	24-JUL-12	1 m	L1201940-12	3	6.30		
Doris Lake South	20-AUG-12	1 m	L1201944-16	1	2.30	3.05	0.45
Doris Lake South	20-AUG-12	1 m	L1201944-17	2	3.86		
Doris Lake South	20-AUG-12	1 m	L1201944-18	3	2.98		
Doris Lake South	16-SEP-12	1 m	L1213787-10	1	4.85	6.65	1.25
Doris Lake South	16-SEP-12	1 m	L1213787-11	2	9.06		
Doris Lake South	16-SEP-12	1 m	L1213787-12	3	6.05		
Doris Lake North	15-APR-12	1 m	L1138000-14	1	5.24	4.5	0.7
Doris Lake North	15-APR-12	1 m	L1138000-15	2	3.85		
Doris Lake North	24-JUL-12	1 m	L1201940-13	1	4.54	5.23	0.37
Doris Lake North	24-JUL-12	1 m	L1201940-14	2	5.82		
Doris Lake North	24-JUL-12	1 m	L1201940-15	3	5.34		
Doris Lake North	20-AUG-12	1 m	L1201944-13	1	3.18	3.97	0.79
Doris Lake North	20-AUG-12	1 m	L1201944-14	2	5.56		
Doris Lake North	20-AUG-12	1 m	L1201944-15	3	3.18		
Doris Lake North	16-SEP-12	1 m	L1213787-13	1	4.21	6.06	0.93
Doris Lake North	16-SEP-12	1 m	L1213787-14	2	7.17		
Doris Lake North	16-SEP-12	1 m	L1213787-15	3	6.81		
Roberts Lake	17-APR-12	1 m	L1138000-8	1	9.80	9.80	
Roberts Lake	23-JUL-12	1 m	L1201940-1	1	2.45	1.78	0.44
Roberts Lake	23-JUL-12	1 m	L1201940-2	2	1.93		
Roberts Lake	23-JUL-12	1 m	L1201940-3	3	0.948		
Roberts Lake	14-AUG-12	1 m	L1201944-1	1	1.96	2.73	0.39
Roberts Lake	14-AUG-12	1 m	L1201944-2	2	3.20		
Roberts Lake	14-AUG-12	1 m	L1201944-3	3	3.03		
Roberts Lake	15-SEP-12	1 m	L1213787-4	1	1.96	1.60	0.51
Roberts Lake	15-SEP-12	1 m	L1213787-5	2	0.594		
Roberts Lake	15-SEP-12	1 m	L1213787-6	3	2.24		
Reference Lake B	18-APR-12	1 m	L1138000-9	1	0.312	0.467	0.155
Reference Lake B	18-APR-12	1 m	L1138000-10	2	0.621		
Reference Lake B	24-JUL-12	1 m	L1201940-7	1	0.105	0.207	0.091
Reference Lake B	24-JUL-12	1 m	L1201940-8	2	0.388		
Reference Lake B	24-JUL-12	1 m	L1201940-9	3	0.128		
Reference Lake B	15-AUG-12	1 m	L1201944-4	1	0.151	0.253	0.108
Reference Lake B	15-AUG-12	1 m	L1201944-5	2	0.469		
Reference Lake B	15-AUG-12	1 m	L1201944-6	3	0.139		
Reference Lake B	16-SEP-12	1 m	L1213787-16	1	0.448	0.337	0.057
Reference Lake B	16-SEP-12	1 m	L1213787-17	2	0.262		
Reference Lake B	16-SEP-12	1 m	L1213787-18	3	0.302		
Little Roberts Lake	15-APR-12	1 m	L1138000-3	1	2.38	2.35	0.58
Little Roberts Lake	15-APR-12	1 m	L1138000-4	2	3.33		
Little Roberts Lake	15-APR-12	1 m	L1138000-5	3	1.33		
Little Roberts Lake	23-JUL-12	1 m	L1201940-4	1	1.70	1.29	0.22
Little Roberts Lake	23-JUL-12	1 m	L1201940-5	2	0.944		

(continued)

Annex A.5-2. Lake Phytoplankton Biomass Data, Doris North Project, 2012 (completed)

Lake Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
Little Roberts Lake	23-JUL-12	1 m	L1201940-6	3	1.24		
Little Roberts Lake	16-AUG-12	0.9 m	L1201944-10	1	1.44	1.76	0.47
Little Roberts Lake	16-AUG-12	0.9 m	L1201944-11	2	1.15		
Little Roberts Lake	16-AUG-12	0.9 m	L1201944-12	3	2.68		
Little Roberts Lake	15-SEP-12	1 m	L1213787-1	1	1.25	3.5	1.1
Little Roberts Lake	15-SEP-12	1 m	L1213787-2	2	4.70		
Little Roberts Lake	15-SEP-12	1 m	L1213787-3	3	4.48		
Reference Lake D	16-APR-12	1 m	L1138000-11	1	1.50	1.75	0.17
Reference Lake D	16-APR-12	1 m	L1138000-12	2	2.08		
Reference Lake D	16-APR-12	1 m	L1138000-13	3	1.66		
Reference Lake D	26-JUL-12	1 m	L1201940-16	1	0.738	0.434	0.152
Reference Lake D	26-JUL-12	1 m	L1201940-17	2	0.278		
Reference Lake D	26-JUL-12	1 m	L1201940-18	3	0.286		
Reference Lake D	16-AUG-12	1 m	L1201944-7	1	0.701	0.405	0.148
Reference Lake D	16-AUG-12	1 m	L1201944-8	2	0.275		
Reference Lake D	16-AUG-12	1 m	L1201944-9	3	0.240		
Reference Lake D	15-SEP-12	1 m	L1213787-7	1	0.131	0.34	0.19
Reference Lake D	15-SEP-12	1 m	L1213787-8	2	0.165		
Reference Lake D	15-SEP-12	1 m	L1213787-9	3	0.729		

SE = standard error of the mean



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.

Phytoplankton Biomass (as Chlorophyll *a*) in Marine Sites, Doris North Project, 2012

Figure A5-3

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Annex A.5-3. Marine Phytoplankton Biomass Data, Doris North Project, 2012

Marine Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
RBW	19-APR-12	1 m	L1138000-6	1	0.064	0.066	0.000
RBW	19-APR-12	1 m	L1138000-7	2	0.067		
RBW	22-JUL-12	1 m	L1201945-1	1	0.390	0.257	0.074
RBW	22-JUL-12	1 m	L1201945-2	2	0.133		
RBW	22-JUL-12	1 m	L1201945-3	3	0.248		
RBW	18-AUG-12	1 m	L1201939-4	1	0.162	0.156	0.007
RBW	18-AUG-12	1 m	L1201939-5	2	0.164		
RBW	18-AUG-12	1 m	L1201939-6	3	0.143		
RBW	19-SEP-12	1 m	L1213786-4	1	0.082	0.10	0.01
RBW	19-SEP-12	1 m	L1213786-5	2	0.123		
RBW	19-SEP-12	1 m	L1213786-6	3	0.109		
RBE	19-APR-12	1 m	L1138000-1	1	0.040	0.092	0.052
RBE	19-APR-12	1 m	L1138000-2	2	0.144		
RBE	22-JUL-12	1 m	L1201945-4	1	0.825	0.58	0.14
RBE	22-JUL-12	1 m	L1201945-5	2	0.339		
RBE	22-JUL-12	1 m	L1201945-6	3	0.567		
RBE	18-AUG-12	1 m	L1201939-7	1	0.360	0.177	0.092
RBE	18-AUG-12	1 m	L1201939-8	2	0.065		
RBE	18-AUG-12	1 m	L1201939-9	3	0.106		
RBE	19-SEP-12	1 m	L1213786-7	1	0.339	0.827	0.332
RBE	19-SEP-12	1 m	L1213786-8	2	0.681		
RBE	19-SEP-12	1 m	L1213786-9	3	1.46		
REF-Marine 1	19-APR-12	1 m	L1138000-19	1	0.105	0.096	0.010
REF-Marine 1	19-APR-12	1 m	L1138000-20	2	0.086		
REF-Marine 1	26-JUL-12	1 m	L1201945-7	1	0.192	0.194	0.018
REF-Marine 1	26-JUL-12	1 m	L1201945-8	2	0.225		
REF-Marine 1	26-JUL-12	1 m	L1201945-9	3	0.164		
REF-Marine 1	17-AUG-12	1 m	L1201939-1	1	0.214	0.146	0.049
REF-Marine 1	17-AUG-12	1 m	L1201939-2	2	0.052		
REF-Marine 1	17-AUG-12	1 m	L1201939-3	3	0.172		
REF-Marine 1	17-SEP-12	1 m	L1213786-1	1	0.112	0.134	0.012
REF-Marine 1	17-SEP-12	1 m	L1213786-2	2	0.153		
REF-Marine 1	17-SEP-12	1 m	L1213786-3	3	0.138		

SE = standard error of the mean

A.6 2012 BENTHIC INVERTEBRATES

The following sections present the benthic invertebrate taxonomy data collected in August 2012 from stream, lake, and marine sites. Benthos data were used to calculate several community descriptors including: total density, taxa richness, evenness, diversity, and the Bray-Curtis Index. Details of these calculations are provided in the main body of the AEMP report.

A.6.1 Stream Data

Figure A.6-1 presents the density and taxonomic composition of stream benthos communities. Figure A.6-2 presents the family richness, Simpson's Evenness Index, and the Simpson's Diversity Index, and Figure A.6-3 presents the Bray-Curtis Index calculated for stream benthos communities. Annex A.6-1 provides the raw stream benthos taxonomy data, and Annex A.6-2 presents the summary statistics calculated for the community descriptors.

A.6.2 Lake Data

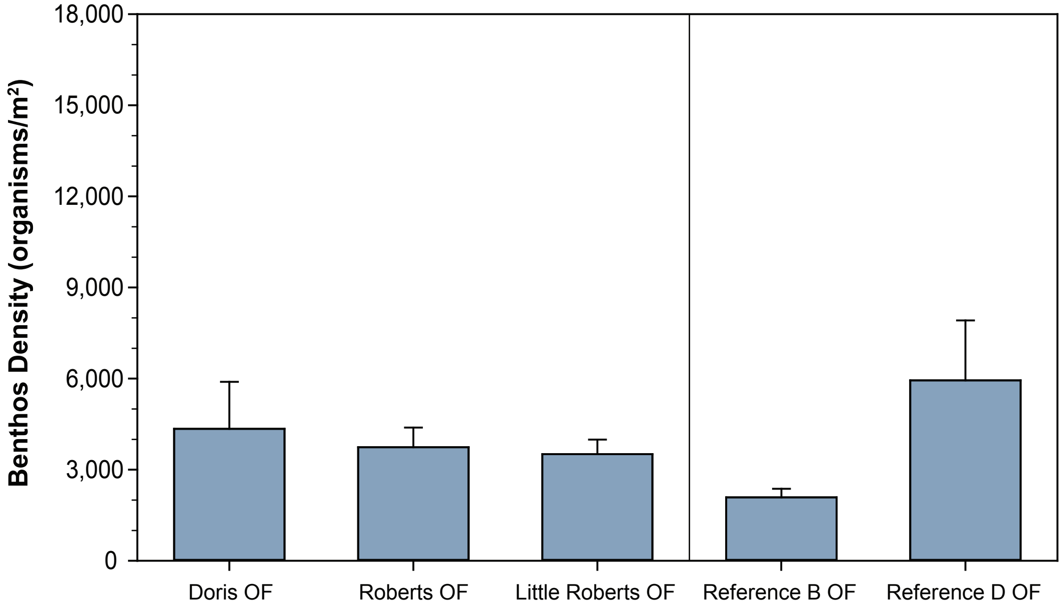
Figure A.6-4 presents the density and taxonomic composition of lake benthos communities. Figure A.6-5 presents the family richness, Simpson's Evenness Index, and the Simpson's Diversity Index, and Figure A.6-6 presents the Bray-Curtis Index calculated for lake benthos communities. Annex A.6-3 provides the raw lake benthos taxonomy data, and Annex A.6-4 presents the summary statistics calculated for the community descriptors.

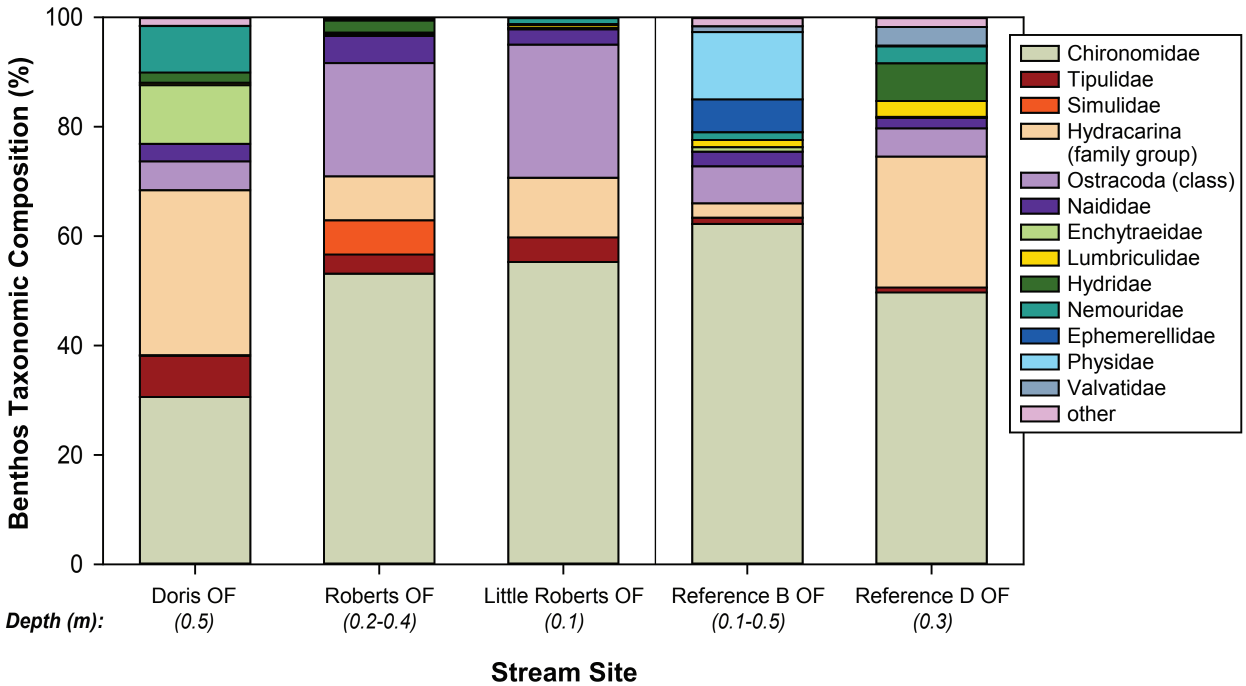
A.6.3 Marine Data

Figure A.6-7 presents the density and taxonomic composition of marine benthos communities. Figure A.6-8 presents the family richness, Simpson's Evenness Index, and the Simpson's Diversity Index, and Figure A.6-9 presents the Bray-Curtis Index calculated for marine benthos communities. Annex A.6-5 provides the raw marine benthos taxonomy data, and Annex A.6-6 presents the summary statistics calculated for the community descriptors.

A.6.4 Quality Assurance/Quality Control (QA/QC) Data

A re-sorting of randomly selected sample residues was conducted by taxonomists on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. Results of this QA/QC procedure are provided in Annex A.6-7.





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

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Benthos Density and Taxonomic Composition in Stream Sites, Doris North Project, August 2012

Figure A6-1

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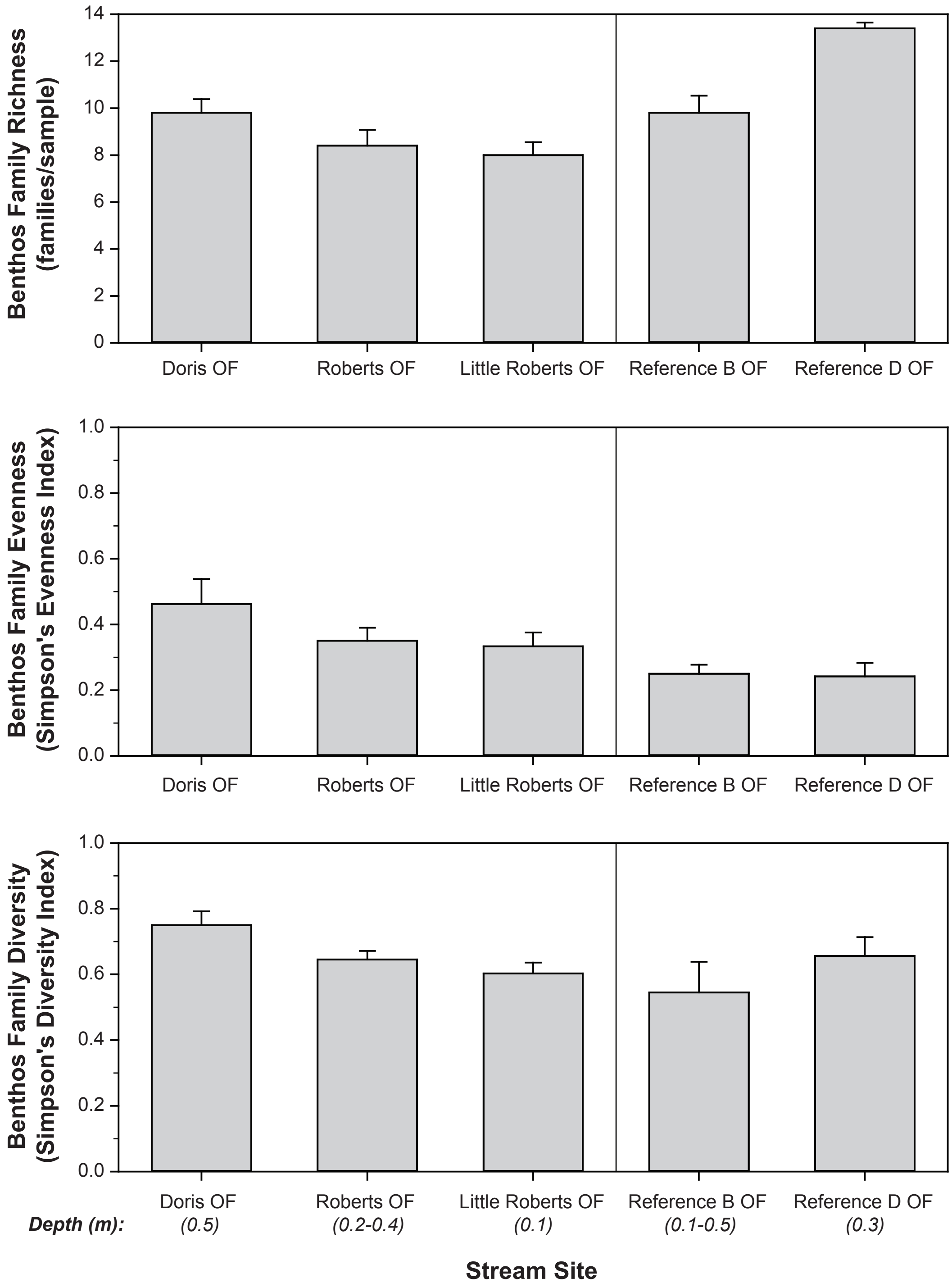

Note: Error bars represent the standard error of the mean.

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Benthos Richness, Evenness, and Diversity in Stream Sites, Doris North Project, August 2012

Figure A6-2

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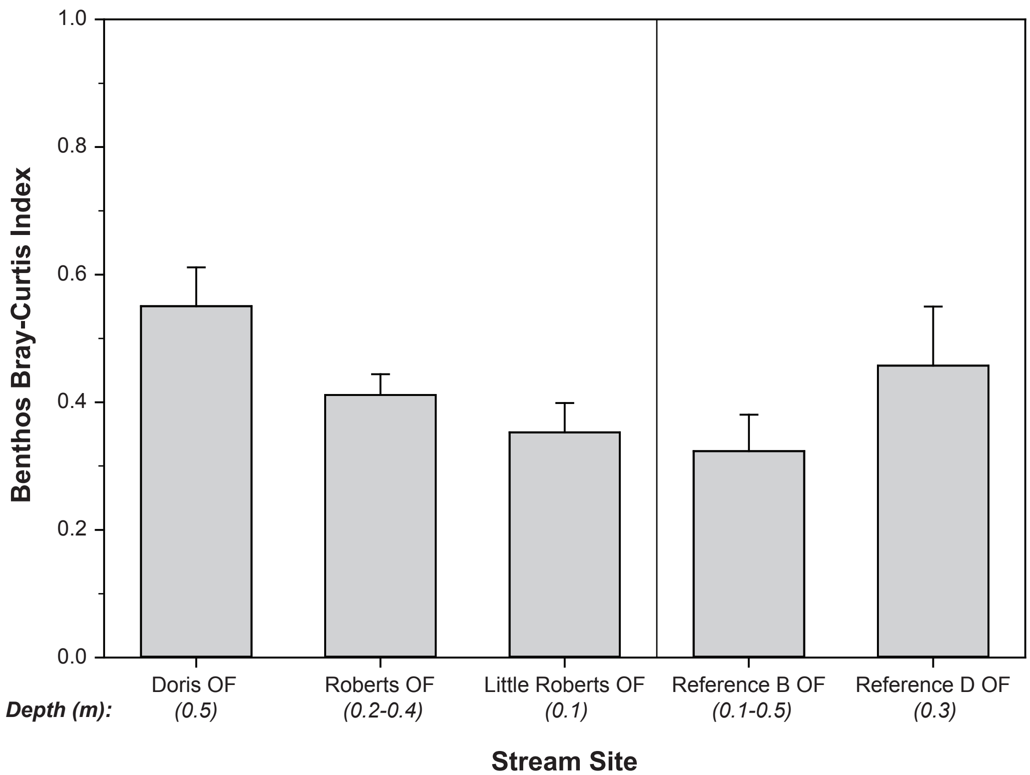

Note: Error bars represent the standard error of the mean.

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Benthos Bray-Curtis Index for Stream Sites, Doris North Project, August 2012

Figure A6-3

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Annex A.6-1. Stream Benthos Taxonomy Data, Doris North Project, 2012

Taxonomic Identification					Doris OF					Roberts OF					Little Roberts OF				
					25-Aug-12					22-Aug-12					24-Aug-12				
Major Group	Family	Subfamily	Tribe	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
Coelenterata	Hydridae	-	-	*Hydra*	24		24	46	16	60	12	10		40		8			
Nematoda*	-	-	-	-	44	16	8	30	32	180	39	93	123	45	65	10	145	129	16
Hirudinea	Piscicolidae	-	-	*Piscicola punctata*										10					
Oligochaeta - cocoon																			
Oligochaeta	Enchytraeidae	-	-	-	138	105	33	308	17					20			8	8	
	Lumbriculidae	-	-	-		14		2	1					12	2	12	1	10	
	Naididae	Naidinae	-	-				8			4				8		8		
	Naididae	Tubificinae	-	-	46	36	12	36	59	20	32	10	143	34	24	40	16	18	16
Gastropoda	Physidae	-	-	*Physa*															
	Valvatidae	-	-	*Valvata sincera*															
Pelecypoda	Sphaeriidae	-	-	(i/d)															
		-	-	*Sphaerium*															
		-	-	*Pisidium*															
Hydracarina	-	-	-	-	212	284	296	680	136	180	52	110	40	40	104	128	144	120	48
Copepoda - Calanoida*	-	-	-	-	8		12	8											
Copepoda - Cyclopoida*	Cyclopidae*	Cyclopinae*	-	*Acanthocyclops**						160	8				24	16	16		
Copepoda - Cyclopoida*	Ergasilidae*	-	-	*Ergasilus**															
Ostracoda	-	-	-	-	48	20	84	60	112	300	140	270	140	180	192	272	289	208	200
Cladocera*	Chydoridae*	-	-	*Eurycercus**							4								
	Daphnidae*	-	-	*Daphnia**															
Amphipoda	Epimeriidae	-	-	*Epimeria loricata*															
Malacostraca	Mysidae	-	-	*Mysis relicta*								1							
Isopoda	Chaetiliidae	-	-	*Saduria entomon*									4				2		
Ephemeroptera	Baetidae	-	-	*Baetis*	26	16	8	8	1										
	Ephemerellidae	-	-	*Ephemerella*				3										1	
	Heptageniidae	-	-	*Heptagenia*															
Plecoptera	Nemouridae	-	-	*Nemoura*	89	98	81	34	25	1			1	14	8	9	10	20	8
	Perlodidae	-	-	*Skwala*															
Trichoptera		-	-	(pupa)															
	Brachycentridae	-	-	*Brachycentrus*															
		-	-	*Micrasema*															
	Hydroptilidae	-	-	*Agraylea*															
	Limnephilidae	-	-	(i/d)															
		-	-	*Grensia praeterica*											3				
		-	-	*Sphagnophylax meiops*															
Coleoptera	Dytiscidae	-	-	*Oreodytes*															
Diptera	Chironomidae	-	-	(pupa)	1	4		66		40		10		10	32	8	24	18	16
		Tanypodinae	Pentaneurini	(i/d)	8					20									
				Ablabesmyia															
				Thienemannimyia group	87	96	93	125	211	221	97	274	204	216	202	74	82	407	96
			Procladiini	*Procladius*						20		10	2		8	9			8
		Diamesinae	Diamesini	*Potthastia longimana* group						1	1				2	1	17		
				Pseudokiefferiella	45	22	2	704	28	103	18	42	6	34	32	44	76	11	10
			Protanypini	*Protanypus*															
		Prodiamesinae		*Monodiamesa*															
		Orthocladiinae	-	(i/d)				6			4								
			Orthocladiini	*Cricotopus/Orthocladius*	37		8	812	41	360	28	150	260	194	178	121	456	221	192
				Corynoneura															
				Eukiefferiella	8			1											
				Euryhapsis	1	5		8	28		4				1				
				Heterotrissocladius															
				Parakiefferiella			4	8									32		
				Parametriocnemus	1														
				Psectrocladius						80			1		24		16	8	8
				Synorthocladius												1			

(continued)

Annex A.6-1. Stream Benthos Taxonomy Data, Doris North Project, 2012 (continued)

Taxonomic Identification					Doris OF					Roberts OF					Little Roberts OF				
					25-Aug-12					22-Aug-12					24-Aug-12				
Major Group	**Family**	**Subfamily**	**Tribe**	**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**
				Tvetenia	6	17	12	48	1			1				8	16	34	16
				Zalutschia															
		Chironominae	Chironomini	(i/d)															
				Chironomus						22		10							
				Cladopelma															
				Demicryptochironomus									1						
				Dicrotendipes						1							8	1	8
				Glyptotendipes ?									1						
				Polypedilum						20									
				Sergenta		4	4	8		82	22	10	82	20			26	1	
				Stictochironomus	1	20	16			1			62	11					
			Tanytarsini	(i/d)													8		
				Cladotanytarsus	8							20	20		8			40	
				Constempellina								10	20	20	32				
				Corynocera															
				Micropsectra					8			20	60				16	9	
				Micropsectra / Tanytarsus										11					
				Paratanytarsus				10			10				1		24		
				Rheotanytarsus											32		64	42	32
				Tanytarsus	8					20	8			10			32		
	Simulidae			*Simulium*										10					
		-	-	*Simulium* - pupa				10		43	17	32	99	136					
	Tipulidae	-	-	*Tipula*	80	85	70	43	95	34	17	25	79	29	71	36	44	46	25
Terrestrial*	-	-	-	-	1	8		8	9		8						8		24
Fish*	Gasterosteidae*	-	-	*Pungitius pungitius* (Ninespine Stickleback)*						2		4		1		1		1	
Total number of individuals					927	850	767	3080	820	1971	525	1112	1348	1097	1053	798	1588	1353	723

Notes:

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses.*

i/d = immature or damaged

Cyclopoid and calanoid copepods were excluded because they are generally planktonic.

Nematodes were excluded because they are meiofauna and are not adequately sampled using a 500 um sieve bucket.

Terrestrial organisms and fish were excluded because they are not aquatic invertebrates.

The total number of individuals was divided by 3 times the surface area of the Hess sampler (i.e., 3 x 0.096 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Hess samples).

Annex A.6-1. Stream Benthos Taxonomy Data, Doris North Project, 2012 (continued)

Taxonomic Identification					Reference B OF					Reference D OF				
					25-Aug-12					21-Aug-12				
Major Group	Family	Subfamily	Tribe	Genus	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5
Coelenterata	Hydridae	-	-	*Hydra*						272		216	40	20
Nematoda*	-	-	-	-	8	13	10	4	4	52	31	63	12	68
Hirudinea	Piscicolidae	-	-	*Piscicola punctata*										
Oligochaeta - cocoon									4					
Oligochaeta	Enchytraeidae	-	-	-	12	8					1	2		24
	Lumbriculidae	-	-	-	16	1	10	7	5	110	20	12	32	5
	Naididae	Naidinae	-	-				7		40	8	34	25	20
	Naididae	Tubificinae	-	-				37	32		1			
Gastropoda	Physidae	-	-	*Physa*	146	61	40	55	28					
	Valvatidae	-	-	*Valvata sincera*			2	6	25	103	51	11	2	50
Pelecypoda	Sphaeriidae	-	-	(i/d)					5					
		-	-	*Sphaerium*										
		-	-	*Pisidium*										
Hydracarina	-	-	-	-	16	28	16	8		392	73	536	236	864
Copepoda - Calanoida*	-	-	-	-										
Copepoda - Cyclopoida*	Cyclopidae*	Cyclopinae*	-	*Acanthocyclops**		8	8	4	4		8			
Copepoda - Cyclopoida*	Ergasilidae*	-	-	*Ergasilus**										
Ostracoda	-	-	-	-	16	8	24	56	100	152	72	32	8	60
Cladocera*	Chydoridae*	-	-	*Eurycercus**										
	Daphnidae*	-	-	*Daphnia**										
Amphipoda	Epimeriidae	-	-	*Epimeria loricata*										
Malacostraca	Mysidae	-	-	*Mysis relicta*										
Isopoda	Chaetiliidae	-	-	*Saduria entomon*										
Ephemeroptera	Baetidae	-	-	*Baetis*		4					8	8	1	20
	Ephemerellidae	-	-	*Ephemerella*	59	74		2	4	1			5	4
	Heptageniidae	-	-	*Heptagenia*								1	8	20
Plecoptera	Nemouridae	-	-	*Nemoura*	5	14		8	8	66	11	62	45	12
	Perlodidae	-	-	*Skwala*						1			1	
Trichoptera		-	-	(pupa)										
	Brachycentridae	-	-	*Brachycentrus*	5	5		18		5	1	2		4
		-	-	*Micrasema*								1		
	Hydroptilidae	-	-	*Agraylea*							16			
	Limnephilidae	-	-	(i/d)	1									
		-	-	*Grensia praeterica*	2					1	4			
		-	-	*Sphagnophylax meiops*	1									
Coleoptera	Dytiscidae	-	-	*Oreodytes*							1			
Diptera	Chironomidae	-	-	(pupa)		8				16	8			80
		Tanypodinae	Pentaneurini	(i/d)										
				Ablabesmyia										
				Thienemannimyia group	54	12	63	17	12	104	10	157	107	116
			Procladiini	*Procladius*						1				
		Diamesinae	Diamesini	*Potthastia longimana* group			8				2			
				Pseudokiefferiella	8	5				50	84	217	76	1260
			Protanypini	*Protanypus*										
		Prodiamesinae		*Monodiamesa*										
		Orthocladiinae	-	(i/d)										
			Orthocladiini	*Cricotopus/Orthocladius*	32	49	8	1		192	106	174	58	380
				Corynoneura				4						
				Eukiefferiella		4				16		24		40
				Euryhapsis	16			4		69	46	128	70	352
				Heterotrissocladius				1						
				Parakiefferiella										
				Parametriocnemus										
				Psectrocladius	57	4	228	112	146		2			
				Synorthocladius										

(continued)

Annex A.6-1. Stream Benthos Taxonomy Data, Doris North Project, 2012 (completed)

Taxonomic Identification					Reference B OF 25-Aug-12					Reference D OF 21-Aug-12				
Major Group	Family	Subfamily	Tribe	Genus	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5
				Tvetenia									8	48
				Zalutschia										
		Chironominae	Chironomini	(i/d)				1						
				Chironomus			22	1	4					
				Cladopelma										
				Demicryptochironomus										
				Dicrotendipes	51	78	56	75	85	10	36			
				Glyptotendipes ?										
				Polypedilum						8			1	
				Sergenta			2						8	
				Stictochironomus			50	10	4					20
			Tanytarsini	(i/d)										
				Cladotanytarsus										
				Constempellina	4									
				Corynocera										
				Micropsectra										
				Micropsectra / Tanytarsus			2	1						
				Paratanytarsus	8	40	364	69	144		8			
				Rheotanytarsus						80	8	57	49	396
				Tanytarsus	12	4	1	18	32					
	Simulidae			*Simulium*										
		-	-	*Simulium* - pupa										
	Tipulidae	-	-	*Tipula*	13		1	15	2	4	2	5	29	3
Terrestrial*	-	-	-	-					1					
Fish*	Gasterosteidae*	-	-	*Pungitius pungitius* (Ninespine Stickleback)*										
Total number of individuals					542	428	915	541	649	1745	618	1742	821	3866

Notes:

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses.*

i/d = immature or damaged

Cyclopoid and calanoid copepods were excluded because they are generally planktonic.

Nematodes were excluded because they are meiofauna and are not adequately sampled using a 500 um sieve bucket.

Terrestrial organisms and fish were excluded because they are not aquatic invertebrates.

The total number of individuals was divided by 3 times the surface area of the Hess sampler (i.e., 3 x 0.096 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Hess samples).

Annex A.6-2. Stream Benthos Summary Statistics, Doris North Project, 2012

	Doris OF					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	2,594	10,535	2,868	4,347	3,463	1,549
Family Richness	9.0	12.0	9.0	9.8	1.3	0.6
Simpson's Diversity Index	0.59	0.83	0.77	0.75	0.09	0.04
Simpson's Evenness Index	0.20	0.66	0.49	0.46	0.17	0.08
Bray-Curtis Index	0.33	0.70	0.59	0.55	0.14	0.06

	Little Roberts OF					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	2,372	4,927	3,347	3,514	1,069	478
Family Richness	6.0	9.0	8.0	8.0	1.2	0.5
Simpson's Diversity Index	0.54	0.72	0.59	0.60	0.07	0.03
Simpson's Evenness Index	0.24	0.45	0.32	0.33	0.09	0.04
Bray-Curtis Index	0.20	0.46	0.40	0.35	0.10	0.05

	Roberts OF					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	1,618	5,656	3,649	3,740	1,457	652
Family Richness	7.0	11.0	8.0	8.4	1.5	0.7
Simpson's Diversity Index	0.58	0.72	0.62	0.65	0.06	0.03
Simpson's Evenness Index	0.30	0.51	0.32	0.35	0.09	0.04
Bray-Curtis Index	0.34	0.53	0.40	0.41	0.07	0.03

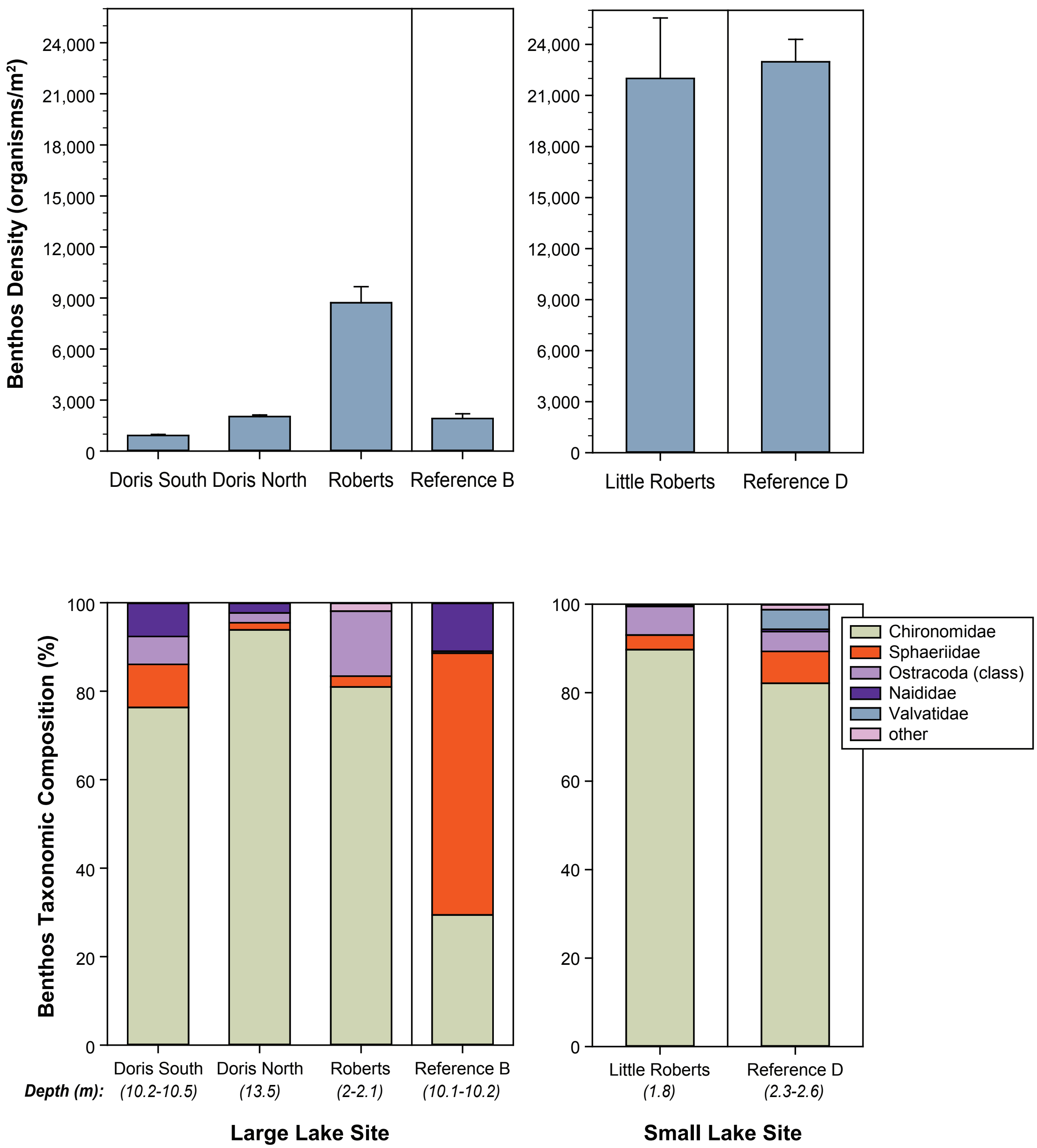
	Reference B OF					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	1,413	3,115	1,854	2,088	639	286
Family Richness	7.0	11.0	10.0	9.8	1.6	0.7
Simpson's Diversity Index	0.19	0.70	0.62	0.54	0.21	0.09
Simpson's Evenness Index	0.18	0.32	0.24	0.25	0.06	0.03
Bray-Curtis Index	0.16	0.44	0.36	0.32	0.13	0.06

	Reference D OF					
	Min	**Max**	**Median**	**Mean**	**SD**	**SE**
Density (#/m^2)	2,010	13,188	5,830	5,943	4,410	1,972
Family Richness	13.0	14.0	13.0	13.4	0.5	0.2
Simpson's Diversity Index	0.45	0.80	0.68	0.66	0.13	0.06
Simpson's Evenness Index	0.13	0.38	0.24	0.24	0.09	0.04
Bray-Curtis Index	0.22	0.75	0.51	0.46	0.21	0.09

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean



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

Figure A6-4

Benthos Density and Taxonomic Composition in Lake Sites, Doris North Project, August 2012

NEWMONT NORTH AMERICA

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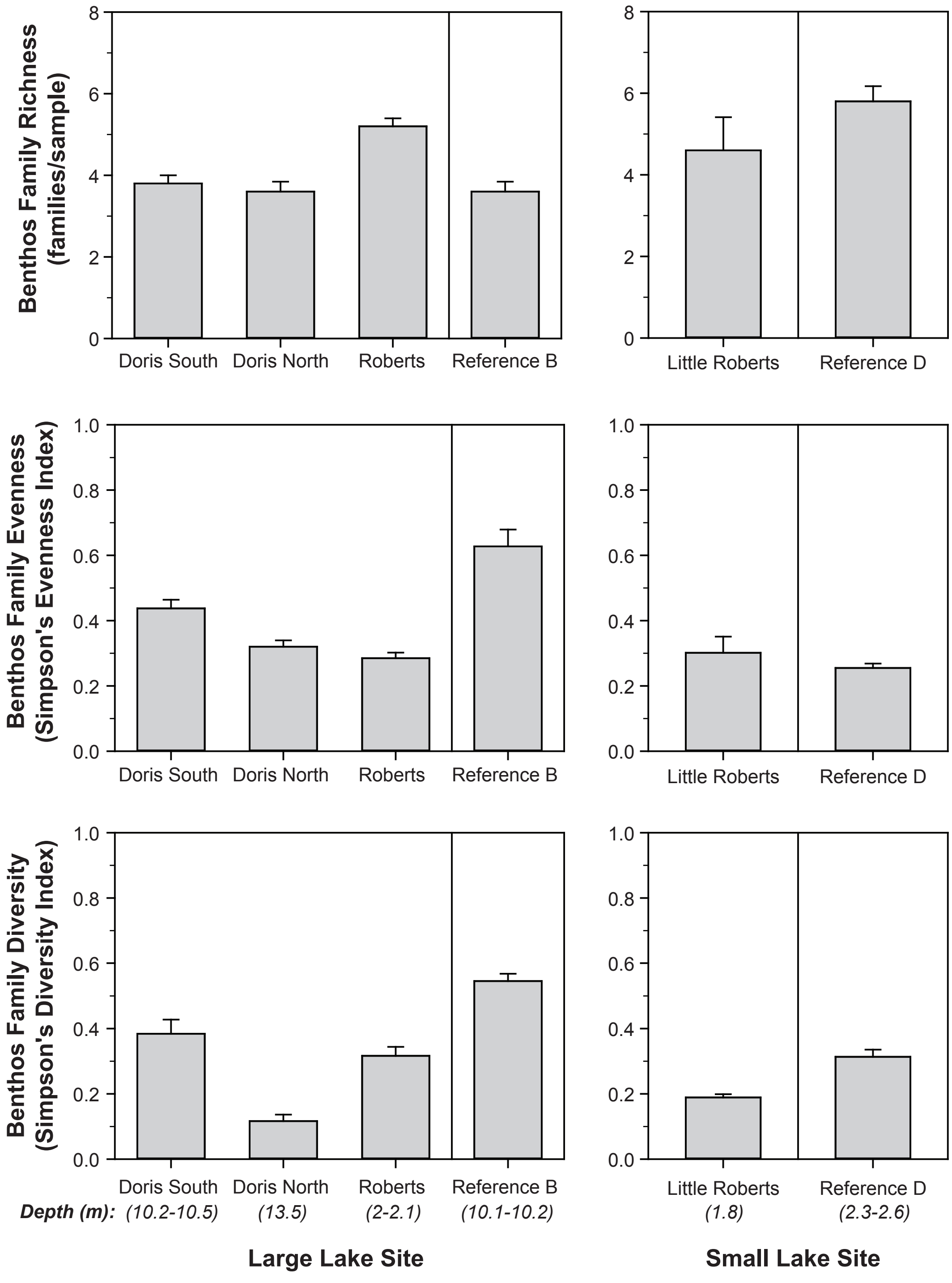

Note: Error bars represent the standard error of the mean.

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Benthos Richness, Evenness, and Diversity in Lake Sites, Doris North Project, August 2012

Figure A6-5

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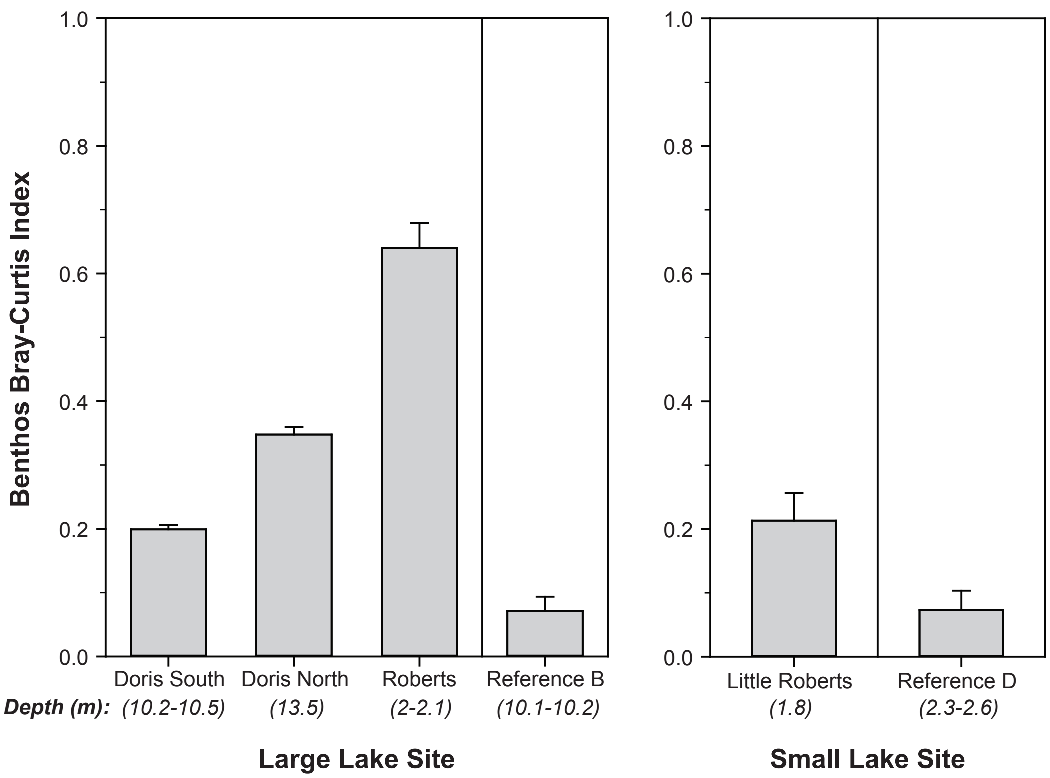

Note: Error bars represent the standard error of the mean.

Figure A6-6

Benthos Bray-Curtis Index for Lake Sites, Doris North Project, August 2012

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Annex A.6-3. Lake Benthos Taxonomy Data, Doris North Project, 2012

Taxonomic Identification					Doris Lake South					Doris Lake North					Roberts Lake					Reference Lake B				
					20-Aug-12					20-Aug-12					14-Aug-12					15-Aug-12				
Major Group	Family	Subfamily	Tribe	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
Coelenterata	Hydridae	-	-	*Hydra*																				
Nematoda*	-	-	-	-									1	2			9	24	8	27	37	12	40	15
Hirudinea	Piscicolidae	-	-	*Piscicola punctata*													1							
Oligochaeta - cocoon										6														
Oligochaeta	Enchytraeidae	-	-	-																				
	Lumbriculidae	-	-	-																				
	Naididae	Naidinae	-	-																				
	Naididae	Tubificinae	-	-	6	10	4		3	6		5	3	1						14	21	18	9	7
Gastropoda	Physidae	-	-	*Physa*																				
	Valvatidae	-	-	*Valvata sincera*																				
Pelecypoda	Sphaeriidae	-	-	(i/d)	8	2	1	9	2	1	3		1	1					16	40	63	41	74	46
		-	-	*Sphaerium*																2	1	2		1
		-	-	*Pisidium*	6		1	2	2	3	1		1		23	3	5	2	8	14	35	21	26	12
Hydracarina	-	-	-	-											8		8	8	8					
Copepoda - Calanoida*	-	-	-	-						2				2										
Copepoda - Cyclopoida*	Cyclopidae*	Cyclopinae*	-	*Acanthocyclops**											48	72	88	96	48					
Copepoda - Cyclopoida*	Ergasilidae*	-	-	*Ergasilus**													8							
Ostracoda	-	-	-	-	2	4	9	2	1	3	3	2	1	6	128	88	96	136	16	1	1		1	
Cladocera*	Chydoridae*	-	-	*Eurycercus**																				
	Daphnidae*	-	-	*Daphnia**																	1			
Amphipoda	Epimeriidae	-	-	*Epimeria loricata*																				
Malacostraca	Mysidae	-	-	*Mysis relicta*																				
Isopoda	Chaetiliidae	-	-	*Saduria entomon*											5	4	1	3	4					
Ephemeroptera	Baetidae	-	-	*Baetis*																				
	Ephemerellidae	-	-	*Ephemerella*																				
	Heptageniidae	-	-	*Heptagenia*																				
Plecoptera	Nemouridae	-	-	*Nemoura*																				
	Perlodidae	-	-	*Skwala*																				
Trichoptera		-	-	(pupa)												1								
	Brachycentridae	-	-	*Brachycentrus*																				
		-	-	*Micrasema*																				
	Hydroptilidae	-	-	*Agraylea*																				
	Limnephilidae	-	-	(i/d)																				
		-	-	*Grensia praeterica*																				
		-	-	*Sphagnophylax meiops*																				
Coleoptera	Dytiscidae	-	-	*Oreodytes*																				
Diptera	Chironomidae	-	-	(pupa)						2	2	2	2	4		16	4	24	16				1	
		Tanypodinae	Pentaneurini	(i/d)											16									
				Ablabesmyia																				
				Thienemannimyia group											113	93	129	101	20			1		
			Procladiini	*Procladius*	4	4	3	3	2			2			1		1	8	20					
		Diamesinae	Diamesini	*Potthastia longimana* group												1								
				Pseudokiefferiella																				
			Protanypini	*Protanypus*																2	3	1	1	2
		Prodiamesinae		*Monodiamesa*	9	11	8	12	10										8		1			
		Orthocladiinae	-	(i/d)																				
			Orthocladiini	*Cricotopus/Orthocladius*													8							
				Corynoneura																				
				Eukiefferiella																				
				Euryhapsis																				
				Heterotrissocladius																				
				Parakiefferiella																	1			
				Parametriocnemus																				
				Psectrocladius													8		8		3		2	
				Synorthocladius																				

(continued)

Annex A.6-3. Lake Benthos Taxonomy Data, Doris North Project, 2012 (continued)

Taxonomic Identification					Doris Lake South 20-Aug-12					Doris Lake North 20-Aug-12					Roberts Lake 14-Aug-12					Reference Lake B 15-Aug-12				
Major Group	**Family**	**Subfamily**	**Tribe**	**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**
				Tvetenia																				
				Zalutschia																11	20	9	19	7
		Chironominae	Chironomini	(i/d)				1																
				Chironomus	2	3	2	1	2	110	152	129	123	115	4	25	1	9	8					
				Cladopelma																				
				Demicryptochironomus																				
				Dicrotendipes																				
				Glyptotendipes ?																				
				Polypedilum																				
				Sergenta				2	1						1	9	8	8	16					
				Stictochironomus	34	22	21	35	30								20		24					
			Tanytarsini	(i/d)																				
				Cladotanytarsus																				
				Constempellina																				
				Corynocera																3	3	4	1	3
				Micropsectra			1									8	8	32		1		2		
				Micropsectra / Tanytarsus																				
				Paratanytarsus											297	375	318	372	156	6	31	13	20	6
				Rheotanytarsus																				
				Tanytarsus	2	3	2	4	4					1	24		16	21	16	2	5	6	3	4
	Simulidae			*Simulium*																				
		-	-	*Simulium* - pupa																				
	Tipulidae	-	-	*Tipula*																				
Terrestrial*	-	-	-	-																				
Fish*	Gasterosteidae*	-	-	*Pungitius pungitius* (Ninespine Stickleback)*											1									
Total number of individuals					**73**	**59**	**52**	**71**	**57**	**133**	**161**	**140**	**132**	**132**	**669**	**695**	**737**	**844**	**400**	**123**	**226**	**130**	**197**	**103**

Notes:

(continued)

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses.*

i/d = immature or damaged

Cyclopoid and calanoid copepods were excluded because they are generally planktonic.

Nematodes were excluded because they are meiofauna and are not adequately sampled using a 500 um sieve bucket.

Terrestrial organisms and fish were excluded because they are not aquatic invertebrates.

The total number of individuals was divided by 3 times the surface area of the Ekman sampler (i.e., 3 x 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Ekman grabs).

Annex A.6-3. Lake Benthos Taxonomy Data, Doris North Project, 2012 (continued)

Taxonomic Identification					Little Roberts Lake					Reference Lake D				
					16-Aug-12					16-Aug-12				
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
Coelenterata	Hydridae	-	-	*Hydra*										
Nematoda*	-	-	-	-				10	4	76	8	8	2	22
Hirudinea	Piscicolidae	-	-	*Piscicola punctata*		10								
Oligochaeta - cocoon														
Oligochaeta	Enchytraeidae	-	-	-										2
	Lumbriculidae	-	-	-				1						
	Naididae	Naidinae	-	-				20						
	Naididae	Tubificinae	-	-		8	1			10		8	11	12
Gastropoda	Physidae	-	-	*Physa*										
	Valvatidae	-	-	*Valvata sincera*						65	48	111	67	58
Pelecypoda	Sphaeriidae	-	-	(i/d)	10	47	10	30	16	40	78	70	60	10
		-	-	*Sphaerium*						50	45	14	69	9
		-	-	*Pisidium*	11	40	40	35	15	50	4	12	25	24
Hydracarina	-	-	-	-							28	18	1	40
Copepoda - Calanoida*	-	-	-	-										
Copepoda - Cyclopoida*	Cyclopidae*	Cyclopinae*	-	*Acanthocyclops**		16		40	2					
Copepoda - Cyclopoida*	Ergasilidae*	-	-	*Ergasilus**										
Ostracoda	-	-	-	-	60	110	80	119	88	70	40	30	40	142
Cladocera*	Chydoridae*	-	-	*Eurycercus**										
	Daphnidae*	-	-	*Daphnia**										
Amphipoda	Epimeriidae	-	-	*Epimeria loricata*		1								
Malacostraca	Mysidae	-	-	*Mysis relicta*										
Isopoda	Chaetiliidae	-	-	*Saduria entomon*		2		3						
Ephemeroptera	Baetidae	-	-	*Baetis*										
	Ephemerellidae	-	-	*Ephemerella*										
	Heptageniidae	-	-	*Heptagenia*										
Plecoptera	Nemouridae	-	-	*Nemoura*										
	Perlodidae	-	-	*Skwala*										
Trichoptera		-	-	(pupa)										
	Brachycentridae	-	-	*Brachycentrus*										
		-	-	*Micrasema*										
	Hydroptilidae	-	-	*Agraylea*										
	Limnephilidae	-	-	(i/d)										
		-	-	*Grensia praeterica*										
		-	-	*Sphagnophylax meiops*										
Coleoptera	Dytiscidae	-	-	*Oreodytes*										
Diptera	Chironomidae	-	-	(pupa)	1				8			10	10	2
		Tanypodinae	Pentaneurini	(i/d)										
				Ablabesmyia			20	20	8	1	28		15	
				Thienemannimyia group										
			Procladiini	*Procladius*	55	73	70	43	58	5	1	21	7	3
		Diamesinae	Diamesini	*Potthastia longimana* group					1			10	1	
				Pseudokiefferiella										
			Protanypini	*Protanypus*										
		Prodiamesinae		*Monodiamesa*				1						
		Orthocladiinae	-	(i/d)					1					
			Orthocladiini	*Cricotopus/Orthocladius*		1		10			8			
				Corynoneura							8			
				Eukiefferiella										
				Euryhapsis										
				Heterotrissocladius										
				Parakiefferiella										
				Parametriocnemus										
				Psectrocladius	11									
				Synorthocladius										

(continued)

Annex A.6-3. Lake Benthos Taxonomy Data, Doris North Project, 2012 (completed)

Taxonomic Identification					Little Roberts Lake					Reference Lake D				
					16-Aug-12					16-Aug-12				
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**	**Rep-1**	**Rep-2**	**Rep-3**	**Rep-4**	**Rep-5**
				Tvetenia										
				Zalutschia	30	20	10	31	4					
		Chironominae	Chironomini	(i/d)										
				Chironomus	88	114	198	126	56	113	68	83	101	77
				Cladopelma						35			4	
				Demicryptochironomus										
				Dicrotendipes										
				Glyptotendipes ?										
				Polypedilum										
				Sergenta		50	35	52	14	128	144	479	230	215
				Stictochironomus										
			Tanytarsini	(i/d)										
				Cladotanytarsus										
				Constempellina										
				Corynocera						116				
				Micropsectra	10	9	30	11	36					
				Micropsectra / Tanytarsus										
				Paratanytarsus	352	1341	1073	1445	825	730	1025	934	848	649
				Rheotanytarsus						10				
				Tanytarsus	96	45	10	113	62	120	21	60	10	64
	Simulidae			*Simulium*										
		-	-	*Simulium* - pupa										
	Tipulidae	-	-	*Tipula*										
Terrestrial*	-	-	-	-										10
Fish*	Gasterosteidae*	-	-	*Pungitius pungitius* (Ninespine Stickleback)*							1			1
Total number of individuals					**724**	**1887**	**1577**	**2110**	**1198**	**1619**	**1555**	**1868**	**1501**	**1340**

Notes:

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses.*

i/d = immature or damaged

Cyclopoid and calanoid copepods were excluded because they are generally planktonic.

Nematodes were excluded because they are meiofauna and are not adequately sampled using a 500 um sieve bucket.

Terrestrial organisms and fish were excluded because they are not aquatic invertebrates.

The total number of individuals was divided by 3 times the surface area of the Ekman sampler (i.e., 3 x 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Ekman grabs).

Annex A.6-4a. Large Lake Benthos Summary Statistics, Doris North Project, 2012

	Doris Lake South					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	770	1,081	874	924	136	61
Family Richness	3.0	4.0	4.0	3.8	0.4	0.2
Simpson's Diversity Index	0.25	0.47	0.43	0.38	0.10	0.04
Simpson's Evenness Index	0.33	0.48	0.46	0.44	0.06	0.03
Bray-Curtis Index	0.18	0.22	0.20	0.20	0.02	0.01

	Doris Lake North					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1,852	2,385	1,941	2,030	215	96
Family Richness	3.0	4.0	4.0	3.6	0.5	0.2
Simpson's Diversity Index	0.08	0.19	0.10	0.12	0.05	0.02
Simpson's Evenness Index	0.27	0.37	0.31	0.32	0.04	0.02
Bray-Curtis Index	0.31	0.38	0.35	0.35	0.03	0.01

	Roberts Lake					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	5,096	10,726	9,230	8,720	2,124	950
Family Richness	5.0	6.0	5.0	5.2	0.4	0.2
Simpson's Diversity Index	0.26	0.41	0.30	0.32	0.06	0.03
Simpson's Evenness Index	0.24	0.34	0.27	0.29	0.04	0.02
Bray-Curtis Index	0.49	0.71	0.68	0.64	0.09	0.04

	Reference Lake B					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1,304	2,785	1,748	1,917	627	280
Family Richness	3.0	4.0	4.0	3.6	0.5	0.2
Simpson's Diversity Index	0.48	0.59	0.57	0.55	0.05	0.02
Simpson's Evenness Index	0.50	0.81	0.60	0.63	0.12	0.05
Bray-Curtis Index	0.01	0.14	0.06	0.07	0.05	0.02

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

Annex A.6-4b. Small Lake Benthos Summary Statistics, Doris North Project, 2012

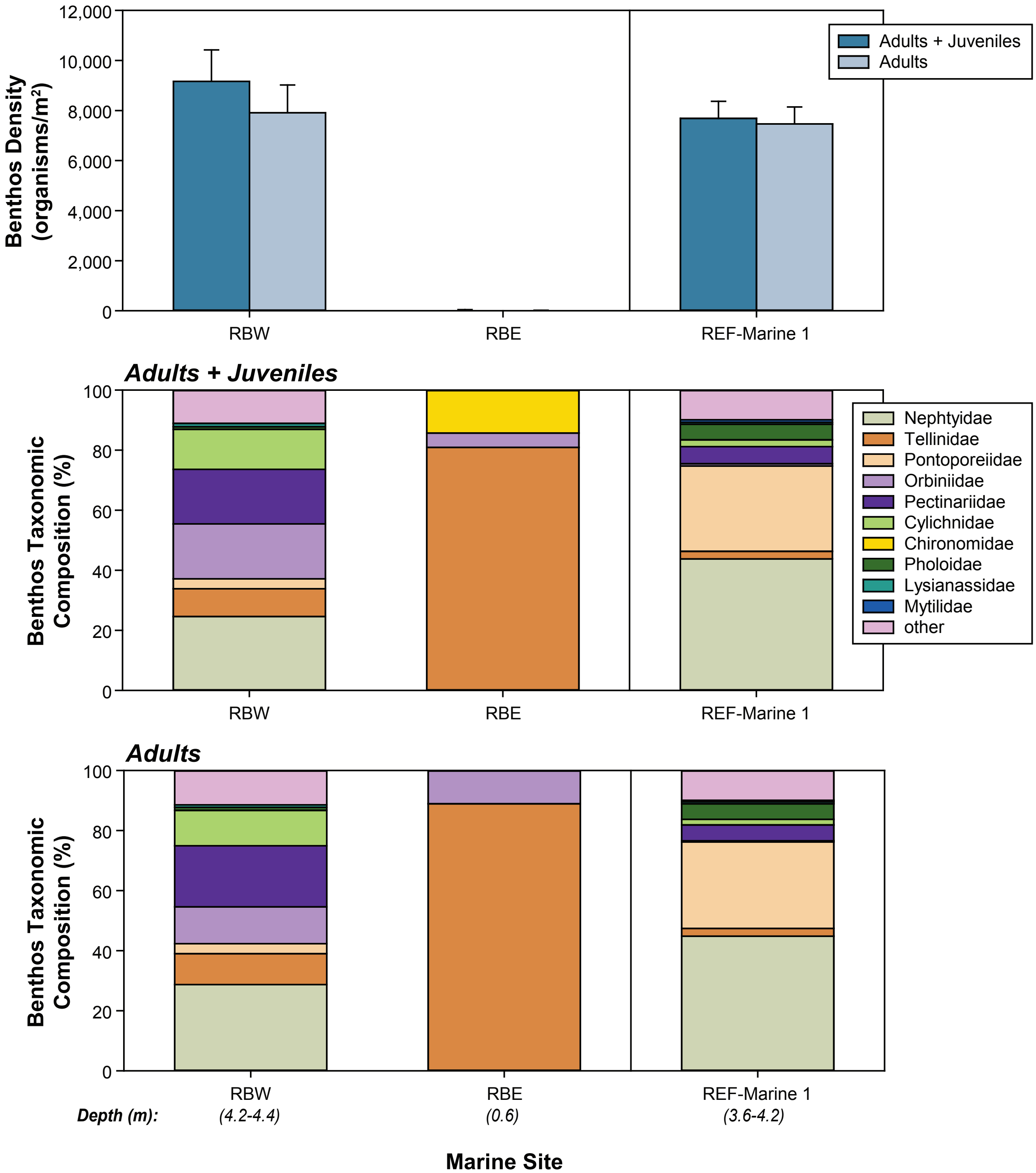
	Little Roberts Lake					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	10,726	30,518.52	23,362.96	21,997.04	7,954.10	3,557.18
Family Richness	3.0	7.0	4.0	4.6	1.8	0.8
Simpson's Diversity Index	0.16	0.21	0.19	0.19	0.02	0.01
Simpson's Evenness Index	0.18	0.42	0.30	0.30	0.11	0.05
Bray-Curtis Index	0.13	0.37	0.18	0.21	0.10	0.04

	Reference Lake D					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	19,363	27,556	22,859	22,978	2,943	1,316
Family Richness	5.0	7.0	6.0	5.8	0.8	0.4
Simpson's Diversity Index	0.26	0.39	0.32	0.31	0.05	0.02
Simpson's Evenness Index	0.22	0.30	0.24	0.26	0.03	0.01
Bray-Curtis Index	0.02	0.17	0.03	0.07	0.07	0.03

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean



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

NEWMONT NORTH AMERICA

Benthos Density and Taxonomic Composition in Marine Sites, Doris North Project, August 2012

Figure A6-7

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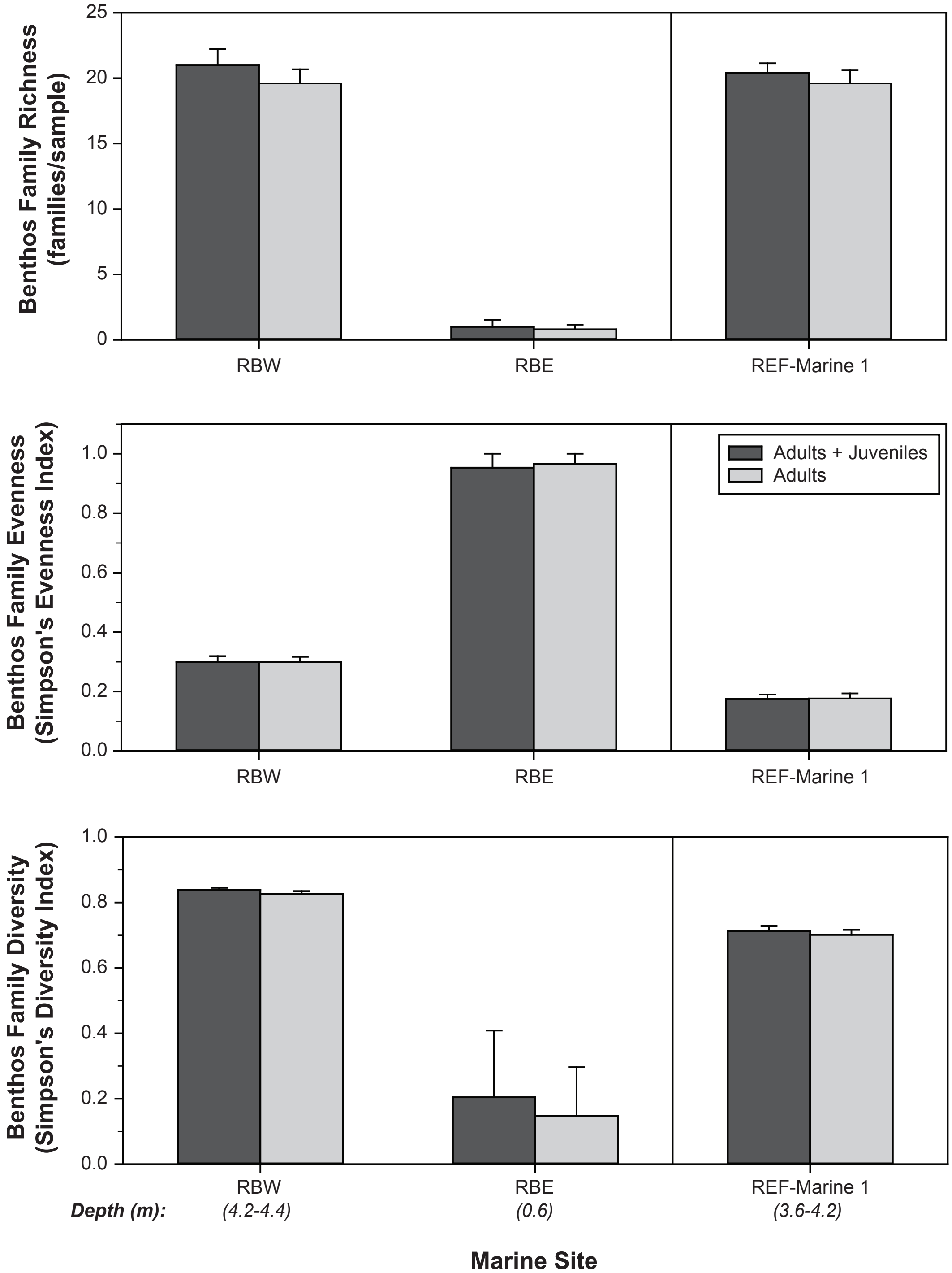
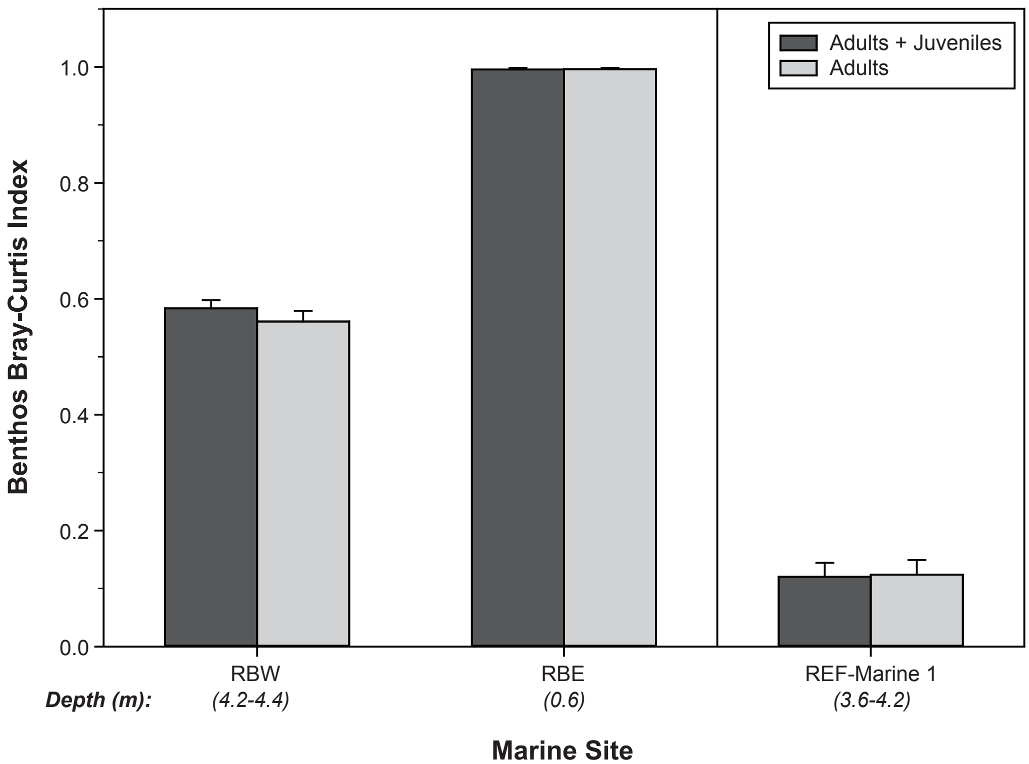


Note: Error bars represent the standard error of the mean.

Benthos Richness, Evenness, and Diversity in Marine Sites, Doris North Project, August 2012

Figure A6-8



Note: Error bars represent the standard error of the mean.

Benthos Bray-Curtis Index for Marine Sites, Doris North Project, August 2012

Figure A6-9

Annex A.6-5. Marine Benthos Taxonomy Data, Doris North Project, 2012

Taxonomic Identification			Roberts Bay West 18-Aug-12										Roberts Bay East 19-Aug-12										Reference Marine 1 17-Aug-12									
			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	
Major Group	Family	Genus/Species	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J
Hydrozoa sp. indet.*	Hydrozoa (Class)*	Hydrozoa sp. indet.*			3				1																							
NEMERTEA	Lineidae	Cerebratulus sp.						1	2		2																					
		Lineidae sp indet.			3						2																					
	Nemertea (Phylum)*	Nemertea sp indet.*			1		3		1																							
	Tubulanidae	Tubulanus sp.	1		3		3		2		2																					
ANNELIDA																																
Polychaeta Errantia	Phyllodocidae	Eteone longa	1		2		2				2														1		2		1			
		Eteone nr. pacifica	1		2		1		1																							
		Eulalia sp.	1																													
		Phyllodoce groenlandica			1		5		1		2																					
	Polynoidae	Harmothoe imbricata Cmplx.	2																												1	
		Harmothoe sp.																					1		1		1		1		1	
		Polynoidae sp indet.					1																									
	Hesionidae	Hesionidae sp indet.					1																									
		Micropodarke sp.					1				1												13	1	10	1	7		10		13	
	Nephtyidae	Nephtys sp.	145		199		180		80		172												156		216	1	311	1	273		182	6
	Pholoidae	Pholoe nr. inornata							1		2												10		33		25		21		31	
		Pholoe sp.	4		2		4		6		3												3		4		3			1		2
Polychaeta Sedentaria	Cirratulidae	Aphelochaeta sp.	1	2			7		9	1	24																					
		Chaetozone sp.									1																					
	Paraonidae	Aricidea catherinae	8		16		16		13		24	1											3		2		2		2		1	
	Capitellidae	Capitella capitata Cmplx.	4		6		3																						1			
		Mediomastus sp.	4		28		9		2		9																				2	
	Cossuridae	Cossura sp.									1																					
	Maldanidae	Euclymeninae sp indet.									2																		2			
	Orbiniidae	Leitoscoloplos sp.	65	31	87	80	66	57	35	27	79	52	1										3	1	3	3	2	3		3		1
	Pectinariidae	Pectinaria granulata	110	4	229	6	109	3	39	4	104	2											22	3	26	3	22	3	18	4	39	2
	Spionidae	Polydora sp.							1																							
		Prionospio steenstrupi			2		1				1												1									
		Spio sp.																									2		1			
	Scalibregmatidae	Scalibregma inflatum									1																					
	Chaetopteridae	Spiochaetopterus typicus	1																													
	Trichobranchidae	Terebellides stroemi	2		2						1												15		7		10		9		6	
ARTHROPODA																																
Amphipoda	Calliopiidae	Apherusa glacialis																							1		2					
		Weyprechtia pinguis																							2		1					
	Lysianassidae	Boeckosimus affinis					2	1	8	6													2				1		5		1	
		Orchomene minuta	5																						7						1	
	Gammarcanthidae	Gammaracanthus loricatus																					20		8		17		20		3	
	Gammaridae	Gammarus wilkitzkii																					1				1					
	Oedicerotidae	Monoculodes sp.	4																													
		Monoculopsis longicornis									3												1		2		3		3		1	
	Pontoporeiidae	Pontoporeia femorata	18	1	22	6	14	4	12	2	21	1											74	2	137	2	161	2	185	3	181	1
Ostracoda	Ostracoda (Class)*	Ostracoda sp indet.*	2																													
Cumacea	Diastylidae	Diastylis nr. goodsiri																							1				1		2	
		Diastylis rathkei																							1		4					
	Leuconidae	Leucon nr armatus			1																											
Isopoda	Idoteidae	Saduria entomon	1				1		1		1																1				1	1
MOLLUSCA																																
Gastropoda	Cylichnidae	Cylichna alba	109	5	90	18	52	36	31	12	44	23											7	2	1	3	11	4	22	2	8	1
	Conidae	Oenopota sp.	1						1																							
	Retusidae	Retusa sp.					3					1																				

(continued)

Annex A.6-5. Marine Benthos Taxonomy Data, Doris North Project, 2012 (completed)

Taxonomic Identification			Roberts Bay West 18-Aug-12										Roberts Bay East 19-Aug-12										Reference Marine 1 17-Aug-12									
			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	
Major Group	**Family**	**Genus/Species**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**	**A**	**J**
MOLLUSCA ***(cont'd)***																																
Bivalvia	Astartidae	Astarte borealis	11	1	7	11	8	1	1		3	4																				
	Cardiidae	Clinocardium ciliatum		1		7		3		2		7																				
		Clinocardium sp.																						1								
	Hiatellidae	Hiatella arctica	8								3												3	1	3		1		5			
	Tellinidae	Macoma balthica	81		32		62	3	28	3	43	2			1		1						14		13		9		11		14	1
		Macoma calcarea	12		12		5						2																			
		Macoma sp.												1																		
	Mytilidae	Musculus niger			1																											
	Mytilidae	Mytilus trossulus																						3	1	2	3	1	1	3	8	
	Myidae	Myidae sp. indet.																													1	
INSECTA	Chironomidae	Chironomidae larvae												3																		
	Diptera (Order)*	Diptera larvae*														1																
TOTAL number of individuals			**602**	**45**	**751**	**128**	**559**	**109**	**276**	**57**	**553**	**93**	**3**	**4**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**349**	**14**	**480**	**15**	**602**	**14**	**592**	**16**	**497**	**15**

Notes:

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses because these taxa were not identifiable to the family level and made up a minor proportion (<2%) of the benthos assemblage in each replicate.*

The total number of individuals was divided by 3 times the surface area of the Petite Ponar (i.e., 3 x 0.023 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Petite Ponar grabs) except Reference Marine 1 where the total number of individuals was divided by 3 times the surface area of the Ekman sampler (i.e., 3 x 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Ekman grabs).

A = adult

J = juvenile

Annex A.6-6. Marine Benthos Summary Statistics, Doris North Project, 2012

	Roberts Bay West (RBW) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	4,797	12,681	9,362	9,165	2,817	1,260
Family Richness	18.0	25.0	21.0	21.0	2.7	1.2
Simpson's Diversity Index	0.82	0.86	0.84	0.84	0.01	0.01
Simpson's Evenness Index	0.25	0.37	0.29	0.30	0.04	0.02
Bray-Curtis Index	0.55	0.63	0.59	0.59	0.03	0.01

	Roberts Bay West (RBW) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	3,971	10,826	8,058	7,913	2,483	1,111
Family Richness	17.0	23.0	19.0	19.6	2.4	1.1
Simpson's Diversity Index	0.80	0.85	0.83	0.83	0.02	0.01
Simpson's Evenness Index	0.25	0.37	0.29	0.30	0.04	0.02
Bray-Curtis Index	0.52	0.62	0.56	0.56	0.04	0.02

	Roberts Bay East (RBE) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	0	101	14	26	43	19
Family Richness	0.0	3.0	1.0	1.0	1.2	0.5
Simpson's Diversity Index	0.00	0.61	0.00	0.20	0.35	0.20
Simpson's Evenness Index	0.86	1.00	1.00	0.95	0.08	0.05
Bray-Curtis Index	0.98	1.00	1.00	1.00	0.01	0.00

	Roberts Bay East (RBE) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	0	43	14	14	18	8
Family Richness	0.0	2.0	1.0	0.8	0.8	0.4
Simpson's Diversity Index	0.00	0.44	0.00	0.15	0.26	0.15
Simpson's Evenness Index	0.90	1.00	1.00	0.97	0.06	0.03
Bray-Curtis Index	0.99	1.00	1.00	1.00	0.00	0.00

	Ida Bay (REF-Marine 1) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	5,378	9,126	7,585	7,686	1,523	681
Family Richness	19.0	23.0	20.0	20.4	1.7	0.7
Simpson's Diversity Index	0.67	0.76	0.72	0.71	0.03	0.01
Simpson's Evenness Index	0.13	0.22	0.18	0.17	0.03	0.01
Bray-Curtis Index	0.06	0.21	0.11	0.12	0.05	0.02

	Ida Bay (REF-Marine 1) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	5,170	8,919	7,363	7,465	1,519	679
Family Richness	17.0	23.0	20.0	19.6	2.3	1.0
Simpson's Diversity Index	0.66	0.74	0.70	0.70	0.03	0.01
Simpson's Evenness Index	0.13	0.23	0.17	0.18	0.04	0.02
Bray-Curtis Index	0.07	0.22	0.11	0.12	0.06	0.02

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

Annex A.6-7. Results of Benthos QA/QC Sorting Efficiencies, Doris North Project, 2012

Sample ID	# from First Sort	1st QAQC Re-sort # Found	Initial Sort Efficiency (%)	Re-sort Required?	2nd QAQC Re-sort # Found	Final Efficiency (%)
Freshwater						
Reference B OF, rep 4	541	5	99.1	N	-	99.1
Reference B, Rep 1	123	1	99.2	N	-	99.2
Doris Lake North, rep 3	140	0	100	N	-	100
Doris Lake South, rep 4	71	0	100	N	-	100
Roberts OF, rep 2	525	8	98.5	N	-	98.5
Marine						
REF-Marine 1, rep 1	363	0	100	N	-	100
REF-Marine 1, rep 2	495	0	100	N	-	100
REF-Marine 1, rep 3	616	1	99.0	N	-	99.0
REF-Marine 1, rep 4	608	0	100	N	-	100
REF-Marine 1, rep 5	512	0	100	N	-	100
RBE, rep 1	7	0	100	N	-	100
RBE, rep 2	2	0	100	N	-	100
RBE, rep 3	1	0	100	N	-	100
RBE, rep 4	0	0	100	N	-	100
RBE, rep 5	0	0	100	N	-	100
RBW, rep 1	647	0	100	N	-	100
RBW, rep 2	879	1	99.0	N	-	99.0
RBW, rep 3	668	0	100	N	-	100
RBW, rep 4	333	1	99.0	N	-	99.0
RBW, rep 5	646	0	100	N	-	100

Notes:

If the efficiency is 90% or better nothing further is done and the QA/QC invertebrates are not added to the data.

If the efficiency is less than 90%, the QA/QC invertebrates are added to the sample, it is re-sorted, and a second 20% QA/QC is performed.

*Freshwater data: % Sorting Efficiency = [1- {# in QA/QC re-sort/(# sorted originally + # in QA/QC re-sort)}]*10C*

*Marine data (20% of sample is re-sorted): % Sorting Efficiency = [1- {(5 x # in QA/QC re-sort)/(# sorted originally + (5 x # in QA/QC re-sort))}]*10C*

Appendix B

2012 Evaluation of Effects Supporting Information

Engineers and Scientists

Appendix B. 2012 Evaluation of Effects Supporting Information

Appendix B. 2012 Evaluation of Effects Supporting Information

B.1 BASELINE DATA SELECTION RATIONALE FOR EVALUATION OF EFFECTS

The tables presented in this section present a summary of the baseline water quality, sediment quality, and primary producer biomass data collected at the AEMP sites, as well as the rationale for the inclusion or exclusion of certain baseline data from the 2012 evaluation of effects.

B.1.2 Water Quality Data

Table B.1-1 presents a summary of the baseline water quality data collected at AEMP stream, lake, and marine sites, and the rationale for the inclusion or exclusion of certain baseline data from the 2012 evaluation of effects. The selection of historical data to include in the water quality evaluation of effects was mainly based on similarity of baseline sampling locations to 2012 sampling locations, methodology, and sampling depth.

B.1.1 Sediment Quality Data

Table B.1-2 presents a summary of the baseline sediment quality data collected at AEMP stream, lake, and marine sites, and the rationale for the inclusion or exclusion of certain baseline data from the 2012 evaluation of effects. The selection of historical data to include in the sediment quality evaluation of effects was mainly based on the comparability of the depth strata sampled between baseline and 2012 samples, the proximity of baseline sampling sites to the 2012 sites, and the similarity of sampling techniques.

B.1.2 Phytoplankton and Periphyton Biomass Data

Table B.1-3 presents a summary of the baseline phytoplankton and periphyton biomass data collected at AEMP stream, lake, and marine sites, and the rationale for the inclusion or exclusion of certain baseline data from the 2012 evaluation of effects. The main criteria for the selection of historical phytoplankton and periphyton biomass data for inclusion in the evaluation of effect were the proximity of baseline sampling sites to 2012 AEMP sampling sites, and the comparability of sampling methodologies.

Table B.1-1. Baseline Data Selection Rationale for Water Quality, Doris North Project, 2012

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
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	
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	
Little Roberts OF	1996	June, August	None	All	• 1996-1997 sampling site was further downstream than the 2003-2012 sampling site.
	1997	June, July, August	None	All	• 1996-1997 sampling site was further downstream than the 2003-2012 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	
Reference B OF	2009	June, August, September	All	None	
Reference D OF	no pre-2010 baseline data available				

(continued)

Table B.1-1. Baseline Data Selection Rationale for Water Quality, Doris North Project, 2012 (continued)

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Lakes					
Doris South	1995	May, June, July, August	Included May and June under-ice samples and August samples collected from boat at site SW4	Excluded shoreline grabs from July and August	• Shoreline grabs from July and August were from a near-shore site that is not comparable to the 2012 Doris South site.
	1996	April, August	All	None	
	1997	April, July, August	All	None	
	1998	April	All	None	
	2000	July, August	All	None	
	2009	April, August	All	None	
Doris North	1995	May, June, July, August	Included May and June under-ice samples and August samples collected from boat at 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 2012 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	
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 2012 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	
Reference B	2009	April, August	All	None	
Reference D	no pre-2010 baseline data available				

(continued)

Table B.1-1. Baseline Data Selection Rationale for Water Quality, Doris North Project, 2012 (completed)

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Marine Sites					
RBW	1996	August	None	All	• 1996-1998 sampling sites were >1 km away from 2012 RBW site.
	1997	August	None	All	• 1996-1998 sampling sites were >1 km away from 2012 RBW site.
	1998	July	None	All	• 1996-1998 sampling sites were >1 km away from 2012 RBW site.
	2009	April, August	Included surface samples from sites WT1 and ST2	Exluded samples from sites: WT2, WT4, WT6, ST1, ST3, ST4, ST5, ST6, and deep sample from site ST2	• Excluded sites that were >1 km away from 2011 RBW site, and excluded deep samples because only surface samples were collected in 2012.
RBE	1996	August	Included single site that was in the eastern basin	None	
	1997	August	None	All	• 1997-1998 sampling site in eastern basin was closer to the mouth of Little Roberts Outflow than the 2012 RBE site (greater freshwater influence).
	1998	July	None	All	• 1997-1998 sampling site in eastern basin was closer to the mouth of Little Roberts Outflow than the 2012 RBE site (greater freshwater influence).
	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	
REF-Marine 1	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 2012 REF-Marine 1 site, and excluded deep samples because only surface samples were collected in 2012.

Table B.1-2. Baseline Data Selection Rationale for Sediment Quality, Doris North Project, 2012

Sampling sites	Years Sampled	Month Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Streams					
Doris OF	2009	August	All	None	
Roberts OF	no pre-2010 baseline data available				
Little Roberts OF	2009	August	All	None	
Reference B OF	2009	August	All	None	
Reference D OF	no pre-2010 baseline data available				
Lakes					
Doris South (deep)	1996	August	None	All	• Sediment sample was separated into layers (0-1 cm and 1-3 cm).
	1997	July	All	None	
	2009	August	Included deep site	Excluded shallow site	• Shallow site was sampled.
Doris North (deep)	2009	August	Included deep site	Excluded shallow site	• Shallow site was sampled.
Little Roberts (shallow)	1996	August	None	All	• Sediment sample was separated into layers (0-1 cm and 1-3 cm).
	1997	July	All	None	
	2009	August	All	None	
Reference B (deep)	2009	August	None	All	• Shallow/mid depth sites and located at opposite end of lake relative to 2012 site.
Reference D (shallow)	no pre-2010 baseline data available				
Marine Sites					
RBW (shallow)	1997	August	None	All	• Mid-depth/deep sites and located >1 km from 2012 RBW site.
	2002	August	Included shallow site RB4	Excluded sites RB1, RB2, RB3	• RB1 and RB2 were >1 km from 2012 RBW site; RB3 was a mid-depth site.
	2009	August	None	All	• Sites were all ~0.4 km or more away from 2012 RBW site.
RBE (shallow)	1997	August	None	All	• sampling site in eastern basin was closer to the mouth of Little Roberts Outflow than the 2012 RBE site (greater freshwater influence, and depositional zone).
REF-Marine 1 (shallow)	2009	August	Included shallow site RP1	Excluded sites RP2, RP3	• RP2 was a mid-depth site and RP3 was a deep site.

Table B.1-3. Baseline Data Selection Rationale for Primary Producer Biomass (as Chlorophyll *a*), Doris North Project, 2012

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Streams (Periphyton)					
Doris OF	1996	August	None	All	• An instantaneous sample was collected, and chlorophyll *a* concentrations were not measured (only abundance and taxonomy data).
	1997	June-July, July-August	All	None	
	2000	July-August	All	None	
	2009	July-August	All	None	
Roberts OF	no pre-2010 baseline data available				
Little Roberts OF	1996	August	None	All	• 1996 sampling site was further downstream than 2009-2012 sampling site, an instantaneous sample was collected, and chlorophyll *a* concentrations were not measured (only abundance and taxonomy data).
	1997	June-July, July-August	None	All	• 1997 sampling site was further downstream than 2009-2012 sampling site.
	2009	July-August	All	None	
Reference B OF	2009	July-August	All	None	
Reference D OF	no pre-2010 baseline data available				
Lakes (Phytoplankton)					
Doris South	1996	August	None	All	• Chlorophyll *a* concentrations were not measured (only abundance and taxonomy data).
	1997	July	All	None	
	2000	July	All	None	
	2009	April, August	All	None	
Doris North	2003	July, August, September	None	All	• Each sample consisted of a composite of 5 subsamples collected throughout the euphotic zone (not comparable to discrete surface samples collected in 2012).
	2006	September	None	All	• Phytoplankton biomass sampling method not descibed in report.
	2007	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2012).
	2008	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2012).
	2009	April, August	All	None	

(continued)

Table B.1-3. Baseline Data Selection Rationale for Primary Producer Biomass (as Chlorophyll *a*), Doris North Project, 2012 (completed)

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Lakes (Phytoplankton) *(cont'd)*					
Doris North *(cont'd)*	1997	July	All	None	
	2003	July, August, September	None	All	• Each sample consisted of a composite of 5 subsamples collected throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2006	September	None	All	• Phytoplankton biomass sampling method not descibed in report.
	2007	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2008	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2009	April, August	All	None	
Reference B	2009	August	All	None	
Reference D	no pre-2010 baseline data available				
Marine Sites (Phytoplankton)					
RBW	2009	August	Included surface samples from site ST2	Exluded samples from sites: ST1, ST3, ST4, ST5, ST6, and deep samples from site ST2	• Excluded sites that were >1 km away from 2011 RBW site, and excluded deep samples because only surface samples were collected in 2012.
RBE	2006	September	None	All	• Phytoplankton biomass sampling method not descibed in report.
	2007	July, August, September	None	All	• Phytoplankton biomass samples were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2012).
	2008	July, August, September	None	All	• Phytoplankton biomass samples were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2012).
	2009	August	All	None	
REF-Marine 1	2009	August	Included surface samples from site RP3	Excluded samples from site REF-4, and deep samples from site RP3	• Excluded sites that were >1 km away from 2011 REF-Marine 1 site, and excluded deep samples because only surface samples were collected in 2011.

B.2 STATISTICAL METHODOLOGY AND RESULTS FOR EVALUATION OF EFFECTS

The following reports present the statistical methodology and results, including lists of outliers and statistical outputs, for the evaluation of effects on Secchi depth, water quality, sediment quality, phytoplankton and periphyton biomass, and benthic invertebrates.

Appendix B.2.1. Statistical Methodology and Results for Secchi Depth Evaluation of Effects, Doris North Project, 2012

Table of Contents

1. Analysis Methods

1.1 ASSUMPTIONS

The key assumption is that the Secchi depth measurements included in this analysis are representative of each lake site's Secchi depth for that monitoring period.

1.2 TRANSFORMATIONS

No transformation was needed.

1.3 OUTLINE OF ANALYSIS PLAN

There are several classes of statistical tests that can be done to assess evidence of change in the Secchi depth over time and to assess if changes may reflect an impact of the Project.

1.3.1 Before vs. After Analysis

The first analysis conducted compares the mean Secchi depth for all years prior to 2010 (before initiation of construction) to the mean for 2012 (year 3 of construction). Each lake site is treated independently.

The final statistical model (in standard shorthand notation) is:

*Y = Period Season Period*Season Year(period)-R*

where *Y* is the mean Secchi depth for a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest); *Season* is the effect of season (3 seasons in the sampling year: 1) July, 2) August, 3) September); *Period*Season* is an interaction effect between period and season; and *Year(Period)* is a random year effect (applicable if more than one year was sampled during each period). 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 two years pre-construction) as having the same mean and assuming that they are completely independent of each other. This model also "averages" the Secchi depth data in way that weights each baseline year equally rather than weighting by the sample size. For example, suppose that the Secchi depth measured in 2008 was 22 m, while the two Secchi depths measured in 2009 were 25 m and 27 m. The simple mean (22+25+27)/3=24.7 m 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:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2}=24.0$$

This can be extended to multiple years in a similar fashion.

This model was fit using R version 2.15.2. 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.

The key disadvantage of this model is that changes in Secchi depth over time may be unrelated to the effects of the Project, e.g., the average Secchi depth in 2012 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.

1.3.2 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 waterbodies. A BACI analysis was performed for each large Project lake (Doris Lake North and Doris Lake South) versus the corresponding reference lake (Reference Lake B). A BACI analysis was not performed for Little Roberts Lake (small lake) because there is no pre-construction data for Reference Lake D.

The formal statistical model (in standard shorthand notation) is:

*Y = Period Class Period*Class Season Period*SeasonYear(Period)-R*

where *Y* is the parameter of interest; *Period* is the effect of period (before or after construction); *Class* is the effect of the site 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 sites); *Season* is the seasonal (sampling month) effect; *Period*Season* is an interaction effect between period and season; and *Year(Period)* is the random year effect within each period (applicable if more than one year was sampled during each period). 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. If there were multiple reference waterbodies (as is the case for streams), a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for the Project site is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate.

Not all sites were measured in all years and only those Project-Reference pairs of sites that were measured both in the before and after period can be used to estimate this BACI contrast. The results from this comparison are specific to the particular Project-reference 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 (Before-After) over the two classes of sites (Project or reference). The BACI estimate is computed as the “difference in the differences”:

$$BACI = (\mu_{PA} - \mu_{PB}) - (\mu_{RA} - \mu_{RB})$$

where μ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean parameter reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. 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 here.

The BACI model was fit using R version 2.15.2

2. Results

There was no censoring of the Secchi depth data, and preliminary plots of the data showed no obvious outliers.

The lakes were divided into small lakes (Little Roberts Lake and Reference Lake D) and large lakes (Doris Lake North, Doris Lake South, and Reference Lake B) and separate results are presented for each size class of lake. There is no analysis of the small lakes because the Secchi depth always reached the bottom, indicating that light was able to penetrate the entire water column. As water clarity in the small lakes was high in 2012, Secchi depth was not evaluated for Little Roberts Lake or Reference D.

The large lake results from the analysis that compared the means before and after Project construction are presented in Table Large Lake-1. There was no evidence of a change in the mean Secchi depth for any lake between the before and after periods. A before-after analysis was not possible for Reference Lake B because there was too few degrees of freedom in the before period.

There was no evidence of a differential before-after response in the mean Secchi depth in large Project lakes compared to Reference Lake B (Table Large Lake-2).

References

Helsel, D.R. (2005). Nondetects and data analysis. Wiley:New York.

McBride, G.B. (2005). Using statistical methods for water quality management. Wiley: New York.

Smith, E. P. (2002). BACI Design. Encyclopedia of Environmetrics. Wiley: New York.

Table Large Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Large Lake Secchi Depth

	Period		
	Large Lake Site		
	Doris North	Doris South	Reference B
Parameter	Pr> F	Pr> F	Pr> F
Secchi Depth	0.0983	0.5036	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded. A before-after analysis was not possible for Reference Lake B.

Table Large Lake-2. Summary of BACI Comparison of Large Lake Secchi Depth for Individual Project Sites

	Large Lake Site					
	Doris North			Doris South		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Secchi Depth	1.5428	0.8122	0.0867	1.0697	1.987	0.6442

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Appendix B.2.2. Statistical Methodology and Results for Water Quality Evaluation of Effects, Doris North Project, 2012

Table of Contents

1. Analysis Methods

1.1 ASSUMPTIONS

There are several assumptions made for the analyses of water quality. The key assumption is that the samples taken are a random sample of the site's water for that monitoring period (e.g., for that month in that year when measured).

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 were treated as pseudo-replicates (Hurlbert 1984) and values were 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 water quality parameter. The analyses below follow the advice of McBride (2005; Section 11.4.3).

- When the dataset includes a small number of below detection values, these values will be replaced by ½ of the detection limit for the analysis.
- When the majority of the dataset consists of 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 is an 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 Markov chain Monte Carlo (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 water quality parameters fall into one of the two first categories.

It should be noted that for data collected in the late 1990's, the detection limits were often considerably higher than the detection limits available for more recent sampling (often 5× or 6× higher). Consequently, there is little to be gained from using this very early data and it was often 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 parts per million (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 water quality parameter over time and to assess if changes in the means may reflect an impact of the Project.

1.6.1 Before vs. After Analysis

The first analysis conducted compares the mean readings for all years prior to 2010 (before initiation of construction) to the mean for 2012 (year 3 of construction). Each waterbody is treated independently, and each water quality parameter is treated separately.

The final statistical model (in standard shorthand notation) is:

*Y = Period Season Period*Season Year(Period)-R*

where *Y* is the (mean) parameter reading for a date within a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest); *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 (applicable if more than one year was sampled during each period). 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 collected over the baseline years in way that weights each year equally rather than weighting by the sample size. For example, suppose that the water quality parameter measured in 2008 was 22 ppm, while the two readings measured in year 2009 were 25 and 27 µg/L. The simple mean (22+25+27)/3=24.7 µg/L would be more heavily weighted toward the mean in 2009. In order to give each year's data equal weight, the reading over both years is computed as an average of averages:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2} = 24.0 \text{ µg/L}$$

This can be extended to multiple years in a similar fashion.

This model was fit using a mixed-model ANOVA using R version 2.15.2 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.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, e.g., the mean water quality readings in 2012 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 waterbodies. A BACI analysis was performed for each Project waterbody versus the corresponding reference waterbody.

The formal statistical model (in standard shorthand notation) is:

*Y = Period Season Period*Season Class Period*Class Year(Period)-R*

where *Y* is the parameter of interest; *Period* is the effect of period (before or after construction); *Season* is the effect of season (early (June or earlier) or late (July or later)); *Period*Season* represents the interaction between Project and season effects (i.e., is the effect of the period consistent in both seasons); *Class* is the effect of the site 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 sites); and *Year(Period)* is the random year effect within each period (applicable if more than one year was sampled during each period). 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. If there were multiple reference waterbodies (as is the case for streams), a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for the Project site is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate.

Not all sites were measured in all years and only those Project-reference pairs of sites that were measured both in the before and after period can be used to estimate this BACI contrast. The results from this comparison are specific to the particular Project-reference 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 (Before-After) over the two classes of sites (Project or reference). The BACI estimate is computed as the "difference in the differences":

$$BACI = (\mu_{PA} - \mu_{PB}) - (\mu_{RA} - \mu_{RB})$$

whereμ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation,μ_{PB} is the mean parameterreading in the *Project* class of sites *before* Project initiation,μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. 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 here.

The model was fit using R version 2.15.2.

1.6.3 Multivariate Approaches

All of the approaches above analyze each water quality parameter independently of any 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 (values below the detection limit) for the stream data is found in Table Stream-1. High levels of censoring in all streams were found for the cadmium, nitrate, and radium-226 parameters and the results of the analyses for these parameters will be non-informative and should be discarded.

High levels of censoring for TSS, molybdenum, lead, and zinc were found in one or both of the reference streams but lower proportions 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 artefact 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.

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 alkalinity, hardness, molybdenum and nitrate in Doris OF, nitrate in Little Roberts OF, arsenic, nitrate and radium-226 in Roberts OF.

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, with the exception of nitrate in Doris OF, Little Roberts OF and mercury in Roberts OF.

2.2 MARINE DATA

A summary of the amount of censoring (values below the detection limit) for the site data is found in Table Marine-1.

Preliminary plots of the data showed some outliers which were removed prior to analysis (Table Marine-2). Of particular concern are the arsenic readings at the RBE site, which were substantially elevated between 2004 and 2006, but then fell to near or below detection limits from 2007 to 2012. The elevated readings prior to 2007 were treated as outliers and removed from the analysis to ensure that these observations did not artificially inflate the variance estimates, leading to a reduced power to detect effects.

The results from the analysis that compared the means before and after Project construction are presented in Table Marine-3. There was no evidence of a change in the mean between the before and after periods for any marine exposure site except for TSS and mercury at RBW and ammonia and mercury in REF-Marine 1. However, 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.

2.3 SMALL LAKE DATA

A summary of the amount of censoring (values below the detection limit) for the small lake data is found in Table Small Lake-1. High levels of censoring in all streams were found for cadmium and radium-226 parameters and the results of the analyses for these parameters will be non-informative and should be discarded.

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 did not artificially inflate the variance estimates leading to a reduced power to detect effects.

There was evidence of a change in the mean of the pH and molybdenum parameters between the before and after period in the Little Roberts Lake (Table Small Lake-3). In this case, pH levels increased slightly but still were well within CCME freshwater guidelines and molybdenum concentrations increased in the large lakes, suggesting that the increase in Little Roberts Lake is due to regional natural variability

Because water quality samples were not collected at Reference Lake D before construction started, no BACI analysis is possible.

2.4 LARGE LAKE DATA

A summary of the amount of censoring (values below the detection limit) for the large lake data is found in Table Large Lake-1. High levels of censoring in all lakes were found for cadmium and radium-226 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 for total suspended solids, iron, nickel, molybdenum and zinc, and for Roberts Lake for zinc. This will make the BACI comparison difficult to interpret.

Preliminary plots of the data showed some potential outliers that were excluded from the analysis (Table Large Lake-2).

There was evidence of a difference in the means between the before and after periods for total cyanide and mercury in Doris Lake South and aluminum and molybdenum in Doris Lake North (Table Large Lake-3). However, the BACI comparison 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 (Table Large Lake-4).

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Table Stream-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Stream Sampling

	Stream Site				
	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Roberts OF
Parameter	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
Aluminum (Al)	0.00	0.00	0.07	0.00	0.00
Alkalinity	0.00	0.00	0.00	0.00	0.00
Ammonia	0.33	0.35	0.40	0.54	0.31
Arsenic (As)	0.10	0.04	0.13	0.17	0.09
Cyanide (Cn)	0.69	0.53	0.33	0.38	0.62
Cadmium (Cd)	0.82	0.76	0.97	0.96	0.78
Copper (Cu)	0.00	0.00	0.00	0.00	0.00
Iron (Fe)	0.00	0.00	0.00	0.00	0.00
Hardness	0.00	0.00	0.00	0.00	0.00
Mercury (Hg)	0.70	0.63	0.50	0.38	0.53
Molybdenum(Mo)	0.04	0.00	0.73	0.00	0.00
Nickel (Ni)	0.04	0.00	0.33	0.04	0.04
Nitrate	0.80	0.82	0.57	0.58	0.67
Lead (Pb)	0.28	0.24	0.97	0.33	0.20
Radium (Ra)	0.89	0.85	0.83	0.83	0.87
Total Suspended Solids (TSS)	0.12	0.05	0.87	0.42	0.04
Zinc (Zn)	0.38	0.53	0.97	1.00	0.44
pH	0.00	0.00	0.00	0.00	0.00

Table Stream-2. Summary of Potential Outliers from the Stream Data

Stream	Parameter	Year	Date	Rep	Value	Censored (1=yes 0=no)
Doris OF	Ammonia	1997	19JUL97	1	1.359800	0
Doris OF	Ammonia	1997	19JUL97	2	1.402400	0
Doris OF	Ammonia	1997	20AUG97	1	1.353300	0
Doris OF	As	1996	23JUN96	1	0.002000	1
Doris OF	As	1996	22AUG96	1	0.003000	0
Doris OF	As	2012	21JUL12	1	0.002360	0
Doris OF	As	2012	21JUL12	2	0.003720	0
Doris OF	Cd	1996	23JUN96	1	0.000190	0
Doris OF	Cd	1996	22AUG96	1	0.000025	1
Doris OF	Cd	1997	19JUN97	1	0.000100	1
Doris OF	Cd	1997	19JUL97	1	0.000100	1
Doris OF	Cd	1997	19JUL97	2	0.000100	1
Doris OF	Cd	1997	20AUG97	1	0.000100	1
Doris OF	Cd	2000	20JUN00	1	0.000025	1
Doris OF	Cd	2000	20JUN00	2	0.000025	1
Doris OF	Cd	2000	14SEP00	1	0.000025	1
Doris OF	Cd	2000	14SEP00	2	0.000025	1
Doris OF	Cd	2004	24JUN04	1	0.000025	1
Doris OF	Hg	1997	20AUG97	1	0.000025	1
Doris OF	Hg	2000	20JUN00	1	0.000025	1
Doris OF	Hg	2000	20JUN00	2	0.000025	1
Doris OF	Hg	2000	14SEP00	1	0.000025	1
Doris OF	Hg	2000	14SEP00	2	0.000025	1
Doris OF	Hg	2003	28JUL03	1	0.000025	1
Doris OF	Mo	1997	19JUN97	1	0.000500	1
Doris OF	Mo	1997	19JUL97	1	0.000500	1
Doris OF	Mo	1997	19JUL97	2	0.000500	1
Doris OF	Mo	1997	20AUG97	1	0.000500	1
Doris OF	Pb	1997	19JUN97	1	0.000500	1
Doris OF	Pb	1997	19JUL97	1	0.000500	1
Doris OF	Pb	1997	19JUL97	2	0.000500	1
Doris OF	Pb	1997	20AUG97	1	0.000500	1
Little Roberts OF	As	2012	21JUL12	1	0.004420	0
Little Roberts OF	As	2012	21JUL12	2	0.004930	0
Little Roberts OF	Hg	2003	28JUL03	1	0.000025	1
Reference B OF	As	2012	21JUL12	1	0.004420	0
Reference B OF	As	2012	21JUL12	2	0.005030	0
Reference B OF	Cd	2012	20SEP12	1	0.000213	0

(continued)

Table Stream-2. Summary of Potential Outliers from the Stream Data

Stream	Parameter	Year	Date	Rep	Value	Censored (1=yes 0=no)
Reference B OF	Hg	2010	19JUN10	1	0.000050	1
Reference B OF	Hg	2010	19JUN10	2	0.000050	1
Reference D OF	As	2012	21JUL12	1	0.004640	0
Reference D OF	As	2012	21JUL12	2	0.004760	0
Reference D OF	Hg	2010	18JUN10	1	0.000050	1
Reference D OF	Hg	2010	18JUN10	2	0.000050	1
Roberts OF	As	2012	21JUL12	1	0.005170	0
Roberts OF	As	2012	21JUL12	2	0.005170	0
Roberts OF	Hg	2010	18JUN10	1	0.000050	1
Roberts OF	Hg	2010	18JUN10	2	0.000050	1

Notes: Censored values were replaced by ½ of the detection limit.

Table Steam-3. Summary of Test for No Difference in Mean between Before and After Periods for Stream Water Quality Parameters

	Effect				
	Period Stream Site				
	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Roberts OF
Parameter	**Pr> F**	**Pr> F**	**Pr> F**	**Pr> F**	**Pr> F**
Aluminum (Al)	0.5303	0.0121	0.8018	.	0.0837
Alkalinity	**0.0033**	0.3380	0.0836	.	0.6372
Ammonia	0.7205	0.8136	0.9183	.	0.8560
Arsenic (As)	0.2989	0.1636	**<0.0001**	.	**0.0047**
Cyanide	0.6344	0.3238	.	.	0.3110
Cadmium (Cd)	0.6952	0.7289	**<0.0001**	.	0.8267
Copper (Cu)	0.9812	0.7334	0.6948	.	0.7721
Iron (Fe)	0.8458	0.9021	0.5942	.	0.4654
Hardness	**0.0032**	0.1875	0.2561	.	0.3713
Mercury (Hg)	0.7674	0.9068	**<0.0001**	.	0.5176
Molybdenum (Mo)	**0.0004**	0.5358	0.4631	.	0.4846
Nickel (Ni)	0.7171	0.6722	0.8149	.	0.2317
Nitrate	**<0.0001**	**<0.0001**	**0.0065**	.	**<0.0001**
Lead (Pb)	0.2746	0.2469		.	0.2152
Radium (Ra)	0.6833	0.6743	.	.	**<0.0001**
Total Suspended Solids (TSS)	0.8369	0.5841	**0.0024**	.	0.4768
Zinc (Zn)	0.858	0.339	**<0.0001**	.	0.346
pH	0.1344	0.0350	0.0226	.	0.1693

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Stream-4. Summary of BACI Comparison of Water Quality Parameters for Individual Project Stream Sites

	Stream Site								
	Doris OF			Little Robert OF			Roberts OF		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Aluminum (Al)	-0.0409	0.0959	0.672	-0.0974	0.0802	0.235	-0.1234	0.1209	0.365
Alkalinity	2.5000	2.511	0.324	0.4265	1.6727	0.801	-0.5678	1.829	0.772
Ammonia	0.0041	0.0060	0.495	-0.0026	0.0049	0.603	-0.0030	0.0039	0.473
Arsenic (As)	-0.0001	0.0001	0.196	-0.0002	0.0001	0.080	-0.0003	0.0001	0.024
Cyanide	.	.	.	.	.	.	.	.	.
Cadmium (Cd)	0.0000	0.0000	0.455	0.0000	0.0000	0.924	0.0000	0.0000	0.836
Copper (Cu)	-0.0000	0.0003	0.924	-0.0001	0.0002	0.616	0.0000	0.0002	0.915
Iron (Fe)	-0.0158	0.1211	0.897	-0.0362	0.0910	0.693	-0.0060	0.0989	0.955
Hardness	7.888	5.4632	0.155	3.7625	3.8678	0.340	1.0649	2.7612	0.719
Mercury (Hg)	0.0000	0.0000	0.826	0.0000	0.0000	0.566	0.0000	0.0000	**0.0004**
Molybdenum (Mo)	0.0000	0.0000	0.104	0.0000	0.0000	0.950	0.0000	0.0000	0.785
Nickel (Ni)	0.0000	0.0002	0.629	-0.0001	0.0001	0.548	-0.0001	0.0001	0.525
Nitrate	0.1884	0.0044	**<0.0001**	0.1826	0.0060	**<0.0001**	-0.1646	0.0099	**0.0001**
Lead (Pb)	-0.0000	0.0000	0.562	-0.0000	0.0001	0.434	-0.0001	0.0001	0.365
Radium (Ra)	.	.	.	.	.	.	.	.	.
Total Suspended Solids (TSS)	0.4018	3.090	0.897	-2.234	2.160	0.310	1.0955	1.6596	0.545
Zinc (Zn)	-0.0016	0.0022	0.483	-0.0014	0.0015	0.366	-0.0019	0.0019	0.372
pH	0.0056	0.2850	0.985	0.0309	0.1972	0.877	0.0055	0.3827	0.989

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Marine-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Marine Sampling

	Site		
	RBE	RBW	REF-Marine 1
Parameter	Proportion Censored	Proportion Censored	Proportion Censored
Aluminum (Al)	0.05	0.17	0.14
Alkalinity	0.00	0.00	0.00
Ammonia	0.29	0.83	0.71
Arsenic (As)	0.18	0.25	0.14
Cyanide	0.51	0.33	0.45
Cadmium (Cd)	0.42	0.21	0.14
Copper (Cu)	0.11	0.12	0.10
Iron (Fe)	0.16	0.29	0.24
Hardness	0.00	0.00	0.00
Mercury (Hg)	0.64	0.71	0.67
Molybdenum (Mo)	0.11	0.04	0.00
Nickel (Ni)	0.13	0.04	0.10
Nitrate	0.74	0.50	0.76
Lead (Pb)	0.56	0.50	0.52
Radium (Ra)	0.76	0.71	0.80
Total Suspended Solids (TSS)	0.18	0.38	0.33
Zinc (Zn)	0.29	0.38	0.71
pH	0.00	0.00	0.00

Table Marine-2. Summary of Potential Outliers from the Marine Data

Site	Parameter	Year	Date	Rep	Value	Censored (1=yes 0=no)
RBE	Ammonia	1996	28AUG96	1	2.500000	1
RBE	Ammonia	2007	23JUL07	1	0.214000	0
RBE	As	1996	28AUG96	1	0.002500	1
RBE	As	2004	19JUL04	1	0.008020	0
RBE	As	2004	14AUG04	1	0.015200	0
RBE	As	2004	16AUG04	1	0.013100	0
RBE	As	2004	09SEP04	1	0.022300	0
RBE	As	2005	21JUL05	1	0.004730	0
RBE	As	2005	18AUG05	1	0.022100	0
RBE	As	2005	14SEP05	1	0.021200	0
RBE	As	2006	31MAY06	1	0.015200	0
RBE	As	2006	20JUL06	1	0.013300	0
RBE	As	2006	12AUG06	1	0.025600	0
RBE	As	2006	11SEP06	1	0.023680	0
RBE	Cyanide	2007	27MAY07	1	0.250000	1
RBE	Cyanide	2007	23JUL07	1	2.500000	1
RBE	Cd	1996	28AUG96	1	0.003480	0
RBE	Ni	1996	28AUG96	1	0.021500	0

Notes: Censored values were replaced by ½ of the detection limit.

Table Marine-3. Summary of Test for No Difference in Mean between Before and After Periods for Marine Water Quality Parameters

	Effect		
	Period Site		
Parameter	RBE Pr> F	RBW Pr> F	REF-Marine 1 Pr> F
Aluminum (Al)	0.8395	0.6868	0.0891
Alkalinity	0.1404	.	.
Ammonia	0.2713	0.7818	**<0.0001**
Arsenic (As)	0.6907	0.1383	0.0169
Cyanide	0.6876	.	.
Cadmium (Cd)	0.7348	0.1931	0.1746
Copper (Cu)	0.5896	0.7542	0.4357
Iron (Fe)	0.7154	0.7945	0.2667
Hardness	0.6271	0.6262	.
Mercury (Hg)	0.2914	**<0.0001**	**0.0025**
Molybdenum (Mo)	0.4463	0.0528	0.3929
Nickel (Ni)	0.8081	0.3333	0.1835
Nitrate	0.7398	0.0205	0.6592
Lead (Pb)	0.6779	0.9559	0.3105
Radium (Ra)	0.6242	.	.
Total Suspended Solids (TSS)	0.1079	**0.0036**	0.0316
Zinc (Zn)	0.5675	0.2213	1.0000
pH	0.6003	0.0274	0.3747

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Marine-4. Summary of BACI Comparison of Water Quality Parameters for Individual Project Marine Sites

	Marine Project Site					
	RBE			RBW		
	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Parameter						
Aluminum (Al)	-0.0278	0.2456	0.911	0.0109	0.0380	0.903
Alkalinity	.	.	.	.	.	.
Ammonia	0.0057	0.0081	0.495	0.0052	0.0009	**0.0025**
Arsenic (As)	-0.0005	0.0002	0.048	-0.0001	0.0002	0.714
Cyanide	.	.	.	.	.	.
Cadmium (Cd)	-0.0000	0.0000	0.316	-0.0000	0.0000	0.595
Copper (Cu)	-0.0005	0.0016	0.757	-0.0001	0.0003	0.689
Iron (Fe)	-0.0201	0.1792	0.911	0.0056	0.0298	0.860
Hardness	.	.	.	.	.	.
Mercury (Hg)	0.0000	0.0000	0.560	-0.0000	0.0000	0.809
Molybdenum (Mo)	-0.0006	0.0024	0.797	0.0037	0.0010	0.016
Nickel (Ni)	-0.0006	0.0016	0.706	-0.0000	0.0000	0.883
Nitrate	-0.1065	0.1044	0.323	-0.0633	0.1451	0.681
Lead (Pb)	-0.0002	0.0001	0.215	-0.0001	0.0002	0.554
Radium (Ra)	.	.	.	.	.	.
Total Suspended Solids (TSS)	-11.1628	8.1692	0.190	0.7875	2.9559	0.800
Zinc (Zn)	-0.0001	0.0022	0.949	0.0004	0.0004	0.306
pH	0.0413	0.2847	0.886	-0.0113	0.0934	0.909

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Small Lake-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Small Lake Sampling

	Lake	
	Little Roberts	Reference D
Parameter	Proportion Censored	Proportion Censored
Aluminum (Al)	0.03	0.00
Alkalinity	0.02	0.00
Ammonia	0.32	0.77
Arsenic (As)	0.18	0.38
Cyanide	0.69	0.54
Cadmium (Cd)	0.75	1.00
Copper (Cu)	0.00	0.00
Iron (Fe)	0.00	0.00
Hardness	0.00	0.00
Mercury (Hg)	0.58	0.46
Molybdenum (Mo)	0.05	0.00
Nickel (Ni)	0.08	0.15
Nitrate	0.65	0.69
Lead (Pb)	0.12	0.00
Radium (Ra)	0.88	0.92
Total Suspended Solids (TSS)	0.20	0.62
Zinc (Zn)	0.30	0.92
pH	0.00	0.00

Table Small Lake-2. Summary of Potential Outliers from the Small Lake Data

Lake	Parameter	Year	Date	Rep	Reading	Censored (1=yes 0=no)
Little Roberts	Ammonia	2007	24MAY07	1	0.240000	0
Little Roberts	Ammonia	2012	14APR12	1	0.17100	0
Little Roberts	Ammonia	2012	14APR12	2	0.16400	0
Little Roberts	Cd	1995	07MAY95	1	0.000100	1
Little Roberts	Cd	1995	07JUN95	1	0.000100	1
Little Roberts	Cd	1996	27AUG96	1	0.000025	1
Little Roberts	Cd	1996	27AUG96	2	0.000025	1
Little Roberts	Cd	1997	15JUL97	1	0.000100	1
Little Roberts	Cd	1997	15JUL97	2	0.000100	1
Little Roberts	Hg	2003	27JUL03	1	0.000230	0
Little Roberts	Mo	1997	15JUL97	1	0.000500	1
Little Roberts	Mo	1997	15JUL97	2	0.000500	1
Little Roberts	Nitrate	2004	13SEP04	1	5.300000	0
Little Roberts	Ra	2004	13SEP04	1	0.060000	0
Little Roberts	Zn	1995	07MAY95	1	0.327000	0

Notes: Censored values were replaced by ½ of the detection limit.

Table Small Lake-3. Summary of Test for No Difference in Mean between Before and After Periods for Small Lake Water Quality Parameters

	Effect	
	Period	
	Lake	
	Little Roberts	Reference D
Parameter	**Pr> F**	**Pr> F**
Aluminum (Al)	0.8924	.
Alkalinity	0.9342	.
Ammonia	0.5536	.
Arsenic (As)	0.5527	.
Cyanide	0.2282	.
Cadmium (Cd)	0.3712	.
Copper (Cu)	0.7463	.
Iron (Fe)	0.5483	.
Hardness	0.7838	.
Mercury (Hg)	0.3474	.
Molybdenum (Mo)	**<0.0001**	.
Nickel (Ni)	0.9541	.
Nitrate	0.4662	.
Lead (Pb)	0.7316	.
Radium (Ra)	0.3422	.
Total Suspended Solids (TSS)	0.1840	.
Zinc (Zn)	0.3985	.
pH	**0.0046**	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no “before” data available).

Table Large Lake-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Large Lake Sampling

	Lake			
	Doris North	Doris South	Reference B	Roberts
Parameter	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
Aluminum (Al)	0.01	0.05	0.06	0.17
Alkalinity	0.00	0.00	0.00	0.00
Ammonia	0.32	0.58	0.50	0.83
Arsenic (As)	0.14	0.30	0.28	0.83
Cyanide	0.61	0.48	0.37	1.00
Cadmium (Cd)	0.79	0.93	0.91	1.00
Copper (Cu)	0.01	0.00	0.03	0.00
Iron (Fe)	0.08	0.12	0.69	0.17
Hardness	0.00	0.00	0.00	0.00
Mercury (Hg)	0.49	0.68	0.53	0.33
Molybdenum (Mo)	0.05	0.25	0.84	0.00
Nickel (Ni)	0.00	0.18	0.31	0.17
Nitrate	0.69	0.65	0.69	1.00
Lead (Pb)	0.23	0.34	0.38	0.17
Radium (Ra)	0.84	0.86	0.85	0.67
Total Suspended Solids (TSS)	0.10	0.17	0.91	0.20
Zinc (Zn)	0.36	0.58	0.88	1.00
pH	0.00	0.00	0.00	0.00

Table Large Lake-2. Summary of Potential Outliers from the Large Lake Data

Lake	Parameter	Year	Date	Rep	Reading	Censored (1=yes 0=no)
Doris North	As	1995	20AUG95	1	0.003000	0
Doris South	As	1996	28AUG96	1	0.005000	0
Doris South	As	1996	28AUG96	1	0.004000	0
Doris South	As	1996	28AUG96	1	0.007000	0
Doris South	As	1996	28AUG96	1	0.015000	0
Doris North	Cd	1995	04MAY95	1	0.000100	1
Doris North	Cd	1995	07JUN95	1	0.000100	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	04MAY95	1	0.000100	1
Doris South	Cd	1995	07JUN95	1	0.000100	1
Doris South	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	20AUG95	2	0.000050	1
Doris South	Cd	1997	18APR97	1	0.000100	1
Doris South	Cd	1997	18JUL97	1	0.000100	1
Doris South	Cd	1997	18JUL97	1	0.000100	1
Doris South	Cd	1997	18JUL97	2	0.000100	1
Doris South	Cd	1997	18JUL97	2	0.000100	1
Doris South	Cd	1997	22AUG97	1	0.000100	1
Doris South	Cd	1997	22AUG97	1	0.000100	1
Doris South	Cd	1998	25APR98	1	0.000100	1
Doris South	Cd	1998	25APR98	2	0.000100	1
Doris South	Cd	1998	25APR98	3	0.000100	1
Doris South	Hg	1997	22AUG97	1	0.000025	1
Doris South	Hg	1997	22AUG97	1	0.000025	1
Doris South	Hg	1998	25APR98	1	0.000025	1
Doris South	Hg	1998	25APR98	2	0.000025	1
Doris South	Hg	1998	25APR98	3	0.000025	1
Doris South	Hg	2000	24JUL00	1	0.000025	1
Doris South	Hg	2000	24JUL00	2	0.000025	1

Table Large Lake-2. Summary of Potential Outliers from the Large Lake Data

Lake	Parameter	Year	Date	Rep	Reading	Censored (1=yes 0=no)
Doris South	Hg	2000	24JUL00	1	0.000025	1
Doris South	Hg	2000	24JUL00	2	0.000025	1
Doris South	Hg	2000	22AUG00	1	0.000025	1
Doris South	Hg	2000	22AUG00	2	0.000025	1
Doris South	Mo	1997	18APR97	1	0.000500	1
Doris South	Mo	1997	18JUL97	1	0.000500	1
Doris South	Mo	1997	18JUL97	1	0.000500	1
Doris South	Mo	1997	18JUL97	2	0.000500	1
Doris South	Mo	1997	18JUL97	2	0.000500	1
Doris South	Mo	1997	22AUG97	1	0.000500	1
Doris South	Mo	1997	22AUG97	1	0.000500	1
Doris South	Mo	1998	25APR98	1	0.000500	1
Doris South	Mo	1998	25APR98	2	0.000500	1
Doris South	Mo	1998	25APR98	3	0.000500	1
Doris North	Ni	2005	19JUL05	1	0.028300	0
Doris North	Pb	2004	05JUN04	1	0.006690	0
Doris South	Nitrate	1996	28AUG96	1	4.510000	0
Doris North	Ra	2004	10SEP04	1	0.060000	0

Notes: Censored values were replaced by ½ of the detection limit.

Table Large Lake-3. Summary of Test for No Difference in Mean between Before and After Periods for Large Lake Water Quality Parameters

	Effect			
	Period			
	Lake			
	Doris South	Doris North	Reference B	Roberts
Parameter	Pr> F	Pr> F	Pr> F	Pr> F
Aluminum (Al)	**<0.0001**	0.9113	0.0510	.
Alkalinity	0.3821	0.2345	0.0036	.
Ammonia	0.0521	0.7433	**<0.0001**	.
Arsenic (As)	0.1330	0.8580	0.7018	.
Cyanide	0.5028	**<0.0001**	.	.
Cadmium (Cd)	0.6509	0.4025	**<0.001**	.
Copper (Cu)	0.7010	0.4076	0.1339	.
Iron (Fe)	0.8963	0.7425	0.1329	.
Hardness	0.0790	0.0209	0.0162	.
Mercury (Hg)	0.3404	**<0.0001**	0.0002	.
Molybdenum (Mo)	**<0.0001**	0.8956	**<0.0001**	.
Nickel (Ni)	0.5976	0.4415	0.6296	.
Nitrate	0.9313	0.5494	**<0.0001**	.
Lead (Pb)	0.4151	0.4809	0.9922	.
Radium (Ra)	0.0150	.	.	.
Total Suspended Solids (TSS)	0.9597	0.9167	0.0474	.
Zinc (Zn)	0.5227	0.4533	**<0.0001**	.
pH	0.2697	0.2619	0.4867	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Large Lake-4. Summary of BACI Comparison of Water Quality Parameters for Individual Project Large Lake Sites

	Large Project Lake					
	Doris South			Doris North		
Parameter	**BACI est**	**BACI SE**	**p-value**	**BACI est**	**BACI SE**	**p-value**
Aluminum (Al)	0.0347	0.0198	0.095	0.0114	0.0784	0.887
Alkalinity	0.3572	3.4878	0.919	1.310	6.3463	0.840
Ammonia	0.0033	0.0056	0.561	-0.0060	0.0110	0.599
Arsenic (As)	-0.0004	0.0002	0.088	-0.0003	0.0003	0.405
Cyanide	.	.	.	.	.	.
Cadmium (Cd)	0.0000	0.0000	0.896	0.0000	0.0000	0.678
Copper (Cu)	-0.0004	0.0006	0.501	-0.0006	0.0006	0.377
Iron (Fe)	0.02306	0.0520	0.662	-0.0060	0.1510	0.969
Hardness	2.1041	3.0041	0.491	2.3644	2.4002	0.346
Mercury (Hg)	0.0000	0.0000	0.037	0.0000	0.0000	0.040
Molybdenum (Mo)	0.0000	0.0000	0.042	0.0000	0.0001	0.949
Nickel (Ni)	-0.0000	0.0002	0.930	0.0000	0.0003	0.999
Nitrate	-0.0217	0.0180	0.241	-0.0217	0.0140	0.146
Lead (Pb)	-0.0003	0.0002	0.189	-0.0003	0.0003	0.277
Radium (Ra)	.	.	.	.	.	.
Total Suspended Solids (TSS)	1.389	2.142	0.523	2.4452	1.9869	0.240
Zinc (Zn)	-0.0044	0.0189	0.816	-0.0232	0.0435	0.603
pH	-0.0789	0.5039	0.877	-0.2655	0.3302	0.436

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Roberts Lake was not included in this analysis because no 'before' data exists.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Appendix B.2.3. Statistical Methodology and Results for Sediment Quality Evaluation of Effects, Doris North Project, 2012

Table of Contents

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 site's sediment for that monitoring period.

Samples were typically collected only once per year (usually August). Consequently no information is available on month-to-month variation in sediment parameters, and inference will be limited to the sampled months.

For the marine environment, the sampling years before construction are quite different (2002 and 2009) for the two sites for which historical data are available (RBW and REF-Marine 1). 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 varies by waterbody and by chemical parameter. The analyses below follow the advice of McBride (2005; Section 11.4.3).

- When the dataset includes a small number of below detection values, these values will be replaced by ½ of the detection limit for the analysis.
- When the majority of the dataset consists of 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 is an 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 Markov chain Monte Carlo (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 sediment quality parameters fall into one of the two first 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 of the particle size composition 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 are available

(Aitchison 1986), 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 sediment quality 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

The first analysis conducted compares the mean readings for all years prior to 2010 (before initiation of construction) to the mean for 2012 (year 3 of construction). Each waterbody is treated independently, and each sediment quality parameter is treated separately.

The final statistical model (in standard shorthand notation) is:

Y = Period Year(period)-R

Where *Y* is the (mean) parameter reading in a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest), and *Year(Period)* is a random year effect (applicable if more than one year was sampled during each period).

This model is preferable to simply treating all measurement within a period (e.g., over all baseline years) as having the same mean and assuming that they are completely independent of each other. This model also “averages” the sediment quality values collected over the baseline years in a way that weights each year equally rather than weighting by the sample size. For example, suppose that the sediment quality parameter measured in 2008 was 22 mg/kg, while the two readings measured in 2009 were 25 and 27 mg/kg. The simple mean (22+25+27)/3=24.7 mg/kg 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:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2} = 24.0 \text{ mg/kg}$$

This can be extended to multiple years in a similar fashion. Note that in the case of balanced data, i.e. equal number of replicates in all years, the average-of-the-averages and simple-average will be identical. The model with a random year effect is still preferred in the case of balanced data because the readings within a year may be correlated due to year-specific random factors that cause all the readings within a year to increase or decrease in step.

This model was fit using R version 2.15.2. 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.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, e.g., the mean sediment quality readings 2012 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 waterbodies.

For the lake environments, no “before” sediment quality data was available for the reference lakes. Consequently, no BACI analysis can be performed for the lake environments.

For marine and stream environments, the formal statistical model (in standard shorthand notation) is:

*Y = Period Class Period*Class*

where *Y* is the sediment quality parameter reading; *Period* is the effect of period (before or after construction); *Class* is the effect of water body 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, a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for each Project stream is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate. Only one year of baseline data are available for stream and marine sites; therefore, the model does not include a random year effect.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (Before-After) over the two classes of waterbodies (Project or reference).

The BACI estimate is computed as the “difference in the differences”:

$$BACI = (\mu_{PA} - \mu_{PB}) - (\mu_{RA} - \mu_{RB})$$

where μ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean parameter reading in the *Project* class of sites *before* Project initiation,μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. 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 here.

This model was fit using R version 2.15.2.

1.5.3 Multivariate Approaches

All of the approaches above analyze each sediment quality parameter independently of any 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 (values below the detection limit) for the stream data is found in Table Stream-1. High levels of censoring in all streams were found for cadmium and mercury, as a consequence the results of the analyses for this parameter will be non-informative. Preliminary plots of the data failed to show any outliers.

The results from the analysis that compared the means before and after Project construction are presented in Table Stream-2. Differences between before and after means were detected for % gravel and % sand in Doris OF.

The results of the BACI comparison (Table Stream-3) found evidence of a differential change in % sand between Doris OF and reference streams over the before and after periods. In addition, the BACI comparison found evidence of a differential change in % clay, chromium, lead, mercury, total organic carbon, and zinc between Little Roberts OF and reference streams over the before and after periods.

2.2 MARINE DATA

A summary of the amount of censoring (values below the detection limit) for the marine data is found in Table Marine-1. High levels of censoring in all sites were found for the cadmium, mercury, and % gravel parameters and the results of the analyses for these parameters will be non-informative. Preliminary plots of the data showed no outliers.

The results from the analysis that compared the means before and after Project construction are presented in Table Marine-2. At RBW, there was evidence of a difference in means across the periods for % sand, % silt, TOC, arsenic, cadmium (highly censored), chromium, copper, lead, and zinc.

BACI could not be done for RBW because of a lack of degrees of freedom in the before periods. Additionally, BACI and before-after comparisons could not be done for RBE because sediment quality data was not collected pre-construction.

2.3 LAKE DATA

A summary of the amount of censoring (values below the 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 no evidence of outliers.

There was evidence of a change between the before and after periods in the mean % gravel (highly censored) and copper concentrations in Doris Lake South; % silt, % clay, copper and lead in Doris Lake North; and % clay, % gravel (highly censored), arsenic and lead in Little Roberts Lake (Table Lake-2). Because no reference lakes were measured in the before period, no BACI comparisons were possible.

References

Aitchison, J. (1986). *The Statistical Analysis of Compositional Data*.Chapman & Hall.

Helsel, D.R. (2005). *Nondetects and data analysis*.Wiley:New York.

McBride, G.B. (2005). *Using statistical methods for water quality management*. Wiley: New York.

Smith, E. P. (2002). *BACI Design.Encyclopedia of Environmetrics*. Wiley: New York.

Table Stream-1. Summary of the Proportion of Measurements that were Below Detection Limit

	Stream Site					
	Doris OF	Little Roberts OF	Reference B OF	Reference D OF	Roberts OF	All Sites
Parameter	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
% Clay (<4μm)	0.17	0.00	0.25	0.00	0.00	0.09
% Gravel (>2mm)	0.00	0.42	0.00	0.00	0.44	0.17
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00	0.00	0.00	0
% Silt (0.063mm – 4μm)	0.08	0.00	0.00	0.11	0.00	0.04
Arsenic (As)	0.00	0.00	0.00	0.00	0.00	0
Cadmium (Cd)	1.00	1.00	0.92	1.00	0.67	0.93
Chromium (Cr)	0.00	0.00	0.00	0.00	0.00	0
Copper (Cu)	0.00	0.00	0.00	0.00	0.00	0
Lead (Pb)	0.25	0.00	0.33	0.33	0.00	0.18
Mercury (Hg)	0.75	0.50	0.83	1.00	0.67	0.74
Total Organic Carbon	0.17	0.17	0.17	0.33	0.00	0.17
Zinc (Zn)	0.00	0.00	0.00	0.00	0.00	0

Table Stream-2. Summary of Test for No Difference in Mean between Before and After Periods for Stream Sediment Quality Parameters

	Doris OF	Little Roberts OF	Reference B OF	Reference D OF	Roberts OF
Parameter	Pr> F	Pr> F	Pr> F	Pr> F	Pr> F
% Clay (<4μm)	0.3891	0.1313	0.0279	.	.
% Gravel (>2mm)	**0.0018**	0.3460	0.9594	.	.
% Sand (2.0mm - 0.063mm)	**0.0001**	0.3680	0.5828	.	.
% Silt (0.063mm - 4μm)	0.6109	0.2237	0.1050	.	.
Arsenic (As)	0.7189	0.0459	0.2826	.	.
Cadmium (Cd)	0.3173	0.3173	0.7194	.	.
Chromium (Cr)	0.8855	0.7774	0.7805	.	.
Copper (Cu)	0.4826	0.0124	0.3536	.	.
Lead (Pb)	0.2297	0.2263	0.7654	.	.
Mercury (Hg)	0.9790	0.0880	0.4128	.	.
Total Organic Carbon	0.8049	0.3291	0.9594	.	.
Zinc (Zn)	0.7469	0.0667	0.3869	.	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Stream-3. Summary of BACI Comparison of Sediment Quality Parameters for Individual Project Stream Sites

Parameter	Stream Site					
	Doris OF			Little Roberts OF		
	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
% Clay (<4μm)	-0.2967	3.3643	0.932	-9.8500	2.0423	**0.0013**
% Gravel (>2mm)	-48.3333	18.4723	0.031	27.7667	17.9184	0.160
% Sand (2.0mm - 0.063mm)	41.9667	9.6187	**0.002**	3.8333	11.2063	0.741
% Silt (0.063mm - 4μm)	6.3333	10.0846	0.5475	-21.8933	10.1863	0.064
Arsenic (As)	-0.8323	0.6226	0.218	-0.9763	0.3434	0.022
Cadmium (Cd)	0.0000	0.0000	0.715	0.0000	0.0000	0.715
Chromium (Cr)	-18.4667	7.7797	0.045	-21.2667	3.8824	**0.001**
Copper (Cu)	-7.1467	7.2091	0.351	-7.6733	3.8912	0.084
Lead (Pb)	-1.4600	1.8313	0.449	-2.8700	0.6627	**0.003**
Mercury (Hg)	-0.0014	0.0014	0.347	-0.0109	0.0018	**<0.001**
Total Organic Carbon	-0.1233	0.2211	0.592	-1.6467	0.2050	**<0.001**
Zinc (Zn)	-13.2333	9.3201	0.193	-27.9000	5.0616	**0.001**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
A BACI analysis could not be performed for Roberts OF as no "before" data was available for this site.

Table Marine-1. Summary of the Proportion of Measurements that were Below Detection Limit

Parameter	Marine Site			All Sites
	RBE	RBW	REF-Marine 1	
	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
% Clay (<4μm)	0.00	0.00	0.00	0
% Gravel (>2mm)	0.67	0.79	0.67	0.72
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00	0
% Silt (0.063mm - 4μm)	0.00	0.00	0.00	0
Arsenic (As)	0.00	0.00	0.00	0
Cadmium (Cd)	1.00	0.93	0.75	0.89
Chromium (Cr)	0.00	0.00	0.00	0
Copper (Cu)	0.00	0.00	0.00	0
Lead (Pb)	0.33	0.00	0.25	0.17
Mercury (Hg)	1.00	0.79	0.50	0.74
Total Organic Carbon	0.67	0.36	0.00	0.32
Zinc (Zn)	0.00	0.00	0.00	0

Table Marine-2. Summary of Test for No Difference in Mean between Before and After Periods for Marine Sediment Quality Parameters

	Marine Site		
	RBE	RBW	REF-Marine 1
Parameter	Pr> F	Pr> F	Pr> F
% Clay (<4μm)	.	0.0193	**<0.0001**
% Gravel (>2mm)	.	0.6760	0.0916
% Sand (2.0mm - 0.063mm)	.	**0.0002**	**<0.0001**
% Silt (0.063mm - 4μm)	.	**<0.0001**	**<0.0001**
Arsenic (As)	.	**<0.0001**	**<0.0001**
Cadmium (Cd)	.	**0.0001**	**<0.0001**
Chromium (Cr)	.	**<0.0001**	**0.0001**
Copper (Cu)	.	**<0.0001**	**<0.0001**
Lead (Pb)	.	**0.0014**	**<0.0001**
Mercury (Hg)	.	0.3071	**<0.0001**
Total Organic Carbon	.	**<0.0001**	**<0.0001**
Zinc (Zn)	.	**<0.0001**	**<0.0001**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Marine-3. Summary of BACI Comparison of Sediment Quality Parameters for Individual Project Marine Sites

	Marine Site					
	RBE			RBW		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
% Clay (<4μm)	.	.	.	-14.07333	3.5838	.
% Gravel (>2mm)	.	.	.	0.6967	2.1101	.
% Sand (2.0mm - 0.063mm)	.	.	.	50.3533	6.9809	.
% Silt (0.063mm - 4μm)	.	.	.	-36.5467	4.3887	.
Arsenic (As)	.	.	.	-1.1433	0.5562	.
Cadmium (Cd)	.	.	.	-0.0410	0.0188	.
Chromium (Cr)	.	.	.	-3.5667	4.0682	.
Copper (Cu)	.	.	.	11.7667	2.7073	.
Lead (Pb)	.	.	.	-0.8667	1.2035	.
Mercury (Hg)	.	.	.	.	.	.
Total Organic Carbon	.	.	.	-0.3733	0.1142	.
Zinc (Zn)	.	.	.	-2.4000	4.0038	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
A BACI analysis could not be performed for RBE as no "before" data was available for this site, or for mercury at RBW as there were not enough degrees of freedom for the analysis.

Table Lake-1. Summary of the Proportion of Measurements that were Below Detection Limit

Parameter	Lake Site						All Sites
	Doris North	Doris South	Little Roberts	Reference B	Reference D	Roberts	All Sites
	Proportion censored	Proportion censored	Proportion censored	Proportion censored	Proportion censored	Proportion censored	Proportion censored
% Clay (<4μm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Gravel (>2mm)	0.92	1.00	1.00	0.56	1.00	1.00	0.91
% Sand (2.0mm - 0.063mm)	0.08	0.11	0.00	0.00	0.00	0.00	0.04
% Silt (0.063mm - 4μm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium (Cd)	0.00	0.10	0.08	0.00	0.22	0.00	0.07
Chromium (Cr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lead (Pb)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mercury (Hg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Organic Carbon	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc (Zn)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table Lake-2. Summary of Test for No Difference in Mean between Before and After Periods for Lake Sediment Quality Parameters

Parameter	Lake Site					
	Doris North	Doris South	Little Roberts	Reference B	Reference D	Roberts
	Pr> F	Pr> F	Pr> F	Pr> F	Pr> F	Pr> F
% Clay (<4μm)	**0.0085**	0.1053	**0.0010**	.	.	
% Gravel (>2mm)	0.2381	**<0.0001**	**<0.0001**	.	.	
% Sand (2.0mm - 0.063mm)	0.4478	0.9414	0.4652	.	.	
% Silt (0.063mm - 4μm)	**0.0058**	0.1052	0.0242	.	.	
Arsenic (As)	0.1277	0.0194	**0.0050**	.	.	
Cadmium (Cd)	0.0162	0.8750	0.9954	.	.	
Chromium (Cr)	0.4807	0.5933	0.4098	.	.	
Copper (Cu)	**0.0006**	**<0.0001**	0.5490	.	.	
Lead (Pb)	**0.0039**	0.0403	**<0.0001**	.	.	
Mercury (Hg)	0.0133	0.8962	0.9395	.	.	
Total Organic Carbon	0.1069	0.1040	0.4744	.	.	
Zinc (Zn)	0.1676	0.5326	0.4664	.	.	

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Appendix B.2.4. Statistical Methodology and Results for Phytoplankton and Periphyton Evaluation of Effects, Doris North Project, 2012

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1. Analysis Methods

1.1 ASSUMPTIONS

The key assumption of this analysis is that the samples collected are representative of each site'speriphyton or phytoplankton biomass (estimated from chlorophyll *a* levels) for that monitoring period.

1.2 REPLICATE SAMPLES

Replicate samples collected on the same date were averaged prior to analysis. For some historical data, only the mean value was available.

1.3 DEALING WITH CENSORING (VALUES BELOW DETECTION LIMITS)

Some phytoplankton chlorophyll *a* concentrations in the marine environment were below analytical detection limits. The analyses below follow the advice of McBride (2005; Section 11.4.3).

- When the dataset includesa small number of below detection values, these values will be replaced by ½ of the detection limit for the analysis.
- When the majority of the dataset consists of 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 is an 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,the marine phytoplankton biomass dataset falls into the first category (few censored values), and the lake and stream datasets did not contain censored values.

1.4 TRANSFORMATIONS

A preliminary analysis found that the variance of the periphyton and phytoplankton biomass values tended to increase with the mean and that the distribution of values was skewed. This suggested that a logarithmic transformation was appropriate.

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 periphyton or phytoplankton biomass over time and to assess if changes in the means may reflect an impact of the Project.

1.5.1 Before vs. After Analysis

The first analysis conducted compares the mean readings for all years prior to 2010 (before initiation of construction) to the mean for 2012 (year 3 of construction). Each waterbody is treated independently.

The final statistical model (in standard shorthand notation) is:

Y = Period Season Year(period)-R

where *Y* is the biomass reading of periphyton or phytoplankton in a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest); *Season* is the effect of season (4 seasons in the sampling year: 1) April or May (under-ice), 2) July, 3) August, 4) September);and *Year(Period)* is a random year effect (applicable if more than one year was sampled during each period).

This model is preferable to simply treating all measurement within a period (e.g., over the baseline years) as having the same mean and assuming that they are completely independent of each other. This model also “averages” the phytoplankton values collected over the baseline years in a way that weights each year equally rather than weighting by the sample size. For example, suppose that the phytoplankton biomass measured in 2008 was 22μg chl *a*/L, while the two readings measured in 2009 were 25 and 27μg chl *a*/L. The simple mean (22+25+27)/3=24.7 μg chl *a*/L 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:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2}=24.0$$

This can be extended to multiple years in a similar fashion. Note that in the case of balanced data, i.e., equal number of replicates in all years, the average-of-the-averages and simple-average will be identical. The model with a random year effect is still preferred in the case of balanced data because the readings within a year may be correlated due to year-specific random factors that cause all the readings within a year to increase or decrease in step.

This model was fit using R version 2.15.2. 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.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, e.g., the average periphyton or phytoplankton biomass readings in 2012 could be higher or lower 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 waterbodies. A BACI analysis was performed for each Project waterbody versus the corresponding reference waterbody.

The formal statistical model (in standard shorthand notation) is:

*Y = Period Season Class Period*Class Year(Period)-R*

where *Y* is the parameter of interest; *Period* is the effect of period (before or after construction); *Season* is the effect of season (4 seasons in the sampling year: 1) April or May (under-ice), 2) July, 3) August, 4) September); *Class* is the effect of waterbody 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 sites); and *Year(Period)* is the random year effect within each period (applicable if more than one year was sampled during each period). Not all sites were measured in all years and only those Project-reference pairs of sites that were measured both in the before and after period can be used to estimate this BACI contrast. The results from this comparison are specific to the particular Project-reference sites. If there were multiple reference waterbodies (as is the case for streams), a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for the Project site is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (Before-After) over the two classes of sites (Project or reference).The BACI estimate is computed as the “difference in the differences”:

$$BACI = (\mu_{PA} - \mu_{PB}) - (\mu_{RA} - \mu_{RB})$$

whereμ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation,μ_{PB} is the mean parameter reading in the *Project* class of sites *before* Project initiation,μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. 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 here.

This model was fit using R version 2.15.2.

For all environments, caution should be used in interpreting the results from the BACI analysis because there was only one reading for phytoplankton or periphyton biomass in one reference site before Project initiation.

2. Results

2.1 STREAM DATA

There was no censoring of the stream periphyton biomass values. Preliminary plots of the data showed one outlier from 1997 which was removed (Table Stream-1).

The results from the analysis that compared the means before and after Project construction are presented in Table Stream-2. Because of the absence of baseline data for Roberts OF and Reference D OF, and a lack of degrees of freedom in the before period for Reference B OF, before-after comparisons were not possible for these streams. There was no evidence of a change in the mean *log(periphyton)* for Doris OF.

The BACI comparison failed to detect evidence of a differential change in before-after trends for either Little Roberts OF or Doris OF compared to the reference streams (Table Stream-3). A BACI analysis could not be conducted for Roberts OF because there was no baseline periphyton data available.

2.2 MARINE DATA

A few marine phytoplankton biomass values were censored (Table Marine-1). No outliers were detected. Because of the scarcity of baseline data available for all marine sites, before-after comparisons could not be conducted (too few degrees of freedom to fit the model).

BACI comparisons for both RBE and RBW sites failed to detect evidence of a differential change compared to the reference site (Table Marine-2).

2.3 LAKE DATA

The lake data was divided into small lakes (Little Roberts and Reference D) and large lakes (Doris South, Doris North, and Reference B). No censoring was observed for the lake phytoplankton data. Preliminary plots of the data did not show any evidence of outliers.

There was no evidence of a change in the mean *log(phytoplankton)* in any lake between the before and after period (Tables Large Lake-1 and Small Lake-1). Because of a lack of degrees of freedom in the before period for Reference Lake B, a before-after comparison was not possible for this lake. However, there was also no evidence of a differential change in the mean *log(phytoplankton)* levels between before/after periods in the large Project lakes compared to Reference Lake B (Table Lake-Large-2). Because phytoplankton biomass levels in Reference Lake D were not measured pre-construction, no BACI comparison is possible for small lakes.

References

Helsel, D.R. (2005). *Nondetects and data analysis*.Wiley:New York.

McBride, G.B. (2005). *Using statistical methods for water quality management*. Wiley: New York.

Smith, E. P. (2002). *BACI Design.Encyclopedia of Environmetrics*. Wiley: New York.

Table Stream-1. Outlier Periphyton Biomass Values

Site	Parameter	Year	Date	Rep	Value	Censored (1=yes 0=no)
Doris OF	Periphyton	1997	19-Jul-1997	1	194.4	0
Doris OF	logPeriphyton	1997	19-Jul-1997	1	5.27	0

Table Steam-2. Summary of Test for No Difference in Mean between Before and After Periods for Stream Periphyton Biomass

Parameter	Proportion Censored	Doris OF Pr> F	Little Roberts OF Pr> F	Reference B OF Pr> F	Reference D OF Pr> F	Roberts OF Pr> F
logPeriphyton	0.00	0.169	0.405	.	.	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In Roberts OF and Reference D OF streams, no readings were taken pre-construction, so no before-after comparison is possible.

Table Stream-3. Summary of BACI Comparison of Stream Periphyton Biomass for Individual Project Sites

	Doris OF			Little Roberts OF		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
logPeriphyton	-1.7190	0.7911	0.0578	1.1458	0.6973	0.1390

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In Roberts OF stream, no readings were taken pre-construction, so no BACI comparison is possible.

Table Marine-1. Summary of the Amount of Censoring in the Marine Sites

	Marine Site			
	RBE Proportion Censored	RBW Proportion Censored	REF-Marine 1 Proportion Censored	All Sites Proportion Censored
logPhytoplankton	0.08	0.08	0.00	0.055

Table Marine-2. Summary of BACI Comparison of Marine Phytoplankton Biomass for Individual Project Sites

	Marine Site					
	RBE			RBW		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
logPhytoplankton	-0.8614	0.9656	0.4381	-1.5493	0.3449	0.0206

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Large Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Large Lake Phytoplankton Biomass

		Large Lake Site		
		Doris North	Doris South	Reference B
Parameter	Proportion Censored	Pr> F	Pr> F	Pr> F
logPhytoplankton	0.00	0.0890	0.9869	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Large Lake-2. Summary of BACI Comparison of Large Lake Phytoplankton Biomass for Individual Project Sites

	Large Lake Site					
	Doris North			Doris South		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
logPhytoplankton	0.1041	0.4412	0.8251	-0.2114	0.5169	0.7035

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Small Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Small Lake Phytoplankton Biomass

		Period	
		Little Roberts	Reference D
Parameter	Proportion Censored	Pr> F	Pr> F
logPhytoplankton	0.00	0.1273	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In Reference D, no readings were taken pre-construction, so no BACI comparison is possible.

Appendix B.2.5. Statistical Methodology and Results for Benthos Evaluation of Effects, Doris North Project, 2012

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1. Analysis Methods

1.1 ASSUMPTIONS

The key assumption of this analysis is that the samples collected are representative samples of the site and year of sampling. Since all samples were taken at the same time of year (August), inference is restricted to comparisons during this period.

1.2 TRANSFORMATIONS

A preliminary analysis found that the variance of several parameter values tended to increase with the mean in some waterbodies, but there was no consistent pattern. Given that only two years of data are available, the evidence for a transformation is weak and so no transformation was done.

1.3 OUTLINE OF ANALYSIS PLAN

1.3.1 Impact Level-by-time Analysis

The benthos data has only been collected since 2010 (post-construction); there is no information available pre-construction. Consequently, before/after or BACI comparisons cannot be done.

In cases where no pre-Project data are available, Wiens and Parker (1995) suggest several alternatives, especially for long-term monitoring. One of their suggestions is the level-by-time comparisons where the trend-lines for Project and reference waterbodies are compared to see if there is evidence of non-parallelism over time.

The final statistical model (in standard shorthand notation) is:

$$Y = Class\ Year\ Class*Year$$

where *Y* is the reading for the benthic parameter; *Class* is the effect of waterbody classification (Project or reference); *Year* is the effect of year; and *Class*Year* is the non-parallelism in the response over time. For marine and lake sites, there is a single site in each class and separate comparisons are made for each site against its corresponding reference site. For streams, multiple reference waterbodies are available for comparison against a single Project waterbody; therefore, the term *Body(Class)-R* (the random site effect within each class) is added for the multiple sites within the classification.

The Class*Year term is the effect of interest representing non-parallel changes over time between the sites.

This model is fit using R version 2.15.2. 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.

1.3.2 Multivariate Approaches

The approach outlined above analyzes each benthic parameter independently. However, the parameters are likely not independent of each other, and presumably higher power would result if a multivariate approach were used. Because only three years of data are available, this has not been attempted in this report.

2. Results

2.1 STREAM DATA

The results from the analysis that tests for parallelism in the mean parameter value over time is presented in Table Stream-1. There was no evidence of non-parallel response in any benthos data.

2.2 MARINE DATA

The marine data was analyzed in two ways: 1) with data for adults and juveniles pooled together and 2) with data for adults only. Results for the tests for parallelism are presented in Tables Marine-1 and Marine-2, respectively.

For the pooled adult and juvenile data, non-parallelism was detected in the density, richness and Simpson's evenness index in RBW and in the richness, Simpson's evenness and Bray-Curtis index in RBE.

For the adult-only data, non-parallelism was detected in the density, richness, Simpson's evenness, and Simpson's diversity index in RBW and the density, richness, Simpson's evenness and Bray-Curtis index in RBE.

2.3 LAKE DATA

The lakes data was divided into large lakes (Doris Lake South, Doris Lake North, and Reference Lake B) and small lakes (Little Roberts Lake and Reference Lake D). Results of the tests for parallelism are presented in Tables Large Lake-1 and Small Lake-1.

There was evidence of non-parallelism in the Bray-Curtis Index in Doris Lake North. 2010 data for Doris Lake South were not included in the analysis because of a change in sampling location between 2010 and 2011; therefore, nothing can be said about parallelism over time for this lake site. No evidence of non-parallelism was found for any benthos parameter in Little Roberts Lake (small lake).

References

Wiens, J. A., and K. R. Parker. 1995. *Analyzing the effects of accidental environmental impacts: approaches and assumptions*. Ecological Applications 5(4), 1069–1083.

Table Stream-1. Summary of Tests for Parallelism for the Stream Benthos Data

	Effect		
	Class*Year Stream Site		
	Doris OF	Little Roberts OF	Roberts OF
Parameter	p-value	p-value	p-value
Bray-Curtis	0.1894	0.1499	0.0558
Density	0.1126	0.9631	0.1111
Diversity	0.5371	0.9095	0.3593
Evenness	0.1409	0.5460	0.1353
Richness	0.3163	0.2501	0.3236

***Notes: To** reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.*

Table Marine-1. Summary of Tests for Parallelism for the Marine Benthos Data (Adults and Juveniles Pooled)

	Effect	
	Class*Year Marine Site	
	RBE	RBW
Parameter	p-value	p-value
Bray-Curtis	**0.0006**	0.0257
Density	0.1770	**<0.0001**
Diversity	0.0829	0.0247
Evenness	**0.0089**	**<0.0001**
Richness	**<0.0001**	**0.0017**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Marine-2. Summary of Tests for Parallelism for the Marine Benthos Data (Adults Only)

	Effect	
	Class*Year Marine Site	
	RBE	RBW
Parameter	p-value	p-value
Bray-Curtis	**0.0007**	0.0340
Density	**<0.0001**	**<0.0001**
Diversity	0.2365	**<0.0001**
Evenness	**0.0007**	**<0.0001**
Richness	**<0.0001**	**0.0004**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Large Lake-1. Summary of Tests for Parallelism for the Large Lake Benthos Data

	Effect	
	Class*Year Large Lake Site	
Parameter	Doris North p-value	Doris South p-value
Bray-Curtis	**0.0066**	.
Density	0.2607	.
Diversity	0.0784	.
Evenness	0.4393	.
Richness	0.5717	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
2010 data for Doris South was not used because of a change in sampling location between 2010 and 2011;consequently, no test for parallelism is possible.

Table Lake-Small-1. Summary of Tests for Parallelism for the Small Lake Benthos Data

	Effect
	Class*Year Small Lake Site
Parameter	Little Roberts p-value
Bray-Curtis	0.2606
Density	0.4674
Diversity	0.1889
Evenness	0.0731
Richness	1.0000

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.